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Demands for Real and Financial Assets in Botswana*'

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Introduction

Traditionally, asset demands are derived as a solution to the individual's or household's problem of allocating wealth among various real and financial alternatives. The demand for each asset depends on the own real rate of return, but also on the real rates of return to alternative assets. The sensitivity to own and cross rates captures the speculative element in portfolio allocation, the motive usually being to maximise end-of-period wealth. Typically, asset demands also depend on income, reflecting the transactions motive for asset holding. These determinants are generally the same, whether the asset choice is seen to take place under conditions of risk or certainty.¹

In Botswana, asset choice clearly takes place under conditions of risk. By far the most important real asset for Botswana's predominantly rural population is cattle, whose real return is influenced by Botswana's semi-arid, highly variable climate and by occasional outbreaks of foot-and-mouth, a cattle disease. The real returns to financial assets also vary, if only because the inflation rate varies.

More important from a theoretical viewpoint, asset demand involves not only the allocation of non-human wealth among real and financial assets, but also an allocation of total wealth between human and non-human forms. Of course a Botswanan household would not realise the capital value of some portion of its human wealth by selling a household member in order to purchase a cow or make a bank deposit. Nor would it sell a cow or cash a cheque to purchase a household member. Nevertheless, the conversion of wealth between human and non-human forms can occur.

^{&#}x27; For a recent comparison of asset demands under the two assumptions, see Frankel and Engel (1984).

Although no market exists in which human wealth is given a capital value, this wealth, or at least the portion of it which is allocated to labour employment, can be measured by the discounted present value of lifetime labour earnings. Opportunities for wage employment in Botswana exist, but especially in the formal sector, require some minimum standards of literacy and education. A rural household may therefore decide to sell a cow to finance the education of a family member who will then take up formal sector employment. This decision would presumably depend, however, on whether the difference between the discounted present value of lifetime earnings in formal sector employment and imputed present value of the member's labour otherwise used in cattle production exceeded the capital value of the cow sold. Conversely, a civil servant in Botswana may use his current life savings (part of his human wealth which has been converted into financial form) to purchase cattle and enter beef production. This decision would depend on whether the capital value of the cattle acquired was greater than the difference between the present value of the future stream of salary he has foregone and the imputed value of his own labour now used in cattle management.

Rural households in Botswana do sell cattle to pay school fees and civil servants do buy cattle. The motivation is presumably to maximise end-of-period wealth. Furthermore, the choice takes place under conditions of uncertainty. It has been observed that households in Botswana diversify their sources of income. Rural households not only hold cattle and grow crops, but also earn labour income from various manufacturing and service activities. Urban household income is mostly labour income, but some urban households also own cattle which they keep in surrounding rural areas.² This behaviour is consistent with the proposition that in the face of risk and given a degree of risk aversion, households will diversify

² See CSO (1976) and CSO (1982), especially Volume 3, Chapter 10.

- 2 -

the forms in which they hold their wealth and consequently diversify the sources of return from such wealth.

If allocation of asset holding occurs not only among various forms of non-human wealth, but also between human and non-human wealth, then the demands for particular real or financial assets should depend on the real returns to both human and non-human wealth.³ A formal treatment of this argument is given in the Appendix. The proposition can be tested by estimating demand functions for various real and financial assets in Botswana where some measure of the real return to human capital, proxied here by the real wage, is included as an explanatory variable. If the real wage is shown to be significant, the results would confirm that the division between human and non-human wealth is an important margin of choice for Botswanan households.

Asset Demand Specification and Data

The most important real asset available to Botswanan households is cattle. Rural households can also choose to store some portion of each year's crop harvest rather than selling it to the parastatal grain marketing agency or on informal local grain markets for immediate cash. Such crop stores or inventories represent another form of real asset holding. Much of the rural land is commonly owned, so that access to tribal communal grazing land is a birthright and allocation of arable land is an administrative Tribal Land Board decision, not a choice variable for individual wealth holders. Nevertheless, urban residential plots can be purchased and held as real assets. On the financial side, the asset menu includes the cash,

- 3 -

³ Furthermore, human wealth, or that portion of it devoted to earning labour income, should also depend on these variables. One implication is that, at least where sufficient non-human forms of wealth are available, the unemployment or underemployment sometimes observed in rural areas may be voluntary, reflecting a preferred position in the allocation between human and non-human wealth. This in turn leads to a testable proposition - that underemployment may fall, rather than increase, with a rise in real wages or the real return to human capital. Our purpose, however, is restricted to examining the demands for real and financial assets.

current, savings and fixed accounts of the commercial banks, the savings accounts of the Post Office Savings Bank (POSB) and the share certificates and savings accounts of the Botswana Building Society (BBS).⁴ Finally, Botswana's exchange control regulations forbid, at least in theory, the holding of foreign assets in either real or financial form.

Data limitations preclude the estimation of demand functions for some of these assets. Ownership of urban residential housing plots, for example, is extremely difficult to establish. Elsewhere, official time series data are generally too short to allow straight time series estimation, so only those demands for which adequate pooled time series cross-section data are available can be estimated. Thus the demand for cash or BBS shares is not examined.

The estimation therefore covers demands for two real and two financial assets - cattle, crop stores, POSB and commercial bank savings accounts. Each demand is estimated as a function not only of the real returns on these four assets, but also the real returns on three of the omitted financial assets - cash, BBS shares and South African Treasury Bills. The BBS rate is included because within the financial sphere, this institution has been an aggressive competitor to the POSB and the banks and has had a very rapid expansion of its deposit and share base over the last decade. The real return on a South African short term security is included because there have at times been substantial interest rate differentials between Botswana and South Africa which have not been offset by exchange rate changes. These differentials might have created sufficient incentive to circumvent exchange control regulations.

- 4 -

⁴ The consumer, agricultural marketing and thrift and loan cooperative societies also accept member deposits, as do the informal burial societies which are prevalent in some areas. However, member contributions to burial societies are usually in turn deposited with a bank (Brown et al. 1982), while the financial operations of the cooperatives are small when compared with mainstream financial institutions (MOA 1979).

In addition to these real rates of return, each asset demand includes both real income and a measure of real income variation. Income variation is included to capture an additional aspect of the transactions demand for assets under uncertainty. Assets can be used as buffers to smooth consumption in the face of income variation. As real income variation increases, a higher average level of transactions balances would be needed to keep real expenditure fluctuations from increasing.⁵ Finally, each asset demand includes a real wage variable to capture the margin of choice between human and non-human forms of wealth holding.

