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Conceptualising seasonal financial market failures in rural household models

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Abstract

A wide variety of farm household models have provided a valuable theoretical basis for empirical and conceptual analysis of interactions between production and consumption resource allocations of poor rural people. A fundamental weakness of the common applications of many of these models, and unfortunately of much empirical and policy analysis, is their failure to also recognise and adequately describe the fundamental seasonal nature of most agricultural production and the effects of pervasive seasonal finance market failures on poor rural people's behaviour and welfare. A general model recognising this is presented, with simple graphical applications showing the potential importance of seasonal finance constraints to the behaviour and welfare of different farm households. Formal methods for investigating the effects of seasonal finance constraints on household behaviour and welfare should be a standard part of the analytical toolkit available to rural development economists.

Introduction

Household models have played a significant role in advancing theoretical understanding and empirical analysis of the behaviour of (particularly poorer) rural people and economies. Their specific contribution lies in the modelling of two key features of (again poorer) smallholder people's livelihoods: the interactions between production and consumption decisions, and the effects of market failures in labour, product and credit markets upon these interactions. The value and behaviour of these models then depends upon the relative importance of farm production in households' incomes and in their consumption, and upon the nature and extent of market failures. The models by and large successfully allow for these important features of farm households and for differences between households with different resource endowments and objectives. They have, however, in both their conceptualisation and operationalisation, generally ignored another key feature of poor smallholders' livelihoods: the critical importance of seasonality in agricultural production leading, with poverty, to seasonality in market failures, notably in credit markets. This has been associated with an unfortunate lack of attention in

much empirical and policy analysis to the effects of seasonality on poor farm household behaviour. Seasonality is, however, a major feature of rainfed agriculture and plays a significant part in perpetuating poverty. This paper develops a relatively simple model formulation to address this and discusses a simple conceptual application of the model.

Following this introduction the paper provides a brief review of farm household model development and application. This leads on to a discussion of the importance and extent of seasonal credit market failures in smallholder agriculture and then the development of a formal farm household model allowing for seasonal credit market failures. Insights from and benefit of this model as compared with current standard models are demonstrated with relatively simple graphical application of the model to describe the situations of households with different resource and consumption characteristics. It then goes on to examine the effects of changes in prices, wages, and technology on these different households. Significant differences from (improvements over) predictions of the standard model are shown for some (generally poorer) households while for other households the standard model predictions are a special case of the seasonal finance model.

Farm household models

A wide variety of farm household models have provided a valuable theoretical basis for empirical and conceptual analysis of interactions between production and consumption resource allocations of poor rural people. Building on standard production economics and early 20th century analysis by Chayanov of peasant agriculture in Russia (**ref**), farm household models developed by Nakajima **(ref)** and by Barnum and Squire **(ref)** have been widely used to develop theoretical understanding of peasant farm households (by investigating theoretical properties of and inferences from these models) and for empirical investigation of the effects of different technical, market and policy changes on different peasant farm households' behaviour, welfare and interactions with produce and factor markets .

Such models have been given significant attention by postgraduate agricultural and rural development text books. Ellis **(1993)**, for example, provides a particularly accessible review of these models and of the insights they provide, with relatively simple formal algebraic representations but very helpful graphical presentations of main features of the models and the insights they can give on the impacts of technical and wage and produce price changes on different households and on labour and produce markets they interact with. **Udry (ref) and Bardhan (ref)** are examples of other micro-economic textbooks introducing students and analysts to the particular features of peasant households and to analytical techniques for investigating and describing the behaviour of peasant households and economies. De Janvry and Sadoulet (**ref**) present a standard farm household model as a key tool in formal agricultural development policy analysis , the focus of their text.

A failure of the models presented in the dominant theoretical and empirical literature and exemplified in the texts discussed above (which both describe and influence theoretical and empirical work), is lack of

the integrated analysis of simultaneous production and consumption decisions (the focus of the farm household models discussed above) with the effects of seasonal capital constraints[1].

