Differential Household Responses in a Poor Agricultural Economy: Implications for Agricultural Policy Analysis

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Abstract

There is increasing interest in differential impacts of and responses to different domestic and global policy and market changes in poor agrarian economies. Conventional analysis, even where it disaggregates between producers and consumers with different resource bundles, tends to apply uniform production and demand functions to these households without examining differences in their underlying behaviour. However, differences in resource access between households, coupled with market failures (or at least large price wedges), are likely to be associated with differential household production responses that do not conform to either standard production functions or uniform supply elasticities (with for example variability in non-separability between different households). This paper examines the extent and implications of such differential responses in Malawi.

A non-linear programming model of farm-household behaviour is applied to households with different resource endowments. Model results describe differences in production responses and household welfare for households with different resource endowments. Some dramatic differences are observed in responses to changes in wages and in staple food prices where, over critical price ranges, seasonal cash constraints may lead to perverse (backward sloping) supply responses for very poor households while over the same price range less poor households show a positive supply response.

While the perverse supply responses found for some households in this study may represent an extreme situation, highly inelastic supply responses are likely to be much more common, given widespread agricultural finance market failures, liquidity constraints facing poor households, and competition between household consumption and seasonal crop investments for scarce working capital. Analysis of impacts of change in national and international policy and trade conditions therefore need to explicitly take account of these issues and of their interactions with household consumption and welfare, with different farm and non-farm activities, and with institutional changes affecting different producers' access to and needs for seasonal capital.

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1 Introduction

The adoption of the International Development Goals has rightly increased development attention to the impacts of development interventions on poverty reduction and on the livelihoods and welfare of different categories of poor people. Important policy questions then arise as regards impacts of domestic and international policy on poor consumers and producers as well as on aggregate measures of economic performance. Disaggregated policy analysis commonly addresses this issue by identifying different categories of household with different bundles of resource endowments. Differential impacts of policy and other change are then explored by tracing price change and other effects through the economy, allowing for their differential effects on the incomes and expenditure patterns of households with different resource bundles – so that, for example, policy changes that lead to increased demand for unskilled labour tend to benefit the poor, whereas policy changes that lead to labour saving technical change tend to reduce wages (and hence reduce incomes of the poor) while increasing incomes from (and the value of) land to land holding households. Commodity price changes also have differential impacts, depending upon differences in household expenditure patterns (so that policy changes that lead to increased staple food prices tend to harm the poor, as consumers).

Brooks 2003 identifies different kinds of disaggregated analysis using households as the basic unit of analysis: cross country regression analysis using household level data, partial equilibrium household models examining household expenditures, and general equilibrium models. More conventional general equilibrium approaches (for example that followed in the standard IFPRI model, Lofgren *et al.* 2002) involves the definition of particular household types as institutions owning factors of production in the social accounting matrix. These factors of production are then allocated to activities which produce commodities, which are consumed by households. Household types are defined principally in terms of their ownership and use of (and income from) different factors, but they may also be associated with particular activities and the production of particular commodities. Production functions (and associated supply elasticities) in each activity are commonly assigned in conformity with supply responses estimated from empirical studies (often in different economies with similar structural characteristics).

A criticism of this approach is the often rather arbitrary definition of a limited range of different household types used in the analysis (often defined in terms of education, land holding, and urban and rural location). 'Micro simulation' CGE models address this problem by taking the disaggregation much further, allowing for particular factor endowments for each household in a household survey (see for example Robilliard 2002). This provides a much richer set of differentiated household impacts, often at the cost of less sophisticated representation of other elements of the economy.

Both the standard and micro simulation approaches, however, suffer from a potentially fundamental weakness in that although they model differential household *impacts* of changes in factor and commodity prices on household incomes, they do not model in any detail differential household production *responses* to change, tending to assume uniform patterns of producer response. If, however, some households differ significantly in their responses to price and other changes, then economy wide models which assume a uniform producer response will fail to properly model

differential impacts on two counts: they will fail first to recognise the way that differential responses modify direct impacts of change on different households and second to capture the second order economy wide effects through the interaction of the impacts of these differential responses (for example in markets). The potential interactions between differential household responses, differential impacts and overall economic outcomes in a rural economy are illustrated in figure 1. This illustrates how some exogenous change or shock can lead to direct changes in the rural economy and/or in the external environment. These changes may then have direct (and differential) impacts on different households, direct impacts on the local market and environment, and lead to direct (and differential) responses by different households. These direct and differential impacts and responses, however, will be modified by their interactions with each other and potentially with their impacts on other parts of the national (and global) environment. While these wider interactions are extensively examined in policy analysis, differential interactions among households' production responses, and their wider impacts, are not often formally investigated in policy analysis models[1]. In this paper we investigate the potential scale and importance of these interactions in the rural economy of Malawi.

2 A non-linear programming model of Malawian farm-households

A non-linear programming model of Malawian farm/ rural household behaviour was formulated as follows:

$$MaxE(U) = \sum_{s} P_s \prod_{j*m} (C_{jm} - \gamma_{jm})^{\beta_{jm}} \quad (1)$$

such that

for m = 1 to 2

$$-t_{jm} + t_{j(m+1)} + \sum_{ij} e_{ijm} x_i + C_{jm} \leq 0 \quad (2)$$

for m = 3 to 4

$$-t_{jms} + t_{j(m+1)s} + \sum_{ij} e_{ijms} x_{is} + C_{jms} \leq B_{jm} \quad (3)$$

for m = 4

$$-t_{j(m+1)s} = t_{j(m=1)} \quad (4)$$

where

m are four periods within a year: *m* = 1 describes the 'cropping period' (November to January); *m* = 2 describes the 'pre-harvest period' (February and March) ; *m* = 3 describes the 'harvest period' (April to June); and *m* = 4 describes the 'post harvest period' (July to October).

[1] Lofgren and Robinson 2003 therefore propose the incorporation of farm household CGE models nested within more conventional models, an approach adopted by Taylor and Adelman 1996.

s are alternative market conditions as regards end of season maize prices (in periods m= 3 and m= 4)

P_s are subjective probabilities of alternative market conditions s

C_{jm} represent total consumption of commodity/ resource j in period m

γ_{jm} are minimum consumption requirements for commodity/ resource j in period m

β_{jm} are the marginal propensities to consume commodity/ resource j in period m

t_{jms} represent transfers of commodity/ resource j from period m to period $m+1$ in market condition s

e_{ijms} are technical and price coefficients of use/ production of resource / commodity j by activity x_{is} in period m under market condition s

x_{is} are activities undertaken by the household. These include cropping activities, buying and selling of stocks and labour, and stock transfers between periods. For those activities which take place wholly in periods 3 or 4 these are distinguished according to the market condition s under which they are followed.

B_{jm} are supply constraints on commodity/ resource j in period m

Commodity/ resource j include land, labour, cash stocks, maize stocks, purchased crop inputs, and post harvest cash crop stocks.

$j^* m$ is the subset of commodities/ resources directly consumed by the household and for which consumption is included in the objective function: cash consumption by period, consumption of maize (or calorific equivalents from other crops) by period, leisure ('slack' labour) by period, and end of season cash savings.

Equation 1 maximises expected utility using a linear expenditure system (LES). Equations 2 and 3 describe constrained resource use and production opportunities in different periods, with buying and selling of those commodities and resources for which there is a market, stock transfers between periods where appropriate, and household consumption where appropriate. Equation 3 allows for alternative stocking, market and off farm employment strategies to be followed under different market conditions (maize price regimes) in the harvest and post harvest periods. Equation 4 ensures that the model maintains the same opening and closing stocks from year to year and does not generate artificial windfall gains by portfolio changes (for example by replacing maize stock by cash).

The model also included upper bounds on some activities to represent practical constraints not allowed for in the general formulation (for example, the effects of timing of activities within time periods, of limited maize storage capacity, and of transport, labour and market constraints on root crop sales).