While asset demand functions show how total wealth is divided among its various forms at a point in time, a consumption or savings function shows how total wealth is accumulated over time. In addition to asset demand functions, a consumption function is also estimated. The determinants of consumption (or saving) are assumed to be the same income and real return variables as appear in the separate asset demands.⁶

Asset demands for cattle holding and crop stores among rural households are estimated from pooled time series cross-section data on these variables. Annual time series for cattle holding cover 1979/80 to 1982/83, representing two years of adequate or good rainfall followed by two drought years. Annual time series for crop stores cover 1980/81 to 1982/83. The cross-sectional classification in both cases is firstly by region and secondly by size of cattle herd.⁷ The latter classification is commonly used in Botswana to divide rural households into general wealth classes, though cattle is only one, albeit an important, form of wealth holding. Separate figures on the size of cattle herds and the volume of crop stores

- 5 -

⁵ See the discussion of this point in Niehans (1978), based in turn on earlier work by Baumol (1952) and Miller and Orr (1966), among others.

⁶ It is unfortunate for our purpose, however, that investment expenditure on human capital, such as education expenditure, is trationally included in National Accounting measures of consumption.

⁷ Botswana's Ministry of Agriculture kindly gave access to the detailed survey results on which its Agricultural Statistics are based and from which data could be extracted according to the double cross-sectional classification. The regional breakdown is that used by the Ministry of Agriculture.

are therefore obtained across time and by region for the following wealth classes: those that hold 1-10 cattle, those that hold 11-80 and those that hold more than 80. In addition, crop storage figures are obtained for those who hold no cattle.⁸ The 1-10 category is clearly a poor group, since a herd of at least ten cattle is required to provide sufficient adult beasts (minimally four) for a full draught team for ploughing. The group holding more than 80 cattle is clearly a wealthy group, while the 11-80 group represents an amalgum of those who may still be deficient in draught power, together with those who have the 30 to 40 beasts minimally required to be economically viable in beef production.⁹ Zero cattle holding has traditionally been associated with rural destitution, although this group would also include a number of salaried or self-employed people engaged outside the agricultural sector.

The financial asset demand functions for POSB and commercial bank savings accounts are also estimated with pooled time series cross-section data. The relevant cross-sectional classification is again by region or location, although it is impossible to establish a further breakdown of accounts by wealth class of depositor.¹⁰ In the case of POSB data, a problem arises because the POSB operates a full multibranch banking service. Account holders can make deposits

⁹ Duggan (1979), (1981), Gulbrandsen (1980), Hubbard (1983).

¹⁰ Botswana's three commercial banks and the POSB kindly provided a branch-by-branch breakdown of accounts, from which time series were constructed for various regions or locations.

⁸ In Botswana, cattle "held" need not equal cattle "owned". Although much has been written about cattle loans and the "mahisa" management system, indications are that these practices are not as prevalent as they once were and that the difference between holding and ownership is proportionally quite small. One remaining problem of some current significance would be where cattle are "held" in rural areas on behalf of urban owners. For want of a means to identify ownership, the data on cattle holding are regressed on income and rate of return variables which assume all cattle holders/ owners are rural dwellers.

or withdrawals at any of the 67 branches throughout the country, so that data on the level of savings accounts is available only in consolidated form, for all branches combined. What is available on a branch or regional basis is the net change in savings accounts (net deposit accumulation) over a given period. It is therefore possible to estimate a flow savings function for POSB savings accounts, though not a stock asset demand function. For this purpose, however, observations from urban branches and those in four of the larger rural villages were dropped when constructing the pooled regional time series. The reason is that for these branches, net deposit assumulation was consistently negative, indicating account holder mobility. Civil servants, for example, can have their salary deposits recorded at an urban branch, but may return periodically to their village of birth to withdraw and spend the money. Similarly, rural account holders may make large withdrawals during a visit to an urban area. By excluding branches whose recorded transactions obviously reflected such mobility, it was judged not unreasonable to attribute the net deposits of the remaining branches in a region to account holders who resided in that region. Regional data on net deposit accumulation in rural areas is thus obtained for the years 1979/80 to 1982/83.

Unlike the POSB, the commercial banks offer a full range of current, savings and fixed term deposit services to customers. The estimation is restricted to the stock of savings accounts, however, on the grounds that these accounts are least likely to be used by incorporated businesses and are most likely to reflect the behaviour only of households,¹¹ the agents who might substitute between human and non-human forms of wealth. The low concentration of bank branches in rural areas means that data cannot be organised on a regional basis. Instead, the cross-sectional classification includes rural observations on a single branch basis and urban observations on a

- 7 -

¹¹ Some confirmation is provided by the fact that savings accounts are proportionately much more heavily used in rural than in urban branches.

town basis.¹² A mix of rural and urban data on bank savings accounts is thus obtained for the years 1978/79, 1981/82 and 1982/83.

Estimation of asset demand or savings functions for cattle, crop stores, POSB and bank savings accounts also requires pooled time series cross-section data on the independent variables - real income, its variation, the real rates of return on these and alternative assets and the real wage. Rural real income by region and cattle ownership, together with urban real income by town and urban wealth class, is obtained by disaggregating national accounting data using the income survey data of the National Migration Study (CSO 1982).¹³Urban wealth class is proxied by housing type - "low" wealth representing habitation in peri-urban areas or servants quarters, "medium" wealth representing high density housing and "high" wealth representing medium or low density housing. The disaggregation of national accounting income was performed for each income source (operating surplus in agriculture, wages in agriculture, manufacturing, etc.) separately and the results added across sources. In this way, an attempt was made to recognize the structural changes which have occurred in the Botswanan economy since the income survey was carried out. A time series of per capita real income variation for each rural and urban area and wealth class category is constructed by measuring the standard deviation of each group's per capita real income from the year in question back to 1977/78, the earliest year for which disaggregated per capita income could be constructed.

¹³ Professor Robert E.B. Lucas at Boston University kindly provided income survey data from the National Migration Study according to the disaggregated categories required here.

- 8 -

¹² The commercial banks operate agencies as well as branches, particularly in remote rural areas. Agency accounts are consolidated with those of branch, rarely one in the same area and normally one in an urban area. Some of the branch or town observations used for estimation therefore include the accounts of remote reporting agencies. Since no basis could be found for separating agency from branch accounts, all accounts have been attributed to the branch.

¹⁴ Although National Accounts exist for earlier years, the Agricultural Statistics used to aid the disaggregation by cattle ownership do not.