Seasonal credit market failures

The particular seasonal nature of much agricultural production (particularly rainfed crop production) is one of the characteristics of agriculture that have traditionally set it apart from other industries or sectors, even in wealthier economies where agriculture is a relatively unimportant part of the economy[2]. The effects of this on farm household and sectoral behaviour and welfare are particularly severe among poorer farm households living in poorer rural areas. Such households face greater seasonal constraints from shortages in working capital, must use such working capital for both consumption and production, and face particular difficulties in accessing seasonal finance markets – but seasonality, poverty and reliance on low productivity agriculture are inherent and mutually reinforcing features of many poor rural economies (Binswanger and Rosenzweig (**ref**),Binswanger and McIntyre (**ref**),Newberry & Stiglitz (**ref**), Feder et al. 1985, Dorward et al 2008, etc.....).

The difficulties facing poor rural households from interactions of consumption and production objectives and activities in the context of seasonality and financial market failures have been recognised in a long standing literature on seasonality and, for example, hungry gaps (periods of particular difficulty for poor rural households with low food stocks, high demands for labour and other crop production investment, high risks of illness, and adverse wage rates and food and asset prices). Most of this literature has been descriptive, focussing on identification and description of seasonal constraints affecting different types of rural households and their responses to these constraints (refs **Corbett, Davis, Longhurst, Chambers**). Formal quantitative modelling has commonly involved the construction of specific linear and non-linear programming models rather than the estimation of more generalisable econometric models (refs see for example **Holden, Alwang, Dorward 2003**) and has not led to the development of general 'seasonal farm household models'. This literature does however clearly show the critical importance of seasonal finance constraints and production / consumption interactions in together constraining the behaviour

[1] There are of course other weaknesses with the farm household models, most importantly their failure to describe the nature and effects of intra-household relations. These issues are, however, widely recognised by analysts and in the text books discussed earlier, and a range of formal models have been developed to address these issues (**ref**).

[2] Other features of agriculture that set it apart from other sectors are the relatively inelastic demand for many agricultural (particularly food) products; the particular importance of food to human consumption; the dispersed nature of crop production; agriculture's dependence and effects on renewable natural resources ; and, in poor agricultural economies, the large proportion of employment and GDP associated with agriculture (particularly in rural areas where poverty incidence and severity tend to be highest); the integration of consumption and production in subsistence and (more commonly) semi-subsistence farm households; and financial (savings, credit and insurance) market failures (particularly in poorer areas and among poorer households predominantly producing food crops) (**refs**).

and welfare of poor rural people[3]. A related literature has explored (with more qualitative approaches) the extent and effects of seasonal poverty traps (**refs Chambers**) while quantitative and qualitative analysis of more general asset poverty traps has been associated with resurgent interest in risk, uncertainty, vulnerability and social protection (eg **Carter, Barrett, Devereux and Sabates Wheeler**) . Sophisticated models have been developed to examine the causes and impacts of credit and other financial market failures but these have not generally been incorporated with standard farm household models, nor have they had a particular focus on seasonal as compared with more general finance market failures[4].

It appears then that the lack of explicit attention to problems arising from seasonal finance market failures represents a critical flaw in the application of these models to analysis of poor rural people's livelihoods. First, the models' focus on household achievement of consumption requirements from own production is concerned only with future (next season) consumption, not with consumption for current survival - but current survival is a major pre-occupation of poor rural people that compromises their ability to invest in future production. Second, the conflation of income from crop production at or after harvest with pre- harvest income and expenditure associated with buying and selling of labour fails to describe capital constraints on livelihood options. These failings are not merely academic and conceptual: seasonal finance constraints restrict poor people's options so that analytical mis-specifications ignoring these constraints can lead to serious errors (a) in diagnosis of the problems facing poor rural people and (b) in policy and other prescriptions to address these problems.

The remainder of this paper suggests

- that the standard farm household model as described by Sadoulet and de Janvry can be easily extended to take account of seasonal finance constraints;
- that such extensions can provide valuable analytical and policy insights where significant numbers of farm households do face serious seasonal finance constraints; and
- that 'seasonal farm household models' should be the standard default that is routinely implemented.

[3] **Dorward (2003)**, for example, shows widely differing responses to and welfare effects of maize price and wage rate changes for poor and less poor people, with backward sloping supply responses to maize prices and wages for the poorest households. **Taylor(ref)**

[4] There has been some attention to financial market failures in agricultural household models (for an early example see **refs**), but these do not deal with the way that seasonal financial market failures separate seasonal labour investment and production.