This model structure is able to address the major design aspirations derived from the conditions facing rural households in Malawi[2], intended uses of the model, and previous experience of

[2] Malawi is one of the poorest countries in the world, and key elements in the poor performance of the Malawian economy and relevant to this paper include very high dependence on agriculture; very high population densities and small holding sizes in some areas; low productivity in production of maize (the staple crop which accounts for around 70% of cultivated area in the country); poor physical infrastructure within the country; poorly developed agricultural markets and services; very high rates of HIV/AIDS infection with multiple effects on livelihoods and the economy (de Waal 2002); very high rates of poverty incidence and severity; and low levels of literacy and education (see Dorward 2003).

smallholder farm/ household modelling in Malawi (Dorward 1984, 1991; Simler 1994 ; Dorward 1996; Dorward 1997; Alwang and Siegel 1999; Dorward 1999a, b), while making best use of limited and patchy data available for model construction (Dorward 2003). Particular features of the model relevant to this paper are its allowance for

1. *Seasonal constraints*: The year is divided into four periods. In the 'cropping period' crops make heavy demands on labour and there are potential trade-offs between on-farm work (generating returns later, at harvest time) and off farm work (generating lower but more immediate returns which, for cash and food scarce, poor households, may be needed to sustain minimal levels of cash and food consumption prior to harvest since households are not able to borrow to meet their immediate consumption needs). In the pre-harvest period there is limited on-farm labour demand and hence limited demand for off-farm work. In the harvest period crop prices fall and farm labour demand and off farm wage rates rise. In the post harvest period crop prices rise, some farm labour is required for land preparation, and there are more off farm employment opportunities (for example in petty trading, in building, collecting grass, etc).
2. *Varied activities*: a range of cropping activities can be modelled, with varying seasonal demands for labour and purchased inputs, and different seasonal activities. The structure allows flexibility in linking these to stocking and buying and selling activities across and within time periods. Off farm activities can be described in terms of hiring out of labour at differing rates in different periods. Technical change and the introduction of new crops or new income earning opportunities can be described by the introduction of new activities.
3. *Heterogeneity*: differences between households can be described in terms of differences in the options open to them (for example different cropping activities in different agro-ecological areas), in asset holdings (for example land, seasonal labour, pre-seasonal holdings of cash and grain stocks), and in the relation between consumption needs and assets (the dependency ratio has interactions with labour available for on and off farm work, consumption needs, and cash and grain stocks available for consumption before harvest).
4. *Partial engagement with imperfect markets*: a 'wedge' was introduced between market, farmgate and local purchase prices. Farmgate sales prices are calculated as market prices less a mark-down, and consumer purchase prices as market prices plus a mark-up[3]. Imperfect markets are represented primarily by a large mark-down depressing farmgate prices, as well as by price uncertainty in food markets (discussed below). Transaction costs (but not risks) are also allowed for in unskilled labour markets, with time demands for supervision when hiring in labour, and for travelling costs when hiring out. Over-supply on the ganyu labour market and wages above market clearing are allowed for by introducing search costs (in terms of time) for those seeking *ganyu* employment[4]. Complete credit market failure is assumed in the base model: households cannot borrow without special interventions, such as credit tied to the provision of tobacco inputs with recovery through tobacco sales.

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[3] To reflect variation between seasons as regards local maize demand and supply, farm gate (sales) prices in the 'crop' period were not subject to the mark-down explained earlier (to allow for local demand), whereas in the harvest and post harvest periods maize could be purchased at the farmgate (marked down) price, to reflect local supply (all purchases, however, incurred a mark-up to represent buying costs).

[4] '*Ganyu*' is a Malawian term that refers to casual labour employment. The model also allows for income from non-farm semi-skilled labour. Household with such labour may sell if off the farm for a higher wage or use it on farm like other household labour. Off farm labour hire also represents self employment in non-farm activities.

5. *Food security objectives in uncertain markets*: It is frequently argued that uncertainty as regards the reliability and costs of purchasing food cause Malawian smallholders to set a high premium on subsistence maize production, inhibiting specialisation in otherwise more productive activities (see for example Dorward 1999a; Orr and Orr 2002). This is commonly modelled by setting some minimum maize production target (for example Simler 1994 ; Alwang and Siegel 1999;), but this approach precludes investigation of the effects of improved market performance (and of trust in market performance). Food consumption was therefore modelled in terms of calorific requirements which could be met in different ways according to season – from consumption of maize stocks from the previous season, of maize purchases, or, in the harvest and post harvest periods of own farm production of other crops (cassava, sweet potato, rice, and groundnuts). Subsistence production of maize (or root crops) was therefore encouraged by the wedge between maize purchase and sales prices, as discussed above. The effect of food price uncertainty on farmers' food security considerations was modelled by introducing three alternative market conditions in the base model, representing expected, high and low maize purchase prices.
6. *Non-separability*: The modelling of seasonal constraints, of imperfections in maize, labour and credit markets (as outlined above), and of household objectives means that there is potential for strong competition and interaction between consumption and production activities, particularly for poorer households affected by seasonal stock constraints and lack of access to credit.

Different household types were identified and characterised using data from the Integrated Household Survey (IFPRI and NSO 2002), differentiating between households first as regards agro-ecological zone (determining the agricultural opportunities potentially available) and second as regards socio-economic characteristics within each zone. Three agro-ecological zones were identified, but subsequent modelling activities focussed only on one of these, representing mid altitude plateau conditions and including an estimated 60% of rural households in Malawi. Cluster analysis of the IHS data set was used to identify groupings or types of household taking account of variation in regular off-farm employment, remittances, value of productive asset holdings, estimated retained maize per household member, holding size per household member, access to credit, and gender of household head. The characteristics of the seven household types identified are detailed in see table 1[5].

Data for different elements from the model were obtained from a wide range of sources. One of the advantages of using a programming model is its use of discrete activities with relatively simple physical or financial budgets which can be obtained from a range of data sources rather than one survey data set. For topics where data sources were limited or gave conflicting information, pragmatic judgements were made, and, where necessary, the effects of alternative assumptions were investigated in a process of model calibration (see Dorward 2003 for further information). The model was written in GAMS code (Brooke *et al.* 1998)[6].

Model validation used four criteria identified by Ignizio 1982 (logical consistency in model construction; reliability of the data on which the model is based; logical consistency of model responses to simple stimuli; and correspondence of model outputs with reality) together with comprehensiveness or scope of the model in describing the effects of major variables affecting the system being modelled. Dorward 2003 examines these in detail and finds that the model performs well on these criteria.

[5] The development of the typology is described in detail in Dorward 2002.

[6] Code is available on request from A.Dorward@imperial.ac.uk.

3 Model results

3.1 Base cropping patterns

Table 2 presents basic model estimates of cropping pattern by household types for the base scenario (using 1997/1998 season prices), showing broad variation that is very close to patterns generally observed in Malawi. The two categories of very poor households have very small cultivated areas and are constrained from increasing this by constraints on land access and/or by seasonal labour constraints, which arise from severe seasonal capital constraints and their consequent need to hire out labour during the cropping season to provide for immediate consumption requirements. Their land is almost entirely devoted to local maize, with a small amount of cassava (with differing maize prices and wage rates these households move in and out of cassava, sweet potatoes and intercropped beans). The next poorest group, the 'borrowers', have considerably higher stocks of maize and cash at the start of the season (see table 1) and have access to credit with which to buy tobacco inputs. However, these households are still heavily constrained by shortages of seasonal capital, hiring out labour to finance some of their consumption. 'Medium farmers with assets' start the season with substantially larger amounts of cash and maize and are able to invest this in maize and tobacco. They hire out semi-skilled labour during the cropping period, and hire in *ganyu* to replace this, but have surplus labour to hire out during subsequent periods. The 'large farm' category, with larger pre-seasonal stocks of cash and maize and larger land:labour ratios, hire out their semi-skilled labour throughout the year, hiring *ganyu* in all periods, but particularly during peak farm labour demand in the cropping season. Two other household categories have substantial non-farm income sources, from wage employment and from remittances. Both household types grow local and hybrid maize, investing their non-farm income in hybrid maize inputs. Neither household hires in *ganyu* labour, and indeed both hire out *ganyu* throughout the year.