Nominal interest rates on POSB and commercial bank savings accounts and the nominal returns on BBS shares are published in the Annual Reports of the Bank of Botswana, while the interest rate on South African Treasury Bills is available in the International Financial Statistics of the International Monetary Fund and can be corrected for exchange rate changes between South Africa and Botswana from that source. An adjustment to nominal interest rates is then made to correct for different tax treatments of interest income. POSB interest and BBS dividend payments are tax deductible, while it is assumed that interest earned on South African securities would not be declared for tax purposes. Interest paid by commercial banks is taxable. The interest rates which are not taxed are converted to effective rates comparable to the commercial bank rate for each urban and rural area and wealth class separately.¹⁵ The technical advantage of making this correction is that it introduces an additional source of cross-sectional variation into these interest rate variables and reduces their degree of correlation with the bank interest rate.

All nominal interest rates are then converted to real rates using available price data, the urban and semi-urban cost-of-living index published in the Statistical Bulletins of the Central Statistics Office. Separate indices are available for low, medium and high income groups. These are used throughout to provide distinct deflators for each urban and rural wealth class. The inverse of the inflation rates of these indices is introduced separately into the estimating equations to represent the real rate of return to cash holding.

In some of the estimated equations, a further adjustment is made to the real returns on POSB and commercial bank savings accounts. Because of the relatively low density of commercial bank and POSB branches in rural areas, not all rural households have easy access to bank or POSB savings accounts. To correct for this, use can be

- 9 -

¹⁵ The effective rate i' equals i/(1-t) where i is the actual rate and t is the marginal tax rate. Statutory marginal tax rates are given in Lewis and Mokgethi (1983), while the appropriate tax bracket for each area and wealth class is determined by calculating nominal per household income from the data generated for the real income variable and by assuming one taxpayer per household.

made of the general result that the elasticity of total demand for any commodity with respect to some argument is a weighted average of the elasticities of separate demands by different groups. For example, the elasticity of total demand for cattle with respect to the real return on POSB accounts would be a weighted average of the elasticity of those who have access to a POSB branch and the elasticity, known to be zero, of those who do not. The weights would be the shares of total cattle held by each group. In a log-linear specification, the log of cattle held could be regressed on the log of the real return to POSB savings accounts and the estimated coefficient would measure the cross-interest elasticity of total demand. Alternatively, the log of cattle held could be regressed on the log of the real return to POSB savings accounts, multiplied by the share of cattle held by those with access to a POSB branch, and the estimated coefficient would measure the cross-interest elasticity only of those with such access. The advantage of the second approach is again largely technical. In data which is partly cross-sectional, the regional variation in access can help to reduce the multicollinearity between real returns on alternative financial assets.¹⁶

Real rates of return on cattle holding and crop storage are obtained from the original survey data used by the Ministry of Agriculture in its Farm Management Surveys (FMS). For cattle holding, the variable measured for a given year, region and cattle holding category is the real rate of return on total capital in both cattle and crop production. Crop production is included with cattle operations since cattle are an important source of draught power as well as beef. Although the rate of return is one on total capital, the FMS data shows that the non-cattle component of total capital is small. More importantly, the rate of return is a rate net of imputed wage payments to family labour. This labour has been costed out at the wage rates reported in the FMS survey for hired agricultural labour.

¹⁶ For those equations in which data on the dependent variable was available only by region, not by town or village, the shares were proxied by population shares, e.g. the share of cattle holders with access to a POSB branch. Population figures were obtained from CSO (1983). A village POSB or bank branch was assumed to provide access to the population of the village and its localities (lands, cattleposts, etc.).

For crop storage, the relevant real rate of return is the rate of increase of crop prices relative to the general cost-of-living index.¹⁷ Since crops themselves are a significant component of the consumption bundle, especially for poorer households, one would not expect much variation in this relative price, at least at the national level. Nevertheless, FMS data on the crop prices received by farmers reveal significant regional variation, reflecting the wide variation which can occur between prices on local informal grain markets and the nationwide official price of the parastatal marketing agency. The pooled data on real rates of return to crop storage do therefore display considerable in-sample variation, although they are possibly the least reliable of the official data used.

If the main hypothesis is correct, namely that households in Botswana substitute between human and non-human forms of wealth, then the real wage appropriate to each rural or urban household type in each region cannot be proxied by per capita or per household wage income, since variations in this value could reflect variations in the quantity of labour supplied as well as wage variations. The National Accounts report the compensation of employees by industry, while the Statistical Bulletins report formal sector employment by industry. Since compensation of employees includes mainly formal sector wage income, a measure of nominal wages can be constructed for formal sector employment in each industry. A weighted average of industry wages can then be calculated for each rural and urban household type in each area, with the weights being the shares of wage income from each industry in the total wage income received by that household.¹⁸ An average real wage is then obtained by deflating with the appropriate cost-of-living index.

¹⁷ Ideally, one would also like to correct for the physical deterioration which occurs in stored crops between harvest and sale (or consumption). This deterioration is known to be substantial, but so long as it does not vary much over time or across regions, failure to take account of it may not be a serious omission.

¹⁸ The value weights are obtained from the data generated for the real income variable, although ideally quantity weights should be used. In generating the income data, allowance was made that a small proportion of payments officially designated Operating Surplus in fact measures the return to labour in self-employment. Some basis for making this allowance was provided by the National Migration Study income survey. In constructing the real wage variable, however, the return to labour in self-employment has been ignored on the assumption that it is measured by formal sector wages, at least in an opportunity cost sense.

- 11 -

Finally, estimation of rural and urban consumption functions requires pooled time series cross-section data on real consumption to match that on the explanatory variables. No detailed expenditure survey results are currently available. Time series data on rural consumption by region and cattle holding class and urban consumption by town and wealth class for 1979/80 to 1982/83 are therefore estimated by disaggregating national accounting consumption totals according to the cross-sectional breakdown of consumption given in the 1978/79 Social Accounting Matrix (SAM) which was constructed for Botswana by the Overseas Development Agency in London. ¹⁹ Where the level of disaggregation in the SAM is insufficient to meet current needs the gaps are filled by assuming that within the SAM's categories, real per capita consumption is held constant. This approach is obviously inadequate in an estimation context, but the results can nevertheless be interpreted as showing what the consumption functions would look like were households to behave in the manner assumed here.