A formal farm household model allowing for seasonal credit market failures

The introduction of seasonal finance market failures into algebraic models is conceptually simple, involving the separation of pre-harvest and post-harvest consumption and income in the utility function, the separation of pre-harvest and harvest leisure (or disutility of labour) in the utility function, the separation of pre-harvest and harvest labour equations, the introduction of a seasonal capital equation, and introduction of new variables in the labour and income equations. A minimalist standard seasonal farm household model can then be represented as

$$\text{Max } U = u(C_1, V_2, L_R, H_R) \quad (1)$$

where u is the household utility function with utility U determined by pre harvest consumption C_1, value of post harvest cash and stocks V_2, and harvest and pre harvest leisure (or disutility of household labour) L_R and H_R

such that

$$L_t = L_o + L_F + L_R - L_I \quad (2)$$

$$H_t = H_o + H_F + H_R - H_I \quad (3)$$

$$V_1 = p_1C_1 + V_T + w_1 L_I + V_F + V_S - B - w_1 L_o \quad (4)$$

$$V_2 = V_T + p_2Y + (1+i) V_S - (1+i)B + w_2 H_I - w_2 H_o \quad (5)$$

$$Y = y(L_F, H_F, V_F, D) \quad (6)$$

where L_t = household pre-harvest labour supply; L_o = hiring out of pre-harvest labour; L_F = on farm pre-harvest labour use; L_I = hiring in of pre-harvest labour; H_t, H_o, H_F, H_R and H_I defined as for L_t, L_o, L_F, L_R and L_I but for harvest labour; V_1 = value of pre-seasonal cash and stocks (working capital); V_T = carry forward of pre-seasonal cash and stocks; w = wages for labour hire; V_F = on farm investment of pre-seasonal working capital; V_S = savings/ lending of pre-seasonal working capital at interest rate i; B = borrowing of pre-seasonal working capital; p = price of farm produce; and Y is harvest time production expressed as a production function y of pre-harvest and harvest farm labour use, on farm investment of pre-seasonal working capital and land use.

It should be noted that the model can easily be extended in a number of ways, for example to allow seasonal and/or differential buying and selling wage rates and/or food prices, differentiation between pre-harvest time periods, land rental, separation of farm and purchased consumption, and different farm production activities (see for example **Dorward 2003**). The standard farm household model presented by de Janvry and Sadoulet is a special case of the general seasonal farm household model presented above, where V_1 is large relative to pC_1 and/or i is low such that equation 4 does not constrain equations 5 and 6, and equations 2 and 3 can consequently be conflated, as can equations 4 and 5, with removal of C_1 from equation 1 and the simple summation of L_R and H_R in equation 1.

The model in equations 1 to 6 should be amenable to econometric estimation from farm household data sets, subject to the normal difficulties of obtaining the necessary (reliable) data and of specifying and estimating tractable and appropriate functional forms. Examples of such models are, however, regrettably rare. Incorporation of seasonal consumption objectives and constraints in programming models is much more common. Linear programming models generally represent pre-harvest consumption objectives and disutility of household labour use as constraints (to allow post harvest income maximisation in a linear objective function – see for example **Dorward, Alwang, Holden**). However pre-harvest consumption and leisure objectives can also be explicitly built into the objective function, as, for example, with the use of a Stone-Geary utility function (for example **Dorward, 2003, Taylor**).

A conceptual model of seasonal credit market failure effects on farm household behaviour

The separation of objectives, resources and constraints from a single time period into two time periods in the standard seasonal farm household model presented above contains too many dimensions to be properly represented in simple graphical models. However important and insightful elements of the model can be presented graphically by (a) simplifying the objective function to conflate some of the variables that are treated separately in the algebraic analysis outlined above and (b) identifying particular scenarios with different values for specific variables and presenting these in different graphs.

We begin by ignoring harvest labour constraints (assuming that household labour is sufficient and/or easily replaced by hired labour), assuming that there is effectively a lexicographic ordering across relevant values of C_1 and V_2 with prioritisation of C_1 for immediate survival at low levels of V_1, and hence prioritisation of labour and working capital allocation to consumption in period 1 (C_1) rather than to farm production (Y) which does not yield a return until harvest in period 2 (this could be represented by separate indifference curves between C_1 and V_2 at different values of V_1).