As regards distribution of cultivated land, the households in the two poorest categories have small mean cultivated holdings of less than 0.6 and 0.4 ha respectively, and these households make up 52% of the households in this zone. This is comparable with findings from the last comprehensive agricultural survey (National Sample Survey of Agriculture, 1992/93 – see NSO 1998). Variations between household types as regards cropping patterns show a strong concentration on local maize, with a little cassava, for the poorest households, with less constrained households also producing hybrid maize and tobacco and households with remittances and employment concentrating more on hybrid maize than tobacco.

3.2 Differential first order responses to and impacts of change

We now examine the behaviour of the model when the different household types are subjected to different types of change. We examine here direct 'first order' impacts of changes, ignoring for the moment 'second order' effects that result from the responses of these households themselves affecting markets and prices. A small number of simulations are examined. For each of these simulations, a limited number of responses and impacts are shown to provide insights into critical relationships affecting different households' activities and welfare.

3.2.1 Direct livelihood impacts of maize price variation

A critical dilemma in agricultural policy for poor rural areas relates to prices for locally produced staples: poor, net consumers (who make up the majority of the Malawian population in rural as well as urban areas) benefit from low maize prices, but maize surplus producers should benefit from higher prices, and surplus production for net maize consumers will depend upon the incentives to and ability of less poor farmers to produce surplus maize. There is currently a debate in Malawi as to the extent to which smallholder maize production does respond to price incentives, as although better off farmers may respond to higher maize prices by producing more maize, poorer farmers

find that higher maize prices prior to harvest lead to higher maize expenditures and, due to credit constraints, reduce the resources available for maize production. Furthermore, it is argued, cultural factors and risk aversion make most Malawian households to try to grow as much of their own household maize requirements as possible, irrespective of market prices, while the number of households producing maize to sell is very small, so that higher prices are largely irrelevant to national maize production. On the other hand there is currently substantial surplus maize production by some smallholders in Malawi (since normally the large numbers of net consumer households are fed largely by maize produced by Malawian smallholders: imports, and to a lesser extent estate production, normally play a smaller but still significant role).

Figure 2 shows a range of model results with varying maize price for different households[7]. Proportionate maize price changes were applied across all time periods in the model. There are a number of points of interest in the graphs.

First, for most households and over most of the range of price changes modelled there is a clear positive production response. This results in increases in production and (not shown in the graphs) a switch from a mean annual deficit of around 200kg per person to a surplus of a little over 40kg per person per year. As the first two graphs show, this production increase occurs mainly over a fairly narrow price range (around the prices in the base scenario) and results largely from a switch into production of more intensive maize production using hybrid varieties and inorganic fertilisers. However, these two graphs also show two different patterns of price response among the different households. The pattern that results in the increased maize production is found in less poor households with greater access to seasonal capital. The poor male and female households show a very different price response: in the lower price range their response is initially fairly flat, followed by a modest response. However as prices rise further the price response becomes negative. This results from the higher cost of maize purchases for consumption prior to harvest, requiring them to switch labour from their own farms to off-own farm ganyu labour which offers a more immediate but lower return. As prices rise further they are unable to finance maize purchases and are initially forced to restrict their maize consumption, before the model becomes infeasible, as they cannot afford to buy sufficient maize (hence the lack of observations plotted for these households at the highest prices). For these households, therefore, the model is describing a vicious circle which is often reported in Malawi (e.g. UNICEF 1993; Dorward 1996; Pearce *et al.* 1996)[8]

The second pair of graphs show the simulated impacts of maize price changes on farm labour use (including own-farm family labour and hired in labour) during the cropping period. Consistent with the maize production response pattern we see less poor households showing broad increases in farm labour use (with some variations – at times exaggerated by the use of indices - due to movements in and out of tobacco and groundnuts, which are particularly labour demanding crops).

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[7] Throughout this section responses to change are shown using graphs which show proportionate changes in the independent variable along the horizontal axis, with households' estimated responses, and impacts of change, on the vertical axis, indexed to the 'base' scenario – as discussed above. The use of indices can be misleading where a base scenario variable is very small and relatively small absolute changes may lead to large index changes.

[8] We are aware of only one instance where this has been formally observed and documented (Pearce *et al.* 1996). Pearce's observation was in the Central Region, and Dorward's earlier work in the Northern Region, where land pressure is lower and holding sizes generally larger than in the more crowded and poorer Southern Region: here lower holding sizes of poorer households may mean that there is lower on-farm labour demand and hence the vicious circle described may not be so important. This was investigated with the model by repeating the analysis with a set of households with holding sizes only 50% of those in the base scenario: as might be expected the result is a very similar set of graphs to the first two in figure 1, except that the response curves for the two poorest household types are shifted to the right – indicating that there is still a negative production response to high prices, but this occurs at higher prices. The overall, mean price response across all households has a very similar shape.

The two poorest household types, however, show declining own-farm labour use with increasing maize prices, as at very low maize prices they grow small areas of groundnuts (a labour demanding crop) and cassava, and then with increasing maize prices switch land first to maize, and then at higher maize prices switch land first to less labour and input demanding lower plant density intercropped maize and then to very small areas of fallow, before minimum consumption levels become untenable and the model becomes infeasible. Overall, then, increasing maize prices lead to increased farm labour demand by some households (with increased hired labour demand or decreased hired labour supply), and increased decreased labour supply by others. The overall mean impact is a fairly rapid increase in farm labour demand with price increases in the lower range, and then this flattens off with further price increases. The impact of this on the hired labour (ganyu) market is shown in the fourth graph. Although this needs to be interpreted with caution (as the larger proportionate increases in hired labour demand build on a very low base), higher maize prices lead to a tightening of the labour market, and if this raises wages then this will benefit poorer households who hire out labour, as well as dampening the impacts of higher maize prices on all households.

The first order impacts of maize price increases on household welfare are shown in the graphs in the lower part of figure 2. All households suffer falls in real net income per capita with maize prices in the lower price range, as in this range all households are maize deficit households. As prices increase further, however, and maize production becomes more attractive, some households achieve maize self sufficiency and surplus production, and further price rises begin to benefit these households. This situation does not, of course, arise with the poorest households, who show a steep decline in real income for all maize price increases (again it should be noted that this ignores any second order effects of maize price rises on wages, and the impact of these on household activities and incomes).

The impact of higher maize prices on estimated calorific consumption shows a more consistent decline than the decline in household incomes. This is because where real incomes are falling, the effects of this on calorific (principally maize) consumption are exacerbated by a substitution effect[9], and even where real incomes recover, this substitution effect will still depress calorific consumption.

The final graph depicts estimates of first order impacts of increasing maize prices on the poverty head count, estimated by mapping predicted income changes back onto IHS data, with all households in each cluster having their real per capital daily expenditure changed by the proportionate increase in income estimated by the model. All households suffer rising poverty incidence with price rises in the lower range, but with some households recovering from this, or not affected by, further price rises. The poorest households, however, are the most affected, with the steepest increases in poverty incidence across the range. P_0 and P_1 measures (not shown in figure 2) demonstrate a similar pattern.