Estimating Equations and Techniques

The estimated equations representing asset demands for cattle, crop stores, POSB and commercial bank savings accounts, together with the rural and urban consumption functions, are as follows:

ln	(cat)	=	°ο	+	^α 1	ln	$y + \alpha_2 \ln vy + \alpha_3 \ln w + \alpha_4 \ln r_{ag}$	
				+	^α 5	ln	$r_{cr} + \alpha_6 S_{po} \ln r_{po} + \alpha_7 S_{cb} \ln r_{cb}$	
				+	^α 8	ln	$r_{bs} + \alpha_9 ln r_{sa} + \alpha_{10} ln r_{ca} + \epsilon_{cat}$	(1)
ln	(cst)	=	^β o	+	^β 1	ln	$cp + \beta_2 \ln y + \beta_3 \ln vy + \beta_4 \ln w + \beta_5 \ln z$	r _{ag}
				+	^β 6	ln	$r_{cr} + \beta_7 s_{po} ln r_{po} + \beta_8 s_{cb} ln r_{cb}$	
				+	βg	ln	$r_{bs} + \beta_{10} \ln r_{sa} + \beta_{11} \ln r_{ca} + \epsilon_{cst}$	(2)

¹⁹ For a description of earlier versions of the Botswana SAM, see Greenfield (1977) and Hayden (1981).

$$\ln (\Delta po) = \gamma_{0} + \gamma_{1} \ln y_{p} + \gamma_{2} \ln vy + \gamma_{3} \ln w + \gamma_{4} r_{ag} + \gamma_{5} r_{cr} + \gamma_{6} r_{po} + \gamma_{7} s_{cb}^{*} r_{cb} + \gamma_{8} r_{bs} + \gamma_{9} r_{sa} + \gamma_{10} r_{ca} + \epsilon_{po}$$
(3)
$$\ln (cb) = \delta_{0} + \delta_{1} D_{r} \ln y_{c} + \delta_{2} \ln y_{c} + \delta_{3} \ln vy + \delta_{4} \ln w + \delta_{5} \ln r_{ag} + \delta_{6} \ln r_{cr} + \delta_{7} \ln r_{po} + \delta_{8} \ln r_{cb} + \delta_{9} \ln r_{bs} + \delta_{10} \ln r_{sa} + \delta_{11} \ln r_{ca} + \epsilon_{cb}$$
(4)
$$\ln (rc) = \theta_{0} + \theta_{1} \ln y + \theta_{2} \ln vy + \theta_{3} \ln w + \theta_{4} \ln r_{ag} + \theta_{5} \ln r_{cr} + \theta_{6} s_{po} \ln r_{po} + \theta_{7} s_{cb} \ln r_{cb} + \theta_{8} \ln r_{bs} + \theta_{9} \ln r_{sa} + \theta_{10} \ln r_{ca} + \epsilon_{rc}$$
(5)
$$\ln (uc) = \eta_{0} + \eta_{1} \ln y + \eta_{2} \ln vy + \eta_{3} \ln w + \eta_{4} \ln r_{ag} + \eta_{5} \ln r_{cr} + \eta_{6} \ln r_{po} + \eta_{7} \ln r_{cb} + \eta_{8} \ln r_{bs} + \eta_{9} \ln r_{sa} + \eta_{10} \ln r_{ca} + \epsilon_{uc}$$
(6)

Total cattle holding (cat), crop stores (cst), real commercial bank savings accounts (cb), real net POSB deposit accumulation (Apo) and rural and urban real consumption (rc and uc) are each functions of total real income (y), the variation in per capita real income (vy), the real wage (w), the real rates of return on capital (cattle) in agriculture (r_{aq}) and on crop stores (r_{cr}) and the real interest rates on POSB savings accounts (r po), bank accounts (r cb), BBS shares (r_{bs}), South African Treasury Bills (r_{sa}) and cash (r_{ca}). In addition, crop stores depend on real crop production (cp), since any decision on the amount of crops to be held rather than sold depends on the size of each year's available harvest. A dummy variable D_r has also been included in the demand equation for commercial bank savings accounts. This is the only equation which includes mixed urban and rural observations and the dummy variable is designed to measure the extent to which rural differs from urban behaviour. Experimentation revealed that a rural shift in the coefficient of the real income variable was more appropriate than a rural shift in the constant term. Log-linear specifications were found to be appropriate for all but the equation describing net POSB deposit

accumulation. For this equation a semi-log form was instead used.²⁰

For reasons mentioned earlier, the real returns on POSB and commercial bank savings accounts are multiplied by share variables S_{po} and S_{cb} in some equations to correct for limited rural access to these institutions. The correction is made in the cattle, crop store and rural consumption equations where the cross-sectional classification is on a general regional basis. The correction is also made to the real return on bank accounts in the net POSB deposit accumulation equation. Since not all rural POSB account holders also have access to a commercial bank, r_{cb} has been multiplied by the share of total net deposits made by those who do have such access.²¹ Furthermore, not all asset holders who do have access to a POSB or bank account will use one. For this reason, the total real income variables y_p and y_c in these equations measure only the total real income of account holders within each area.²²

In this way, account has been taken of access limitations for those institutions where "easy access" can be readily defined. Correction could also have been made for access limitations to the BBS, all of whose branches are in urban areas, to South African securities and, at least for urban dwellers, to cattle holding or crop stores. However, this correction would have required more detailed information on the transactions costs involved. The coefficient estimates of these uncorrected returns must therefore be interpreted as weighted average elasticities or semi-elasticities among users and non-users alike.

- 14 -

²⁰ The real rates of return on crop stores and financial assets were measured, in general terms, as $(1+x)/(1+\pi)$ where x was the associated nominal rate and π the rate of inflation, while the real rate on capital in agriculture was measured as (1+r). In this way, real rates were scaled to be always positive.

²¹ The semi-elasticity of total demand for some commodity is likewise a weighted average of the semi-elasticities of separate demands. This is the only case in which the share S is not proxied by a population share.

Within each area (region, village or town) and wealth class, total real income was multiplied by the proportion of the area's population holding a POSB or savings account. Botswana's commercial banks provided data on the number of their accounts. For the POSB, an estimate of the number of account holders was obtained from annual averages of the number of deposit transactions per month, a calculation which assumes each account holder makes one deposit per month on average.

Equations (1)-(6) were first estimated using ordinary least squares. Overall results for cattle, crop stores, rural and urban consumption were obtained using the full time series of observations on all possible area/wealth class combinations. Overall results for POSB and commercial bank savings accounts were obtained with their time series of observations on areas. These overall results are the first estimates reported in each section of Tables 1-3.

An alternative technique for pooled time series cross-section data is that of least squares with dummy variables. Regional dummy variables were introduced, but the results showed that regional differences are fully captured in the existing explanatory variables, particularly real income, crop production or the real wage variable. The addition of regional dummies simply reduced the significance of these variables without raising total explanatory power.