Since labour markets are found in most rural economies and sale of labour is a common source of earnings to provide consumption capital for poorer households – and purchase of labour is a common use of seasonal finance by better off households - we combine equations (2) and (4) above by first rearranging equation (2) ,

$$L_I - L_o = L_F + L_R - L_t \qquad (7)$$

and then substituting this into equation (4)

$$V_1 = p_1C_1 + V_T + V_F + V_S - B + w_1 (L_F + L_R - L_t) \qquad (8)$$

This allows us to define

$$X_{max} = L_F + V_1 / w_1 \quad (9)$$

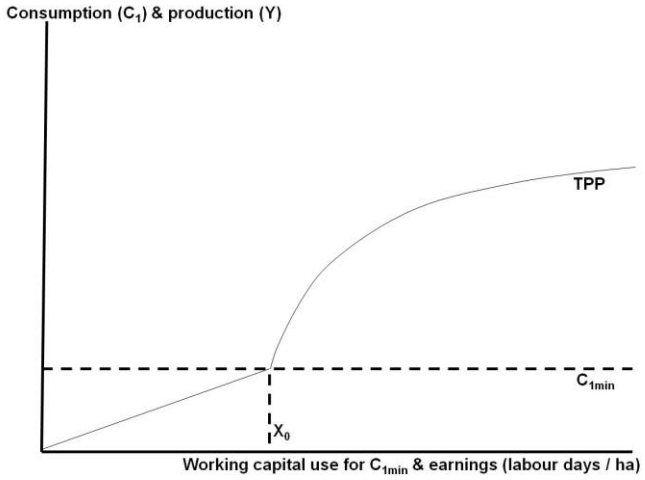
where X_{max} is maximum pre-seasonal working capital available for production and consumption during the season in the absence of borrowing and before lending, hiring out of labour, or leisure, expressed in terms of labour days. Similarly we can define

$$X_0 = C_{1min} / w_1 \quad (10)$$

where X_0 is minimum pre-seasonal working capital required to provide for minimum required consumption during the cropping season (C_{1min}), expressed in terms of labour days.

As in standard graphical analysis of household models (for example Nakajima's model as expounded by Ellis), we allow production of a single food crop, but replace labour by pre-seasonal working capital, with the proviso that in the allocation of pre-seasonal working capital allowance is first made for pre-harvest consumption. Figure 1 shows the TPP curve (per ha) obtained from the use of pre-seasonal working capital X. Resources are applied in sequence: starting from the origin, X_0 working capital must first be used to provide for minimum pre-harvest consumption (C_{1min}) as TPP from end of season harvest cannot be achieved without prior achievement of immediate consumption requirements. The slope of the line from the origin is equal to the wage rate (w_1) expressed in physical terms (kg produce per day). Where $X_{max} > X_0$, the surplus resources beyond seasonal consumption requirements ($X_{max} - X_0$) can then be applied to on-farm production using the same logic as in standard farm household models.

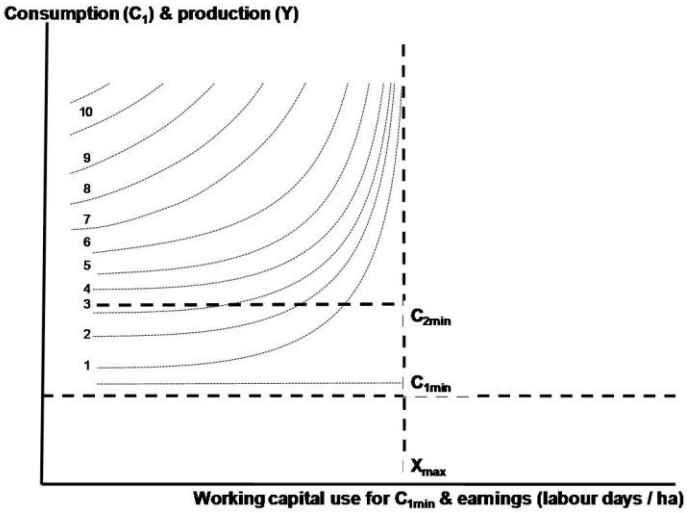
Figure 1. Total physical product of working capital



Following the same approach, Figure 2 shows the indifference curves describing the trade-offs between consumption of working capital above C_{1min} (on the horizontal axis) and consumption and farm production income (on the vertical axis, measured in physical production)[5].