3.2.2 Direct livelihood impacts of variation in unskilled wage rates

Unskilled wage rates are critical to the livelihoods of the poor, and increases in real unskilled wages have been the major historical mechanisms by people have escaped poverty. Figure 3 shows a range of model results with varying unskilled wage rates in the cropping period of November to January, again without allowing for any second order effects within the rural economy. The first graph shows the labour supply response for different households during the cropping period. Of the

[9] The model allows households to substitute own farm produced sweet potato and cassava consumption for maize in the post harvest period, but otherwise calorific consumption must be supplied by purchased or own produced maize, with higher maize prices making non-staple and leisure consumption more attractive.

five household types that hire out unskilled labour, one (households with permanent employment) show a substantial positive response, one (the 'borrowers') show a negative response over the lower range and then a positive response as wages increase further, two (the two poorest household types) have a significant negative response, and one a very slight negative response. The negative responses in the two poorest households and, at lower prices, for the 'borrower' households are associated with cash flow problems. For the 'borrower' households this affects the funds available to invest in crop inputs, so increases in the lower wage rate provides cash in the cropping period that can be used to purchase more maize inputs, leading to higher on farm labour use. For the poor male headed and poor female headed households, increases in wage rates allow households to hire out less labour to finance purchase of the maize they need to consume prior to harvest, and thus to devote more time to own-farm activities, which are more remunerative over the season as a whole. Overall the weighted mean across all households shows a negative supply response for hired labour in the cropping period over most of the range of wage rates modelled[10]. On-farm demand for labour, on the other hand, declines with increasing price, with approximate unit elasticity. The perverse or very inelastic supply curve for *ganyu* labour suggests that shifts in demand will cause large relative shifts in wages with only small changes in total quantity of labour supplied. Since wages have far reaching impacts on the welfare of the poorest households, upward shifts in labour demand during the cropping period have the potential to be very important drivers of poverty reduction. Conversely, contractions of labour demand in this critical period are likely to have very significant detrimental impacts on the poor.

These patterns of supply and demand response to wage changes are reflected in household cropping activities, as higher wages lead to higher maize production among the poorest households and the 'borrower' households (the latter using the higher income from wages to buy more inputs for maize), whereas with higher wages maize production remains fairly constant for other households as they transfer labour out of tobacco production into maize, and from more intensive to less intensive maize production. These changes are reflected in the various welfare indicators in figure 3. Unskilled wage increases lead to a substantial rise in real net incomes for the poorest households and substantial falls in real net incomes for households hiring in unskilled labour, with more ambiguous effects for other households[11]. Calorific consumption, however, increases for all households except for the one household type that hires in labour. Estimates of impact on poverty incidence follow the pattern one would expect from impacts on real net income, with increasing wage rates leading to reductions in poverty incidence, and, across all households, with an overall mean fall of 10 to 15% in poverty incidence depending upon the poverty count estimate.

3.2.3 Direct livelihood impacts of variation in marketing costs

As noted earlier, the base scenario of the model allows for price 'wedges' between farm gate and local market crop prices (for tobacco these are 55% and for other crops 35%**,** estimated from van Donge and al. 2001 and Ngongola 1998). These price wedges depress the selling prices of crops in the harvest and post-harvest periods (and in these periods also lower the prices at which these crops

[10] As with the discussion of maize price responses discussed earlier, the perverse effect depends upon the importance of the vicious circle of 'forced ganyu hire' for poor households in the cropping period. If wage rates are varied for households with much less (half) land, the perverse response is weakened, and the responses in figure 1 become almost horizontal for all households, with labour supply to the ganyu market in the cropping period almost independent of wage rates and totally inelastic.

[11] Calculation of real net incomes allows for changes in wage dependent prices for consumption of locally produced goods and services, estimated to account for about 50% of expenditure on non-staple consumption. This reduces some of the real benefits of wage increases for households dependent upon (and otherwise benefiting from) wages, while for households hiring in unskilled labour it exacerbates the increasing costs of labour hire.

can be bought in rural areas). Better infrastructure and more competitive marketing systems could reduce these wedges, raising prices received by farmers. Figure 4 shows model results with varying (falling) wedges leading to increasing farm gate prices.

The different household types again respond in different ways to these changes. Most households respond with an increase in maize production (two households expand tobacco production at the expense of hybrid maize) and, as one would expect, with increased own-farm labour use, with increased hired farm labour demand and with a slight reduction in hired labour supply. Most households benefit from increased real incomes and falling poverty incidence, but the two poorest households are an exception: as net maize purchasers they are disadvantaged by higher local prices at which they purchase maize, and hence suffer a (modest) fall in real incomes and increase in poverty incidence.

3.2.4 Direct livelihood impacts of variation in sickness

The final type of 'exogenous' change for which we investigate livelihood impact is chronic sickness. Model estimates of labour available to the households make some allowance for the average effect of acute illnesses on household labour supply, but chronic illness, increasingly common with the spread of HIV/AIDS, can be expected to have quite different impacts. To allow simple comparison of the impact of a common shock across different households, sickness was simulated by varying proportionate loss of (a) labour standardized in terms of the proportion of an unskilled female's seasonal labour supply, and (b) 400MK cash expenditure (on treatment, etc).

Figure 5 shows the impact of varying losses of labour and cash on households' welfare and activities. Where sickness occurs in the November to January period the impacts are striking. All households are affected, but the two poorest household types, and particularly poor female headed households, are most seriously affected, as the loss of a fixed amount of labour and of capital has a much greater proportionate impact. The result is a dramatic reduction in net income, and in maize production (with first a shift from maize to cassava and then a reduction in cropped area) [12]. Other households are not affected so seriously, but there are substantial losses in welfare (especially given that the simulations only describe the effects of up to 50% loss of a person's unskilled labour and 200MK expenditure) and changes in cropping pattern, with shifts out of tobacco and in and out of hybrid maize, local maize and cassava. The impact of similar rates of labour and cash loss are much less serious in the post harvest (July to October) period (see the last two graphs in figure 5). These results are very similar to those reported in Shah *et al.* 2002. Consideration of the impact of greater proportionate losses than those modeled, losses of skilled worker's incomes and of remittances, and impacts of all these on labour markets, all suggest that the impact of HIV/AIDS infection on affected households will be even more severe than indicated by these results.

3.3 Differential second order responses to and impacts of change

Model results shown in Figures 2 to 5 show differentiated first order responses to and impacts of changes in maize prices, wages, marketing costs and sickness, with perverse supply responses for maize and labour for some households over some price ranges, leading to highly inelastic aggregate responses. It has been stressed, however, that these are estimates of first order effects, in that they do not take account of second round partial equilibrium effects through local maize and labour markets.

Figure 6 presents a range of results achieved from model simulations that attempt to take account of second round partial equilibrium effects allowing for local labour market adjustments to

[12] These responses, of course, assume a planned response to sickness, whereas its onset will often come after critical cropping decisions have been made.

externally imposed changes in maize prices. These partial equilibrium effects are modelled by calculating changes in local expenditure on non-tradables resulting from changes in real income as a result of maize price changes and household responses to them, and these expenditure changes affect demand for unskilled labour in the rural economy (a consumption linkages effect). This, coupled with direct effects of maize price changes on farm labour use, impacts on local demand and supply of labour, and hence on surplus labour supply to the rest of the economy, so that an increase (fall) in local net labour supply leads to a fall (rise) in wage rates. Unit elasticity of demand for this labour is assumed [13].

Variables in the graphs in figure 6 are broadly similar to those presented in figure 1, with maize production, labour and welfare measures disaggregated by the seven household types. However the simulated range of maize variation price is much smaller.

In many ways the results in figure 6 are similar to those in figure 2: both figures display substantial differences between the responses of different households to maize price changes, and many of these responses are markedly non-linear. The arc elasticities of maize production for the two poorest household types, for example, move from being moderately elastic when prices fall 10% below the base price (with elasticities of 2.3 and 1.3 for poor male and female headed households) to being highly inelastic (with elasticities of 0.2 and 0.3 respectively). Less poor households, however, find it attractive to switch into higher purchased input maize production at higher maize prices, and consequently demonstrate very elastic production response as maize prices rise above the base (as figure 2 suggests, however, this high elasticity is not sustained with further maize price increases due to land constraints). The relatively stable on farm labour demand of the two poorest household types in figure 2 is maintained in figure 6, although is shifts from being mildly negative to mildly positive. Other households, however, show more marked positive or negative responses in figure 6. These sometimes differ from those in figure 2 as the effects of maize price changes are masked by stronger effects from changes in wage rates. Thus a 10% fall or rise in the maize price from the base has first round effects that boosts real incomes (see figure 2), and this (through consumption linkages) leads to increased demand for labour for non-tradable goods and services, pushing up wage rates. This increases incomes of households selling unskilled labour, and this further increases non-tradable demand so that after multiplier effects are allowed for a 10% maize price fall (increase) leads to an estimated increases in nominal wages of 8% (6%). Overall the impacts of the second round effects are generally beneficial to the poor as the effects of higher wages induced by maize price rises counteract the costs of more expensive maize purchases.