More interesting from a theoretical viewpoint is to examine whether asset demand or consumption/saving behaviour varies significantly across wealth classes. Inclusion of wealth class dummies is one approach. This would test whether the constant term in each equation varied significantly across wealth classes. However, where data on the dependent variable has been obtained by both wealth class and area, there are sufficient observations to test whether both constant terms and elasticity estimates vary by wealth class. The cattle, crop, rural and urban consumption equations are therefore estimated for each wealth class separately. The results are those in the second part of each section in Tables 1 and 3.

The overall results for POSB and commercial bank savings accounts are generated from pooled regional time series data which assume that the distribution of POSB or bank account holders among wealth classes is the same as for the area as a whole. Each dependent variable is subsequently tested on income and real wage variables which instead assume that account holders are drawn entirely from a single wealth class, each wealth class taken in turn. The intention is to test whether financial asset holding behaviour is best explained by the income behaviour of a particular subgroup - whether POSB or

- 15 -

1.1 Asset Demand for Cattle (Rural)

	<u> </u>	Explanatory Variable Description												
	Const.		Real Income	Income Variation	Real Wage	Return in Agric.	Return on on POSB	Return on bank	Return on BBS	Return on SA TBs	Return on cash	N	₹ ²	F
Overall	(t statistics	in parentheses)	:		<u> </u>	<u></u>								· · · · · ·
	15.342 (6.348)		0.919 (12.936)	0.506 (6.042)	-2.458 (-7.974)						8.681 (3.642)	72	.859	109.5
Results	by wealth (cat	tle) class:						-				·		
1-10:	6.906 (2.115)		0.630 (9.466)	0.488	-1.237 (-3.538)	• .					3.504 (2.547)	24	.961	144.4
11-80:	10.783 (2.607)		0.645 (4.801)		-1.466 (-2.295)			:	•		. *	24	.528	13.9
80+:	8.929 (4.142)		0.764 (8.285)		-1.319 (-3.923)				•	2.587 (2.008)	·	24	.760	25.2
1.2 <u>Asset De</u>	emand for Crop	Stores (Rural)	• • •		•		· ·							
	Const.	Crop Production	Real Income	Income Variation	Real Wage	Return in Agric.	Return on on POSB	Return on bank	Return on BBS	Return on SA TBs	Return on cash	N	$\bar{\mathtt{R}}^2$	F
Overall	(t statistics	in parentheses)	•		· · · · · ·	<u> </u>								
	-3.258 (-6.827)	1.024 (23.800)		0.224 (2.696)			•				-14.934 (-4.281)	60	.931	267.7
Results	by wealth (cat	tle) class:				ï	·							
0:	-2.206 (-3.282)	0.807 (10.701)							•	· · ·	-18.794 (-3.161)	15	.938	107.6
1-10:	-3.468 (-4.612)	0.904 (10.281)	•	1.149 (3.587)				-34.485 (-4.557)				15	.958	107.2
11-80:	16.309 (5.566)	1.234 (37.498)		1.712 (4.003)	-2.883 (-6.243)							15	.990	471.9
80+:	-7.674 (-5.094)	1.335 (16.912)		1.345 (4.142)				4.		•		15	.958	161.7

- 16 -

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Table 2 - Demand for Financial Assets in Botswana

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2.1 Flow Demand for POSB Savings - Net Deposit Accumulation (Rural)

			· · · · · · · · · · · · · · · · · · ·											
	Const.		Real Income	Income Variation	Real Wage	Return in Agric.	Return on on POSB	Return on bank	Return on BBS	Return on SA TBs	Return on cash	N	\bar{R}^2	F
Overall ((t statistics	in parenthese	es):											,
	68.068 (3.019)	·	2.204 (5.810)		-8.543 (-2.892)		-1.847 (-5.205)				24	.755	24,6
- Results w	rith Alternati	ve Income Mea	sures;					. ·	• •					
0:	7.682 (5.386)		0.936 (2,269)				. · ·	-1.993 (-3.787)	• •		. · · ·	24	.487	11.9
1–10:	5.164 (2.243)		1.146 (2.470)					-2.006 (-3.898)			•	24	.505	12.7
11-80:	65.912 (4.630)		2.657 (5.971)		-8.502 (-4.377)		-1.840 (-5.433)	· · · · · · · · · · · · · · · · · · ·			24	.770	26.7
80+:	23.217 (2.212)		1.833 (5.300)		-2.930 (-1.961) .		-1.947 (-5.490)				24	.741	23.0
2.2 Asset Dem	and for Comme	rcial Bank Sa	avings Account	ts (Mixed Ru	ral and	Urban)				-	<u>.</u>	,		•
	Const.	Rural Income Dummy	Real Income	Income Variation	Real Wage	Return in Agric.	Return on on POSB	Return on bank	Return on BBS	Return on SA TBs	Return on cash	N	₹ ²	F
Overall (t statistics	in parenthese	28):	· · ·			• • •					<u></u>		
	-1.352 (-1.818)	0.235 (5.587)	1.168 (12.505)					30.729 (5.467)	-48.345 (-5.509)	-6.476 (-2.942)		21	.913	43.1
Results w	vith Alternativ	ve Income Mea	asure:											
Low:	24.422 (3.638)	0.201 (3.684) .	0.849 (8.625)		-2.983 (-3.636)						21	.852	39.5
Medium:	22.024 (4.898)	0.189 (3.892)	1.292 (8.024)		-3.009 (-4.737)		29.101 (4.036)	-47.561 (-3.691)	-10.815 (-2.691)		21	.903	32.0
High:	-3.114 (-4.155)	0.158 (5.983)	1.275 (13.876)			2.552 (2.483)		11.593 (3.021)	-16.219 (-2.617)	-6.719 (-2.936)		21	.935	49.2