[5] As in standard graphical analysis of farm household models these are rotated 90° anticlockwise. Direct working capital consumption above C_{1min} is ($X_{max} - X_0 - X'$) where X' is seasonal capital invested in earnings above C_{1min}.

Figure 2. Indifference curves: immediate non-food consumption against immediate food consumption and later production



Utility from consumption of working capital is effectively leisure (or reductions in the disutility of labour) and consumption of non-food goods and services. The shapes of the indifference curves represent this as they become increasingly horizontal at consumption closer to minimum consumption needs and increasingly vertical at working capital allocation closer to maximum capital available.

Note that these graphs are drawn using physical production measures (TPP and consumption) per ha.

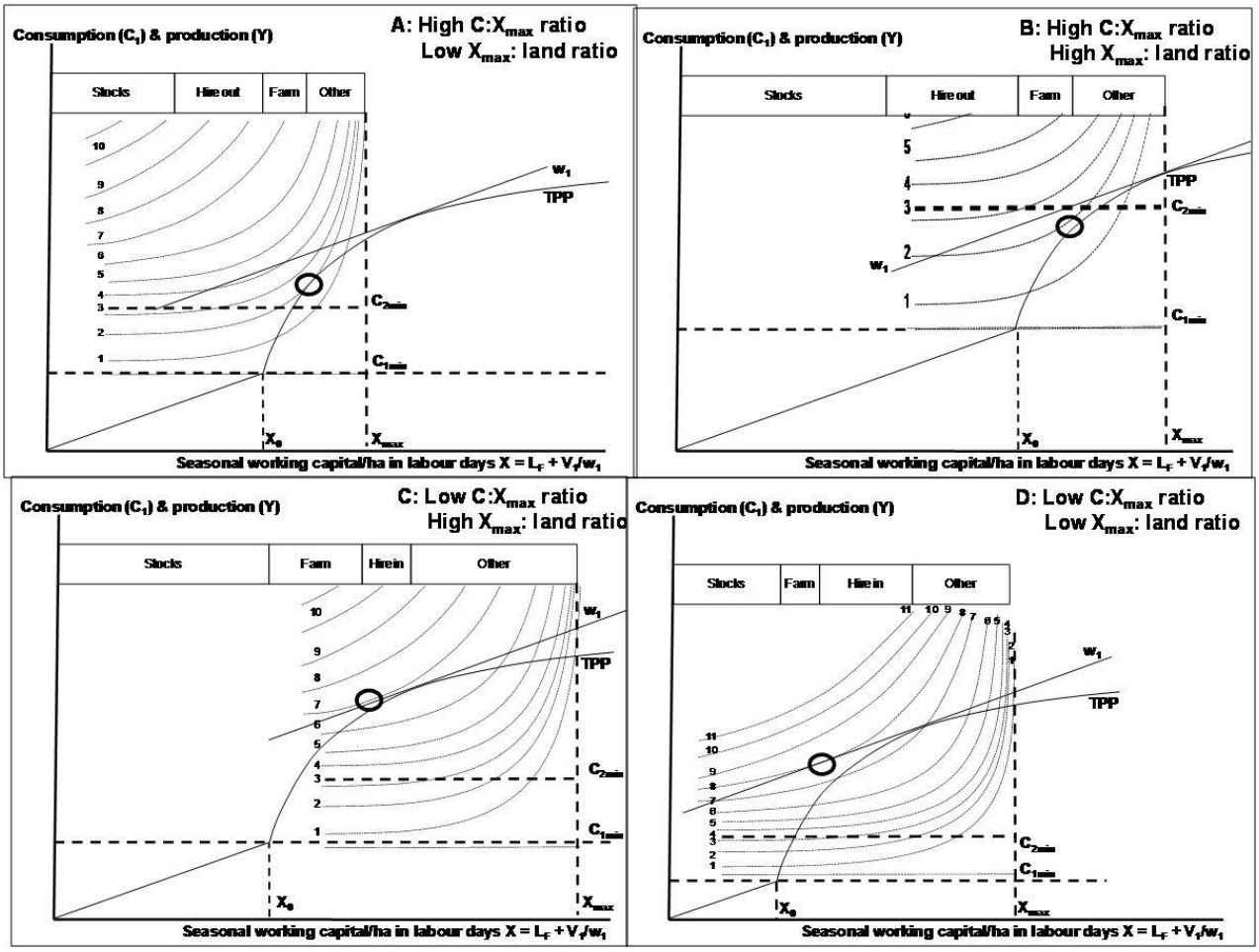
We now combine figures 1 and 2 to find utility maximising allocations of seasonal working capital to food consumption and production. The way that these interact depends upon household consumption and the relative availability of land, labour and capital. We therefore examine four different household types with different ratios of consumption requirements (C_{1min} as defined earlier) to working capital (X_{max} as defined earlier) and different ratios of working capital (X_{max}) to land. These are shown in table 1.