4 Conclusions

The model results reported above demonstrate, even with the simplistic characterization of only seven household types, Malawian households' differential and complex responses to different changes, and the differential and complex welfare impacts of these changes. Some responses do not fit normal patterns of expected economic behaviour (for example the negative or highly inelastic supply responses for hired labour and maize observed among some of the poorest households). Analytical methods which do not take account of this differential and non-standard behaviour of poor households may lead to erroneous conclusions regarding the impacts of policy and other change not only on the poor, but on the overall economic behaviour and performance of economies or sectors where such households play a major role. This in turn can lead to the design and implementation of policies which may be intended to help the poor but in practice bypass them, exclude them or actually damage their livelihoods.

[13] See Dorward 2003 for further details on the modelling of these partial equilibrium effects.

Model results not only demonstrate the potential existence and importance of differential household responses to change, they also explore the causes and nature of differential and non-standard behaviour. This has its roots in the non-separability of production and consumption activities where households can act as both producers and consumers in situations where markets are absent or operate with a high degree of imperfection and large transaction costs and wedges between consumer and producer prices. Critical markets with these characteristics in rural areas are commonly staple food markets and seasonal finance markets.

This leads on to our final point, that although the non-standard behaviour of the poorest households in Malawi may represent an extreme situation, the spotlight it puts on problems arising from seasonal credit market failures is relevant to a very wide range of situations. For poor Malawian households, chronic shortages of basic food needs may force them to hire out labour to meet immediate food requirements, and constrain investment of their labour in crop production, thus perpetuating a vicious poverty trap. However seasonal credit constraints also affect less poor households, and may, for example, prevent them from taking advantage of new opportunities resulting from market liberalisation and trade reform, if expanding production of existing enterprises or movements into new crop or livestock activities requires even fairly modest seasonal investment[14]. This is, unfortunately, a very obvious and basic constraint that is commonly overlooked in formal economy wide models. Analysis of impacts of change in national and international policy and trade conditions need to explicitly take account of these issues. Ideally this should be achieved by the nesting within them of farm-household models that incorporate critical seasonal constraints on different households. This is a major challenge and may not be practicable in many situations. However the general arguments presented here demand not only greater attention to analysis of differentiation of household responses to change, but also greater attention to supply response estimates in policy analysis, with greater care in the selection of supply elasticities used in models and investigation of the effects of different supply elasticity assumptions on the performance of economies being studied and on the welfare of different people within them.

[14] Non farm activities with different and often shorter time lags between investment and return can play an important role in easing seasonal finance constraints in agricultural, a point that is well understood in micro-economic studies of rural income diversification (see for example Reardon *et al.* 1994). Building such interactions between farm / non-farm activities into formal policy models represents another major but important challenge.

Table 1 Characteristics of different farm/household types

		Larger Farmers	Medium Farmers with assets	Borrowers	Poor male headed	Poor female headed	Employed	Remittace
Household	(Semi) Skilled males	0.7	1	0	0	0	1	0
Members	Unskilled males	0	0.3	1.4	1.4	0.5	0.4	1.0
	Unskilled female	0.7	1.1	1.4	1.3	1.4	1.3	1.3
	Children	0.1	0.8	1.6	1.2	1.3	1.3	1.3
	Infants	0.1	0.8	1.1	1.0	0.7	1.0	0.8
	Elderly	0.1	0.1	0.1	0.1	0.1	0.0	0.2
Land area (ha)		1.5	1.3	1.3	0.6	0.4	0.8	1.2
Opening cash stock (MK)		2000	2800	1800	800	600	2500	2300
Opening maize stock (kg)		654	673	364	0	0	160	287
Non staple daily expenditure MK/ cap		4.0	3.5	2.5	1.6	1.5	5.0	5.0
Monthly Remittance income MK		0	0	0	0	0	0	600
Tobacco Credit access		no	no	yes	no	no	no	no

Table 2 Base Scenario Model Results[15]

							Sales	Purchases		Ganyu labour (N-J)	
	AllMaz (ha)	LocMaz (ha)	HybMaz (ha)	Tobacco (ha)	Cassava (ha)	Total (ha)	Maize (kg)	Maize (kg)	Inputs (MK)	Hire in (hours)	Hire out (hours)
1 Large farms	1.42	0.66	0.76	0.08	0.00	1.50	1633	105	2284	881	0
2 Medium assets	1.03	0.45	0.59	0.27	0.00	1.30	888	221	2625	393	0
3 Borrowers	1.03	0.74	0.29	0.27	0.00	1.30	543	358	754	0	401
4 Poor male head	0.54	0.54	0.00	0.00	0.03	0.57	36	660	2	0	875
5 Poor female head	0.36	0.36	0.00	0.00	0.03	0.39	17	501	2	0	642
6 Employed	0.80	0.22	0.58	0.00	0.00	0.80	834	496	1478	0	59
7 Remittance	1.15	0.58	0.57	0.05	0.00	1.20	1043	318	1666	0	150
Average /hhold	0.73	0.47	0.26	0.08	0.01	0.83	437	467	895		

[15] Other crops (groundnuts, beans and sweet potatoes) do not enter the base scenario solutions but do come in with relatively minor price changes for the different crops. 'Ganyu labour (N-J)' indicates unskilled labour hire in the November to January (cropping) period.