4

- 17 -

Table 3 - Consumption Functions for Botswana

3.1 Rural Consumption Function

										· ·			
	Const.	Real Income	Income Variation	Real Wage	Return in Agric.	Return on on POSB	Return on bank	Return on BBS	Return on SA TBs	Return on cash	N	\bar{R}^2	F
Overall (t	t statistics in parer	ntheses):				<u> </u>				······································			
	3.673 (9.828)	0.695 (17.514)	-0.143 (-4.102)			-13.256 (-3.130)				7.784 (3.486)	72	.865	114.6
Results by	y wealth (cattle) cla	ass:											
0-10:	10.711 (5.117)	0.508 (13.570)		-0.743 (-3.076)		-10.061 (-2.986)	•			5.907 (3.612)	24	.967	168.5
11-80:	19.140 (5.176)	1.061 (9.330)		-2.392 (-4.309)			· ·			6.389 (2.463)	24	.827	37.6
80+:	3.379 (7.093)	0.620 (10.977)			-1.221 (-1.802)						24	.838	60.4
3.2 Urban Cons	sumption Function					• •							
	Const.	Real Income	Income Variation	Real Wage	Return in Agric.	Return on on POSB	Return on bank	Return on BBS	Return on SA TBs	Return on cash	N	$\bar{\mathbf{R}}^2$	F
Overall (t statistics in parer	ntheses):						····· .					
	2.137 (4.873)	0.943 (22.653)	-0.118 (-2.433)					-6.356 (-2.346)		10.345 (2.775)	72	.890	144.9
Results by	y wealth class:					· .							
Low:	16.345 (5.020)	0.987 (18.999)		-2.001 (-5.334)	-1.355 (-3.924)						24	.966	218.2
Medium:	-6.222 (-5.912)	0.949 (44.271)	-0.205 (-4.567)	1.050 (9.167)				-4.592 (3.248)		5.141 (2.628)	24	.992	572.8
High:	3.438 (10.697)	0.996 (133.247)	-0.089 (-8.407)	-0.352 (-9.194)				-2.087 (-5.716)		3.904 (8.634)	24	.999	5267.4

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bank savings accounts appeal only to richer groups. These results are in the second part of each section in Table 2.

Not all coefficient estimates in the original specifications were significant and despite the rescaling of some rate of return variables, multicollinearity still precluded the inclusion of certain variable combinations. Therefore, only the results with the preferred subset of explanatory variables are presented.

Results

Over all wealth classes, the asset demand for cattle in Botswana depends on real income and its variation, real wages and the inflation-related return on cash. The significance of income variation suggests a transactions demand for cattle, perhaps surprising for an asset that might appear to be relatively illiquid. Nevertheless, cattle markets in Botswana are not thin, although price comparisons among different outlets suggest there is a liquidity premium associated with cash payment from other farmers or auctions compared with the higher but delayed payment from the Botswana Meat Commission (BMC) or its agents (McDonald 1978). Furthermore, various rural studies have indicated that although cattle would not be sold to meet day-to-day expenses, a beast might be sold to meet a large cash outlay for school fees, or the like (Gulbrandsen 1980, Odell 1980).

The significant negative coefficient of real wages suggests that rural households do regard cattle and human wealth as substitutes. Note that in the framework proposed here, each asset is a separate source of income and total income is therefore the sum of current period returns from all assets. An increase in the real return to human wealth, proxied by the real wage, would have an income effect, as would an increase in the return on any other asset. However, this income effect is captured directly through the income variable. Furthermore, because Botswanan household income sources

- 19 -

are typically diversified, the degree of multicollinearity between each asset return and total real income is not sufficiently high to cause problems. Thus the estimated coefficient of the rate of return, or wage variable in this case, measures a pure substitution effect, which helps to explain its strength.

By contrast, the rate of return on cash has a positive coefficient, meaning that a rise in inflation which reduces the rate of return on cash would also reduce cattle holding. Thus cattle are not treated as hedges against inflation, a result which may not be surprising when it is remembered that crops feature more prominently than beef in the rural household's consumption bundle. A beast will be slaughtered for a wedding or funeral, but otherwise consumption is generally restricted to animals which die of natural causes. In times of inflation, it is purchasing power over crops which needs protection, so that crop stores themselves rather than cattle may be better hedges. Conceivably, cattle could be sold to finance such crop stores.

The cattle results by wealth class show that cattle holding does vary significantly among groups.²³ The transactions motive operates only for the poorest group, whose cash flow would be lowest. And while the financial return that most strongly influences the lowest group's cattle demand is the one on cash, the return most relevant for the wealthiest group is that on South African securities. Thus it appears that even in rural areas, the wealthier (more sophisticated?) people might look beyond Botswana's borders for financial alternatives. In both cases, however, the positive sign suggests that it is probably the effect of inflation on these real returns that generates the result. Neither the transactions motive nor the effect of inflation seems to operate for the middle wealth class. The generally poor results here might reflect that this group is not homogeneous, at least with respect to cattle holding motives and behaviour. Nevertheless, the positive effect that real income has

- 20 -

²³ When all potential explanatory variables are included, a Chow test gives an F(11,39) statistic of 19.77, compared with a critical value of 2.05 at the 5% level.

and the negative effect that real wages have on cattle holding persist across all wealth categories.

A final point is that the real rate of return on capital in agriculture, the "own" rate of these equations, is nowhere significant. Experimentation revealed, however, that when the real wage variable was excluded, the "own" rate was significant and positive for the wealthiest group. Recall that the two poorer groups face cattle-holding threshold targets for draught self-sufficiency and beef production viability which in any event reduces their sensitivity to pure rate of return considerations. However, the own rate of return to cattle holding is negatively correlated with the real wage. The correlation is quite strong for the two poorer groups. Although weaker for the wealthiest group, it is still sufficient apparently to preclude the inclusion of both the real wage and the own rate of return variable in their equation.

The crop store results show firstly that this asset demand does depend on crop production but not on total real income from all sources. One interpretation is that while crop inventory holding is an option for crop producers, it is not an important form of asset holding for those whose income is derived mainly elsewhere. Crop stores also depend on income variation, at least for all but the lowest wealth class.²⁴ Among people for whom subsistence crop production and its variation is an important source of income and its variation, the transactions or inventory motive for crop holding is clear. If there are some non-producers who nevertheless hold crop stores, the use of crops for payments-in-kind could also produce a transactions motive.

Over all wealth classes and for the poorest group separately, crop storage depends negatively on the rate of return to cash, or positively on the inflation rate. For the second lowest wealth group,

²⁴ When income variation was introduced into the equation for this group, its elasticity of 0.417 was not quite significant - a t statistic of 1.775.

the rate of return on bank accounts appears as the relevant variable, although probably it is once again the effect of inflation on this real return that generates the result. Thus crop stores do appear to be used as hedges against inflation, at least by the poorer groups. The high absolute values of these elasticities also show that crop stores and cash (or bank accounts) are very close substitutes, as might be expected when crops are themselves an important consumption commodity. Crop storage by the wealthier groups does not appear to be as sensitive to inflation, however, since their consumption patterns would be more diversified.²⁵ Instead, the broad middle wealth group substitutes away from crop storage (and crop production?) when the real wage rises.