Table 1 Household types

		Ratio of consumption requirements (C_{1min}) to working capital (X_{max}) **C:X ratio**	
		High (high dependency)	**Low** (low dependency)
Ratio of working capital (X_{max}) to land **X:land ratio**	**Low** (more land)	A	D
	High (less land)	B	C

Household types A and B are both poorer households with lower labour and capital resources per consumption unit (with higher dependency ratios), and household type B is also land poor. Household types C and D have more labour and capital resources per consumption unit (with higher dependency ratios), and household type D also has more land. Figure 3 shows utility maximising allocations of seasonal working capital to food consumption and production for each household type[6]. We examine the position of household type A in some detail and compare this with the other household types.

Figure 3. Utility maximising working capital allocations and production by household type (per ha)



[6] It is assumed for simple exposition that food purchase and sales prices are the same, and net wages for hiring in and out are the same, but transaction costs leading to differences could easily be introduced, and would lead to some market failure/ autarchy. Variations in household member wage potentials could also be introduced (as with Low **ref**) with lowest earners to farm tasks where farm MVP is higher than wages, and high wage earners applying their labour first to C_{1min} earnings (this would provide an additional explanation to Low's analysis of off farm employment) and then to further earnings. *Labelling of X axis needs updating as in figures 1 and 2.*

Household type A has limited working capital derived from convertible physical and financial assets (shown as 'stocks' in the upper left of the diagram for household A) and has to hire out household labour to provide for immediate consumption requirements during the cropping season. The limited household labour available for on farm production yields high marginal returns, but a low level of welfare is achieved (as shown by the TPP/ indifference curve tangency at indifference curve 2).

The diagram for household type B (with the same working capital and consumption requirements as household A, but less land) involves higher minimum consumption and resource availability *per unit land*. The overall position outcomes are similar to household A, but involve higher production per ha (not per household) and lower welfare (as shown by the TPP/ indifference curve tangency below indifference curve 2 and lower production as compared with consumption requirements).