Figure 1. Disaggregated impacts of change with differential household responses

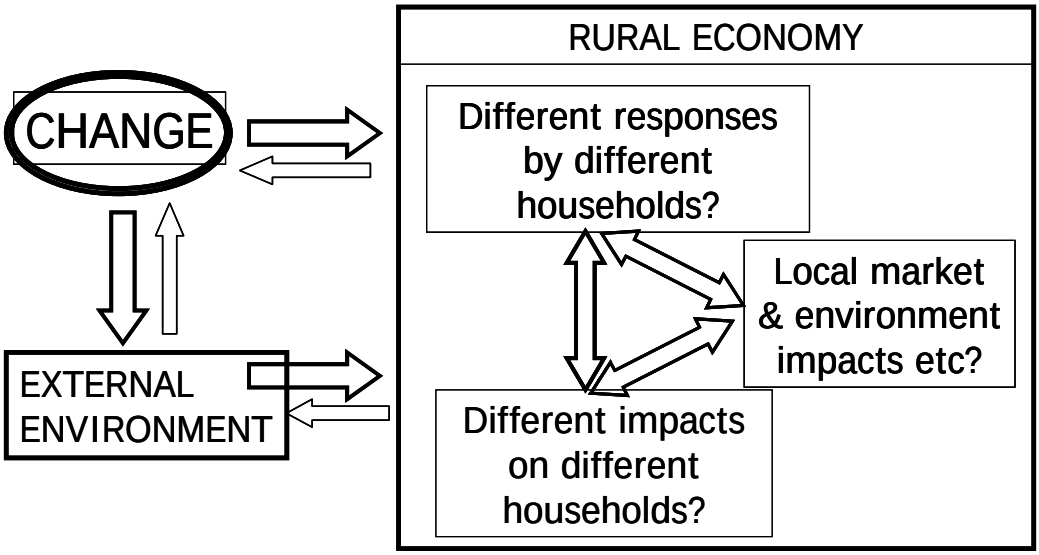


Figure 2. Household first order responses to varying maize prices

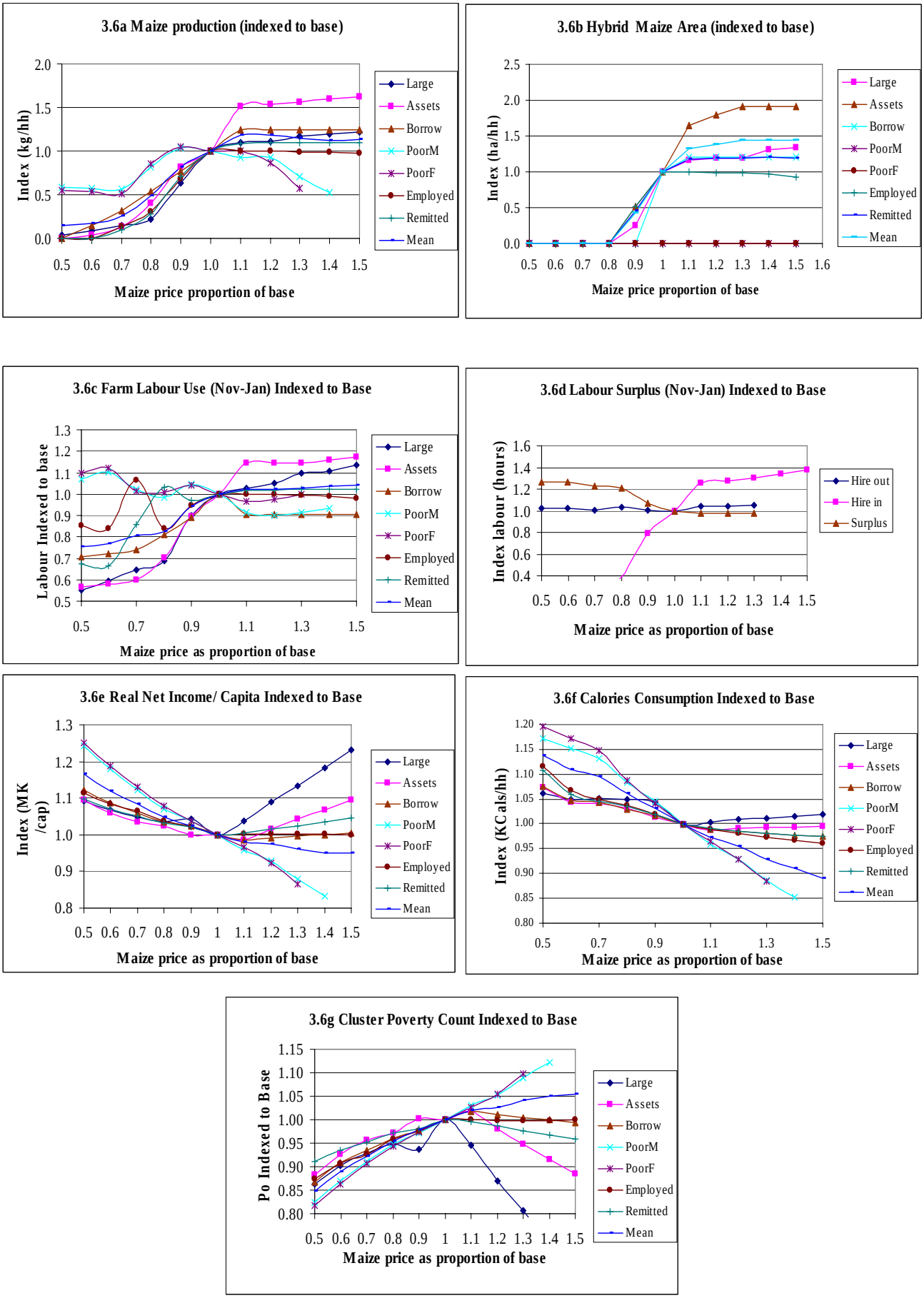


Figure 3 Household first order responses to varying unskilled (ganyu) wage rates

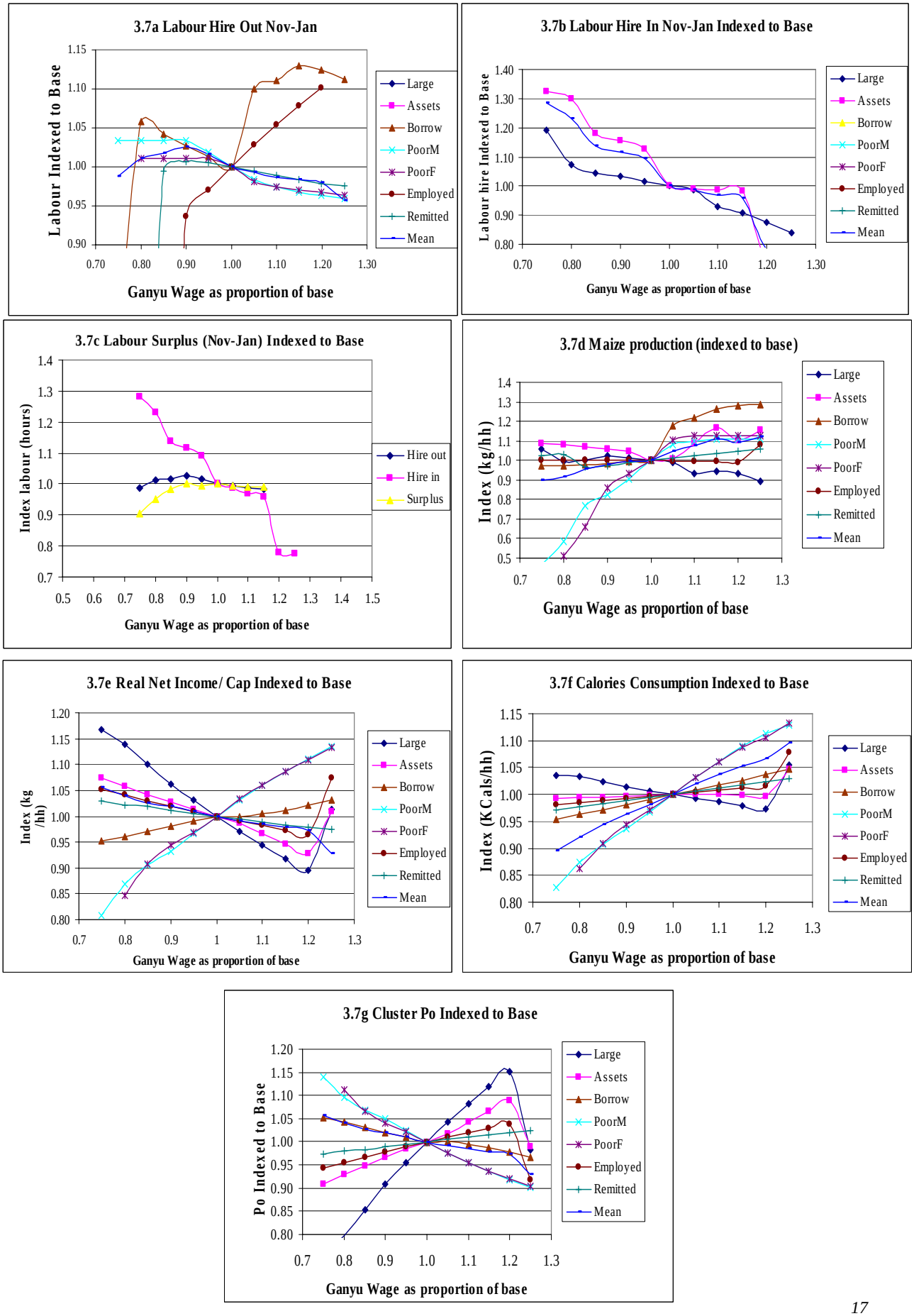
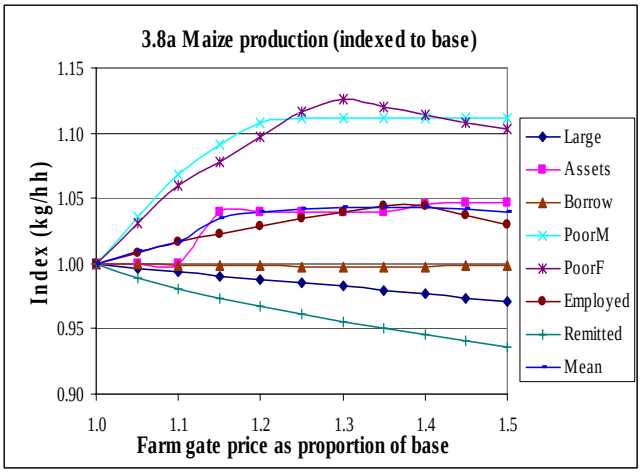
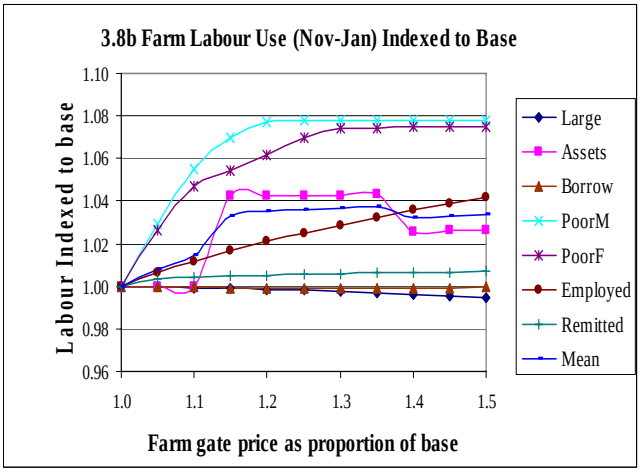
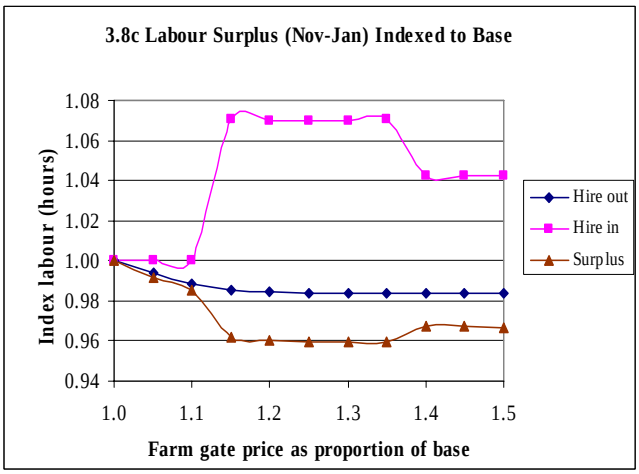