Finally, the rate of return on crop storage, the "own" rate of these equations, was nowhere significant. Since this variable was not significant in any other equation either, it has been omitted from the list of potential explanatory variables. While this result may be partly due to the poor quality of the crop price data, it is also consistent with the idea that for Batswana, who produce crops at or below the subsistence level, crop storage is not primarily a speculative undertaking.

In the overall POSB savings equation of Table 2, the rate of deposit accumulation depends on real income, the rate of return on commercial bank accounts and the real wage. In this equation, the "own" rate of return on POSB savings accounts was not significant, but was also confounded with problems of multicollinearity. The nominal interest rate did not vary greatly over the period of estimation, even once account was taken of its tax deductibility. In any event, the tax concession is not particularly important for rural households whose total income is at the low end of the scale. Thus the real rate varied primarily because of inflation, and was highly

- 22 -

²⁵ When results for the four separate groups are tested against the overall result, and when all potential explanatory variables are included, the differences in behaviour are not statistically significant. A Chow test gives a F (12,12) statistic of 2.46, against a critical value of 2.69 at the 5% level.

correlated with the real return on cash. When either real return was entered separately, its coefficient had the same negative sign, as would be expected from the effect of inflation. And since neither separately showed as significant, this was even more true when they were entered together.But while the rate of POSB deposit accumulation appears insensitive to its own return during the period of estimation, one should not conclude that the same would hold were the nominal interest rate to show more variation.

The overall result does show, however, that there is substitution between POSB and commercial bank accounts. The elasticity measures the degree of substitution only among those who have access to both institutions, so although it is higher than an overall elasticity, it is still quite low. However, bank savings accounts in Botswana have substantially higher minimum deposit requirements than POSB accounts, for example, so the two could not be expected to be perfect substitutes.

The overall result does not show any substitution between POSB savings and real assets. Nor does there seem to be a transactions demand element to POSB saving, since the income variation variable is not significant. Nevertheless, the rate of POSB deposit accumulation falls when the real wage rises, indicating a degree of substitutability between human and financial wealth. In conventional terminology, this substitution might be expected when financial assets are held primarily for precautionary purposes.

Table 2 then shows results when the same data on POSB saving is tested on income and real wage variables which assume that POSB account holders are drawn entirely from a single wealth class, each class taken in turn. If aggregate POSB saving behaviour were best explained by the income behaviour and real wage alternatives of a particular subgroup, this would indicate that POSB accounts were more heavily used by that group. Thus it appears that POSB accounts appeal more to the two wealthier groups, the ones for whom the real wage variable is also significant. As a whole, these wealthier

- 23 -

groups do not appear to devote a higher proportion of their total wealth to human wealth. Certainly the proportion of their total income earned from wage employment is lower than for the poorer groups. Nevertheless, it is likely that the wage income earned by members of rural households in the wealthier categories is derived from formal sector employment and is thus more regular.²⁶ If this were the case, the results on POSB saving would support the idea that the demand for financial assets and financial services is stronger among those with a regular source of cash income, and weaker among those whose transactions are still partly in kind.²⁷

The overall result for commercial bank savings accounts, estimated from mixed urban and rural data, shows firstly that this asset demand depends on real income and further, that the income elasticity is higher for rural than for urban account holders. The coefficient of the real income variable measures the elasticity of the urban group. The coefficient of the rural income dummy variable is positive and measures the amount by which the rural income elasticity exceeds the urban elasticity. Since rural households in Botswana are on average poorer than urban households, we might expect their asset demands to be more income responsive, and perhaps less responsive to real rates of return. With limited degrees of freedom, however, the second proposition could not be tested explicitly.

Overall, the demand for commercial bank savings accounts depends positively on its own real return, and negatively on the real returns to BBS shares and South African Treasury Bills. The coefficients of the own rate and the cross rate with BBS shares are both large in absolute terms, indicating that these two financial assets are very

²⁶ See, for example, CSO (1976). Furthermore, in a few of the rural POSB branches the number of deposit and withdrawal transactions per month is so low that we suspect the only users are the POSB employees themselves!

In a similar connection, the only reference we could find to informal rotating fund credit clubs, similar to the "esusu" in Nigeria or the "kyes" of South Korea, was in Curtis (1973), who observed them operating among rural women with regular cash income from beer parties. An observer reports that such clubs still operate in Gaborone and are likely to be more prevalent in urban areas, since they depend explicitly on a regular cash contribution that requires regular cash income.

close substitutes. The coefficient of the South African rate is not as large, as expected for an asset which involves an additional element of risk. It would be tempting to attribute the sensitivity to South African rates to the urban account holders in the sample, but recall that in rural areas, cattle holding by the wealthiest group was also sensitive to South African returns. Overall, were the real returns on all three financial assets to rise, the net effect on commercial bank saving account holding would be negative. This is not surprising when the real returns on BBS shares and South African treasury bills have been higher than on bank savings accounts, especially once the tax concessions are taken into account. Overall, however, savings account holding appears insensitive to the real returns on real non-human or human forms of wealth. Nor does there appear to be a transactions demand for bank savings accounts.

The same data on commercial bank saving account holding were then tested against income and wage variables which assume that bank account holders are drawn entirely from a single wealth class, each class taken in turn. A comparison of the explanatory power of each equation shows weak evidence that bank accounts might not be heavily used by the poorest group. To the extent that they are, however, the poorest group does not appear a substitute between different forms of financial asset, but does regard its savings accounts as a substitute for human wealth, as might again be expected when the demand for the financial asset is mainly precautionary.

Once again, the rural households would appear to have a higher income elasticity of demand or bank savings accounts than the urban households. This result may simply reflect that the rural wealth classes judged to be "low", for example, are poorer than the urban wealth classes judged to be "low".²⁸ Nevertheless, the substitution

²⁸ Calculations of per capita income for each group suggest this to be the case, not only for the "low" group but also for the "medium" and "high" groups. This might run contrary to the experience in other countries, at least for the "low" group, but could also arise from underestimation of rural income in kind in the National Accounts, the source from which the disaggregated income data was constructed.

between different forms of financial assets appears attributable to the behaviour of the two wealthier groups. And while the middle group would also respond to the real return on human wealth, the richest group would respond instead to the real return on capital in agriculture. The positive sign of this last coefficient presents a puzzle. Since each form of wealth is also a source of income, the income effect of an increase in a real return should be captured in the income variable, not the return itself. It is possible, however, that because of the difficulty of distinguishing cattle "holding" from "ownership", the amount of income earned on cattle, particularly by the urban households in the sample has been underestimated. The positive sign of the return to capital in agriculture could therefore indicate an income effect that has not been captured elsewhere.