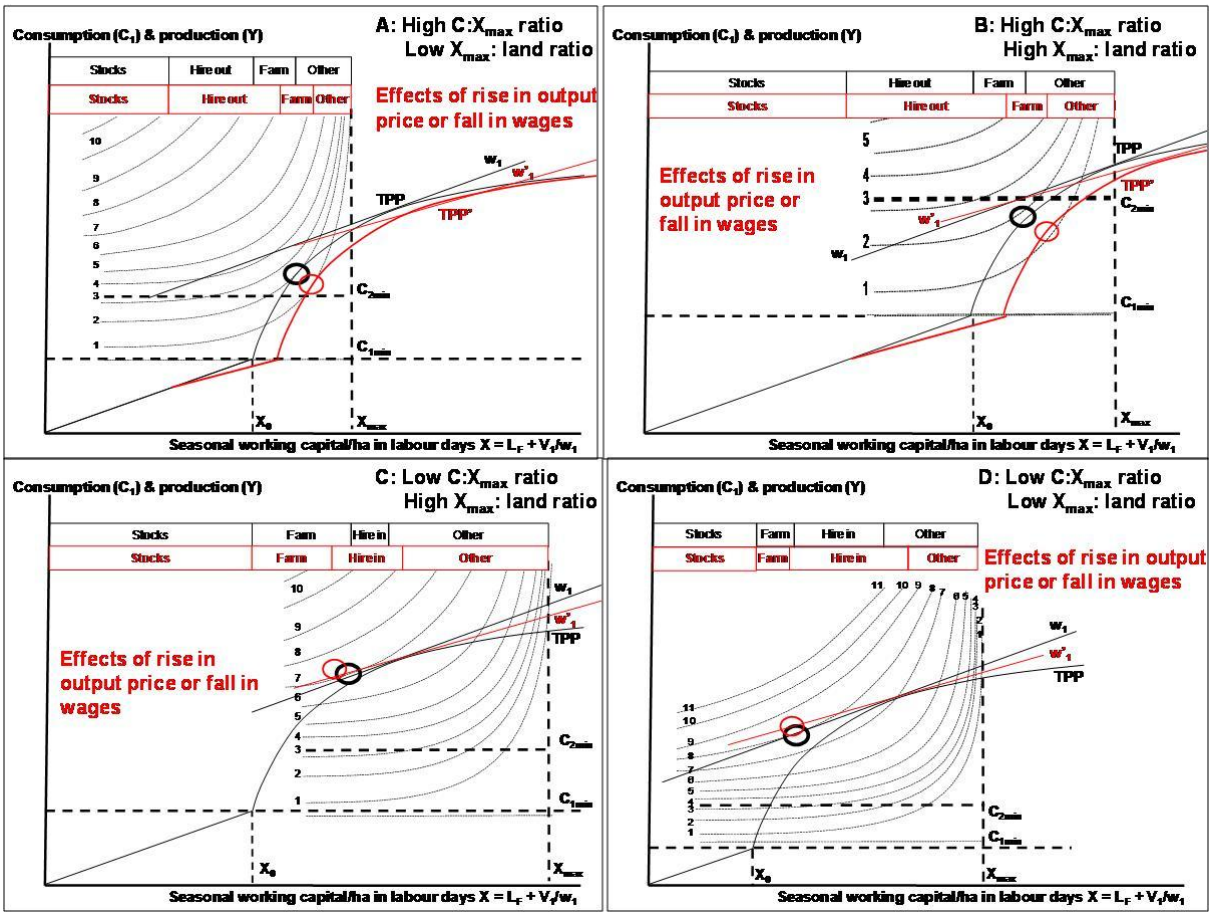
Household type C (with more working capital from physical and financial stocks but limited land) does not need to hire out any labour to meet immediate cropping season consumption requirements and indeed can allocate some extra stocks to hiring in a small amount of labour, leaving resources available for extra consumption or for other investments during the cropping season. It achieves a higher level of welfare (as shown by the TPP/ indifference curve tangency at indifference curve 7 and high production as compared with consumption requirements).

Household type D (with similar working capital from physical and financial stocks as household C but more land) also does not need to hire out any labour to meet immediate cropping season consumption requirements and allocate extra stocks to hiring in more labour, again leaving resources available for extra consumption or for other investments during the cropping season. It achieves the highest level of welfare (as shown by the TPP/ indifference curve tangency at indifference curve 8 and high production as compared with consumption requirements).

This analysis is clearly different from standard farm household analysis, but the results it produces are similar: poorer households hire out labour and have lower welfare achievements, less poor households hire in labour and have higher welfare achievements. Similarly land poor households hire in less labour or hire out more labour and have lower welfare achievements than households with more land. Differences between this analysis and standard farm household analysis do arise, however, when we examine the implications of different types of change. We examine three types of change: in output prices, in wages, and in technology.

Changes in output prices and wages are in fact represented graphically in the same way, as output prices do not appear in the graphical analysis except in the definition of wages. Figure 4 shows the impact of increases in prices or falling wages, and the impacts on labour hire, production and welfare for each household type are summarised in table 2.