Figure 4 Household responses to varying marketing costs







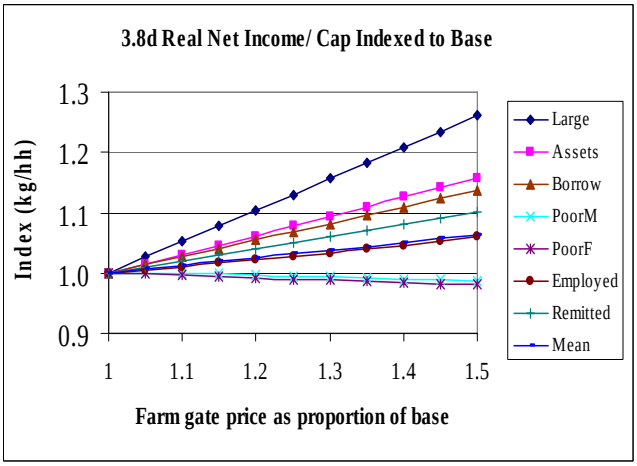


Figure 5. Household responses to effects of chronic sickness

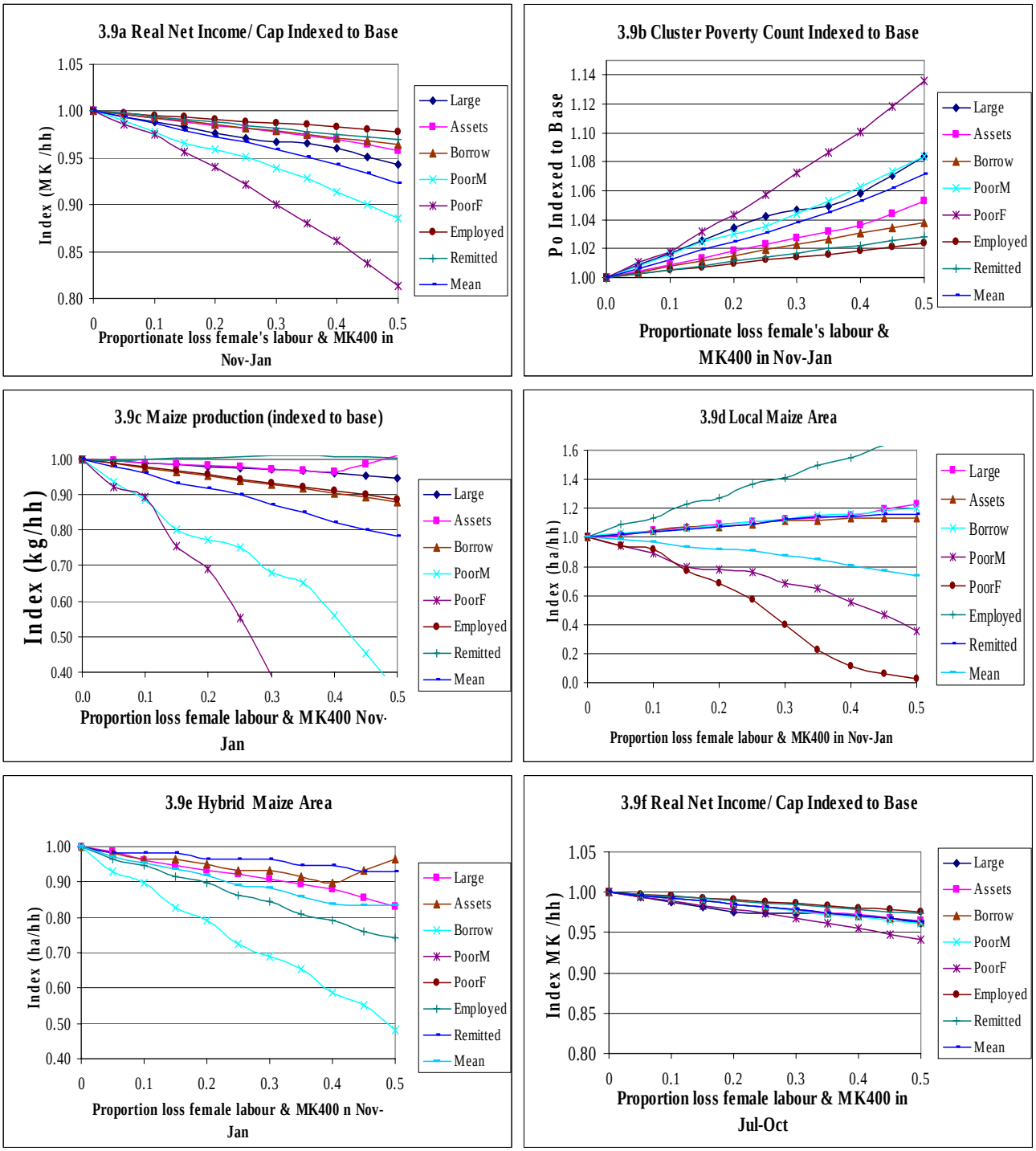
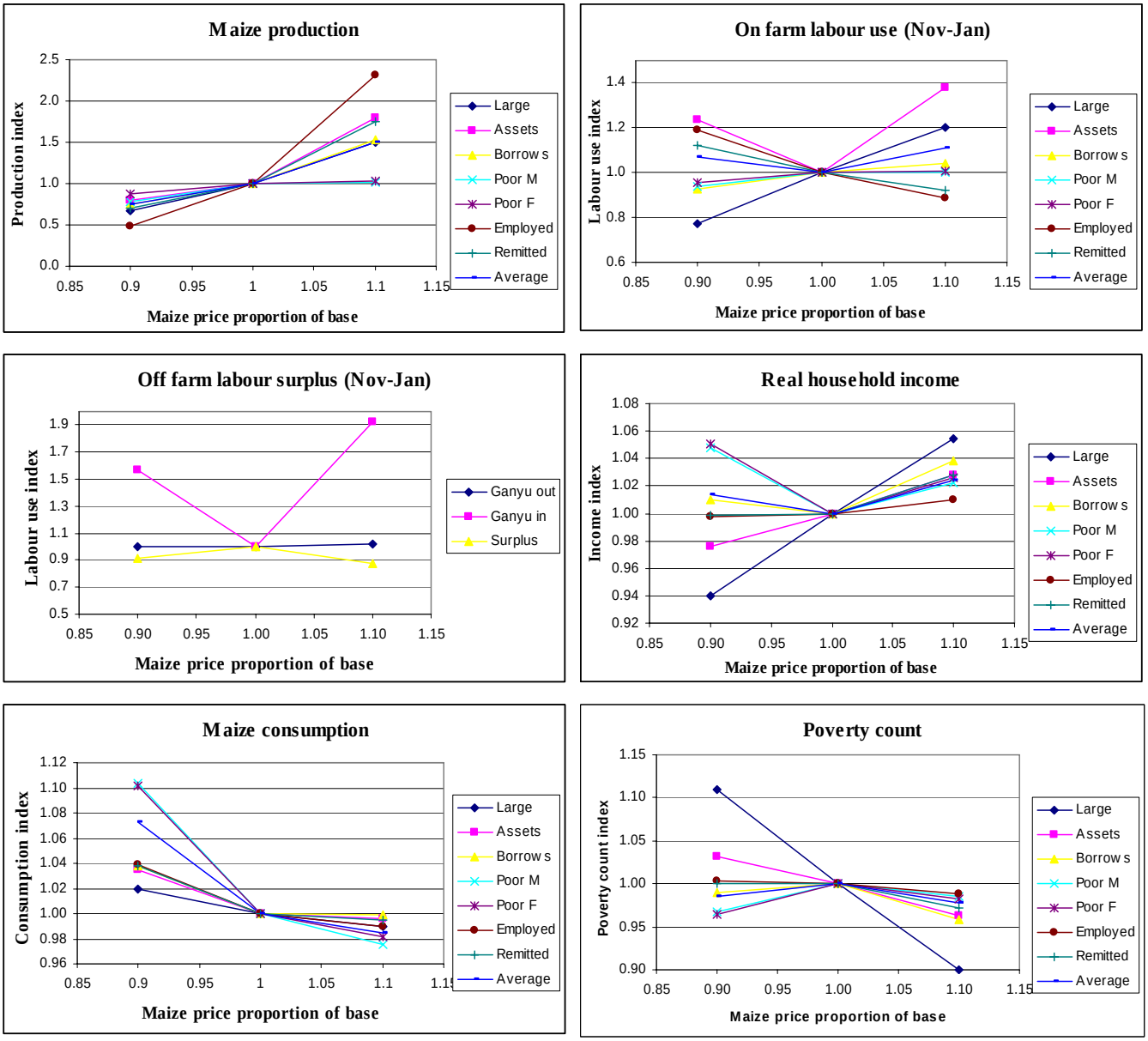


Figure 6 Partial equilibrium responses to maize price changes



References

Alwang, J. and P. B. Siegel (1999). "Labour shortages on small landholdings in Malawi: Implications for policy reforms." *World Development* 27(8): 1461-1475.

Brooke, A., D. Kendrick, A. Meeraus and R. Raman (1998). *GAMS: A User's Guide*. Washington DC, GAMS Development Corporation.

Brooks, J. (2003). *Agricultural policy design in developing countries: the case for using disaggregated analysis*. Paper presented at the Preparatory Meeting of the OECD Global Forum on Agriculture: Agricultural Policies in Developing Countries, the Scope for Using Disaggregated Analysis, Paris, May 19th 2003. Paris, OECD.

de Waal, A. (2002). *'New Variant Famine' in Africa*. Paper presented at SADC VAC Meeting, Victoria Falls, October 2002.

Dorward, A. R. (1984). *Farm Management Methods and their Role in Agricultural Extension to Smallholder Farmers: A Case Study from Northern Malawi*. Department of Agriculture. Reading, University of Reading**:** 262.

Dorward, A. R. (1991). "Integrated Decision Rules as Farm Management Tools in Smallholder Agriculture in Malawi." *Journal of Agricultural Economics* 42: 146-160.

Dorward, A. R. (1996). "Modelling diversity, change and uncertainty in peasant agriculture in northern Malawi." *Agricultural Systems* 51(4): 469-486.

Dorward, A. R. (1997). *Modelling Smallholder Farming in Northern Malawi: An Investigation of Methodological, Theoretical and Policy Issues,*. Wye, UK, Agrarian Development Unit Working Paper, Wye College Press.

Dorward, A. R. (1999a). "Farm size and Productivity in Malawian Smallholder Agriculture." *Journal of Development Studies* 35(5): 141-161.

Dorward, A. R. (1999b). "Modelling embedded risk in peasant agriculture: methodological insights from northern Malawi." *Agricultural Economics* 21(2): 189-201.

Dorward, A. R. (2002). *A Typology of Malawian Rural Households.* Working Paper: Institutions and Economic Policies for Pro-Poor Agricultural Growth, July 2002. Imperial College, London; Wye Campus.

Dorward, A. R. (2003). *Modelling poor farm-household livelihoods in Malawi: lessons for pro-poor policy*. Wye, Ashford, UK, Centre for Development and Poverty Reduction, Department of Agricultural Sciences, Imperial College London.

IFPRI and NSO (2002). *Integrated Household Survey, Malawi, 1997-98, Data CD*. Washington D.C., International Food Policy Research Institute; National Statistical Office, Malawi.

Ignizio, J. P. (1982). *Linear progamming in single and multiple objective systems*, Prentice Hall.

Lofgren, H., R. L. Harris and S. Robinson (2002). *A Standard Computable General Equilibrium (CGE) Model in GAMS.* Microcomputers in Policy Research 5. Washington D.C., International Food Policy Research Institute.

Lofgren, H. and S. Robinson (2003). *General equilibrium simulation models in agricultural economics*. Paper presented the the annual meeting of the UK Agricultural Economics Society, April 2003.

Ngongola, D. (1998). *Agricultural Marketing Study*. Lilongwe, Malawi, Bunda College.

NSO (1998). *National Sample Survey of Agriculture, Malawi*. Zomba, National Statistical Office, Malawi.

Orr, A. and S. Orr (2002). " Agriculture and micro enterprise in Malawi's rural south." *Agren Network Paper*(119).

Pearce, J., A. Ngwira and G. Chimseu (1996). *Living on the Edge: A Study of the Rural Food Economy in the Mchinji and Salima Districts of Malawi*. Lilongwe, Save the Children Fund - UK.

Reardon, T., E. Crawford and V. Kelly (1994). "Links between non-farm income and farm investment in African households: adding the capital market perspective." *American Journal of Agricultural Economics* 76(5): 1172-1176.

Robilliard, A. S. (2002). *Examining the social impact of the Indonesian financial crisis using a micro-macro model*. Paper presented at the OECD Development Centre seminar 'How are globalisation and poverty interacting and what can governments do about it? December 2003. Paris, OECD.

Shah, M. K., N. Osborne, T. Mbilizi and G. Vilili (2002). *Impact of HIV/AIDS on agricultural productivity and rural livelihoods in the Central Region of Malawi*. Lilongwe, CARE International in Malawi.

Simler, K. (1994). *Agricultural Policy and Technology Options in Malawi: Modelling Responses and Outcomes in the Smallholder Subsector*. Cornell Food and Nutrition Policy Program Working Paper 49.

Taylor, J. E. and I. Adelman (1996). *Village economies - the design, estimation and use of village wide economic models.* Cambridge, Cambridge university Press.

UNICEF (1993). *Malawi : situation analysis of poverty*. Lilongwe i, United Nations Children's Fund. Lilongwe Office; United Nations Development Programme; Malawi. Ministry of Women and Children's Affairs and Community Services**:** 209.

van Donge, J. K. and e. al. (2001). *A qualitative study of markets and livelihood security in rural Malawi 2000-01 Targeted Inputs Programme Evaluation Module 2 Part 1*.