Figure 4. Impacts of increased produce prices or reduced wages[7]



For household types C and D (those households not constrained by seasonal capital constraints) the analysis is again not very different from that of standard farm household models, with increases in production, welfare and hiring in of labour. For households A and B, those with serious seasonal capital constraints, the analysis and impacts are however quite different. The fall in returns to hiring out labour, relative to food prices, leads to a flattening of the slope of the curve for working capital not held as food stocks (ie household labour or other physical or financial assets) and consequently more labour has to be used for this and less is available for crop production. The result is that a fall in wages or a rise in produce price for these households leads not only to reductions in welfare (with movement from

[7] A fall in wages should strictly be represented by a shallower slope for the TPP line below C_{1min} for pre-seasonal capital held as stocks as well as labour, together with a shift to the right (increase) for X_{max} and for the indifference curves, to represent the increased value of stocks (with a rise in food prices this only applies for food stocks, not stocks of other convertible assets). For ease of presentation and interpretation X_{max} and the indifference curves the slope of stock conversion to labour and back to stocks is shown as constant before and after the price/wage change, as is the position of X_{max} and the indifference curves. *X axis labelling needs updating as in earlier figures.*

indifference curves 2 to 1) but a rise in hiring out of labour and a fall in production, with backward sloping supply curves for both food production and labour.

Table 2. Impacts of increased produce prices or reduced wages

Farm/hh type	C:X ratio	X:land ratio	Price increase/ wage fall effects			
			Labour Hire		Production	Welfare
			In	Out		
A	High	Low	N/A	+	-	-
B	High	High	N/A	+	-	-
C	Low	High	+	N/A	+	+
D	Low	Low	+	N/A	+	+

A change in technology is most simply represented by an upward, anti-clockwise swivelling of the TPP curve in the analysis for each household. There are, however, few differences in outcomes from analysis with the standard farm household model: production and welfare achievements increase across all households and hired labour demand increases for household types C and D. However if consequent wider market impacts are considered, beyond the household level, then the increased production should lower produce prices and the increased hired labour demand should raise wages, and the impacts of these will be different where seasonal finance constraints are considered – with particular benefits for poorer households.

The stylised findings represented here suggest that representing seasonal finance market failures in theoretical and empirical farm household models can lead to important differences in our understanding of the impacts of different changes on poor rural people and of the markets in which they participate (or fail to participate). The extent and importance of these difficulties will depend upon the extent and nature of seasonal finance constraints affecting rural people in different areas, the numbers of people affected, and the particular interactions of labour and produce markets with utility and production functions. There are a number of further issues not addressed in the simple graphical analysis presented here, but amenable to quantitative analysis, such as the impacts of inter and intra-seasonal wage and price variation, and of different crop and crop technology options. The relevance and robustness of the general conclusions of this paper are, however, supported by results from a series of programming models developed to describe these issues in Malawi. Models described in Dorward (2003) show backward sloping supply of labour and maize for some poor households over some price ranges. Further development of these models Dorward (2007) with examination of maize and rural labour market interactions and their application to analysis of the large scale agricultural input subsidy programme in Malawi led to predictions of differing direct and indirect subsidy impacts for different household types in different areas, with seasonal finance constraints of the type described here having major effects on subsidy impacts (SOAS, 2008). Preliminary analysis of recent field surveys (Dorward and

Chirwa, 2009) suggest that impacts of the subsidy on wages in two different areas have been very much as predicted by the modelling reported in SOAS (2008).

Conclusions

The approach developed in this paper for representing seasonal finance market failures in farm household models suggest that there are no pressing methodological reasons for the widespread failure to examine seasonal finance constraints on poor farm households' behaviour and welfare. We then must ask why seasonal finance market failures are so often overlooked in empirical models.

Two basic reasons may be postulated, first that many (most) analysts have not considered them sufficiently important, and second that data sets have not contained the variables needed for estimation of such models. Since analysts have an important role in specifying the variables included in data sets, analysts' lack of interest in seasonal finance constraints would appear to be the major reason for the absence of models allowing for these constraints. Is this a self perpetuating blind spot (where lack of existing empirical models constrains the development of new empirical models) and if so how can it be addressed?

Inclusions of seasonal finance constraints in more accessible graphical representations of farm household models may be one approach to addressing analysts' lack of attention to these constraints in empirical models, if analysis of such representations can demonstrate the importance of these constraints as critical for understanding poor rural people's behaviour and welfare. The examples presented do indeed demonstrate this importance. Simpler models without explicit representation of seasonal finance constraints should only be adopted as a special case of the general model in those situations where households' initial working capital (for finance and production) and/or their access to financial markets do not significantly or unduly distort farm household behaviour and outcomes from what would prevail with improved access to functional financial markets.

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