As mentioned earlier, the results for the rural and urban consumption functions in Table 3 should not be interpreted too seriously. For rural households, for example, the income elasticity of real consumption is low while the coefficient of the income variation variable is negative. Both results suggest that real income variation is absorbed by adjusting asset holding rather than by adjusting real consumption. But since this behaviour was assumed in constructing the consumption data, the results could merely reflect our statistical artifice. Nevertheless, rural real consumption falls when the real returns to POSB savings accounts and cash increase together. For the two poorest groups, an increase in the real return to human wealth would induce substitution away from consumption toward wealth accumulation, while for the richest rural group, an increase in the real return on cattle in agriculture would have the same effect.

For urban households, an increase in the return on BBS shares and cash together, say from a fall in inflation, would apparently have a positive effect on consumption. A reduction in inflation produces a kind of capital gain on currently held financial assets, and capital gains are one form of income from wealth-holding that has not been properly measured in the income variable itself. The positive net effect of an increase in the returns on all relevant

- 26 -

financial assets therefore measures an income effect not captured elsewhere. Significantly, this income effect appears only for urban households, whose financial asset holding is greater, if only because they have full access to financial institutions. The real consumption of the lowest and highest urban wealth groups falls as they switch to wealth accumulation in the face of a rise in the real return to human wealth. The positive effect that the real wage has on real consumption of the middle group presumably reflects some income effect not measured elsewhere. For the lowest wealth group, real consumption also falls with a rise in the real return to capital in agriculture. Although this result is perhaps surprising, an examination of urban income sources provides a possible explanation - the urban poor, particularly those in peri-urban areas, retain their ties with the surrounding rural areas and earn some of their income from crop, if not from cattle production.²⁹

Conclusion

In general, the empirical results confirm the main theoretical proposition of this paper. Both real and financial assets are seen as substitutes for human wealth in the overall portfolios of Botswanan wealth holders. Beyond that, a more general picture of asset demand and saving behaviour emerges. Firstly, the direct interaction between real and financial asset holding is weak. Crop stores may be used as hedges against inflation, but otherwise the demand for real assets does not respond strongly to the real returns on financial assets. Nor does the demand for financial assets respond strongly to the real returns on real assets, except among the very wealthiest asset holders. Furthermore, if there is a demand for assets to act as buffers with which to shield real consumption from the effects of variation in

- 27 -

²⁹ In both the rural and urban consumption equations, the differences in behaviour between wealth classes are significant. When all potential explanatory variables are included, Chow tests give F(11,39) statistics of 3.88 and 22.77 respectively, against a critical value of 2.05 at the 5% level.

real income, this transactions demand seems to fall on real rather than financial assets. Financial asset demand among the poorer groups appears to be purely a precautionary demand, although the wealthier groups will substitute between different kinds of financial asset to maximize their return from financial asset holding.

Certainly among rural Batswana, financial assets represent a tiny fraction of their total wealth portfolios. A simple comparison of magnitudes establishes the point. In mid 1983, total deposits of all types held by both rural and urban households in Botswana's commercial banks amounted to 67.3 million Pula. Of this, an estimated 25% or 16.8 million Pula can be attributed to holdings in Botswana's rural branches. Add to this the entire 5.0 million Pula or so held by all households at the POSB and obtain an upper estimate of rural financial asset holding of 21.8 million Pula. By comparison, the national cattle herd in 1983 was valued at almost 530 million Pula. Add to this the human wealth embodied in Botswana's almost 800,000 rural residents and the point is sufficiently made. The low proportion of rural wealth held in financial form may partly reflect the limitations which still exist on access to financial institutions in remote rural areas. It could also indicate that, were borrowing easier than it currently is for Botswana's rural population, the optimal financial asset holding would in fact be negative, at least in a drought year. There seems to be no easy way to test whether low financial asset holding reflects an unconstrained preferred position or a corner solution in the face of borrowing constraints. Nevertheless, the empirical results of this paper do suggest that for the rural population on whom the estimation has concentrated, the important margins of choice are over real asset holding and between human and real non-human forms of wealth. Rural Batswana face uncertain, fluctuating real returns on their assets, yet also use these assets as buffers against variation in income from all sources. While the combination of functions might occasionally place a strain on the ability of real assets, particularly cattle, to perform either function well,

³⁰ These strains have been documented in both academic literature and fiction. See, for example, the novel by Bessie Head, "When Rain Clouds Gather."

rural Batswana do respond to real wage changes and do substitute towards human forms of wealth. A policy implication follows - where current wealth-holding options are judged insufficient to allow rural Batswana to adequately insure against the contingencies they face, the further development of wage labour opportunities rather than financial asset options would do more, at least in the short run, to alleviate the problem.

Appendix

The following derivation borrows heavily from the mathematical treatment given to this kind of problem by Frankel and Engel (1984).

Total household real wealth W can be held in three different forms - as real human wealth H, as real assets K or as financial assets with real value A. At any point in time, and given total real wealth, the household must choose the shares it wishes to hold in each form. At the end of the period, total real wealth will be

$$W_{t+1} = W_t \left[\frac{W_t}{W_t} (1 + r_{t+1}^h) + \frac{K_t}{W_t} (1 + r_{t+1}^k) + \frac{A_t}{W_t} (1 + r_{t+1}^a) \right]$$
(1)

where r_{t+1}^h , r_{t+1}^k and r_{t+1}^a are the real rates of return to each form of wealth during the period. Alternatively,

$$W_{t+1} = W_t \times_t R_{t+1}$$
(2)

where x is a column vector of wealth shares and R_{t+1} is a column vector of returns $1+r_{t+1}$.

If the household choice takes place under uncertainty, then the actual returns will not be known in advance, but the household will act on the basis of some expectation, where

$$R_{t+1} = E_t R_{t+1} + \varepsilon_{t+1}$$
(3)

If in addition the household forms its expectations rationally, then its forecast errors will be conditionally unbiased so that $E_{+}(\varepsilon_{++1}/I_{+}) = 0.$

If the usual assumptions apply, the general choice under uncertainty can be seen as a choice over the mean and variance of endof-period wealth alone. This mean and variance is given by

$$E_{t} W_{t+1} = W_{t} x'_{t} E_{t} R_{t+1}$$

$$V_{t} W_{t+1} = W_{t}^{2} x'_{t} \Omega x_{t}$$
(4)
(5)

where Ω is the variance-covariance matrix of returns about their expected values, or the variance-covariance matrix of ε_{t+1} . The household will choose the wealth shares x_t to maximise a function of the mean and variance

 $F[E_{t}(W_{t+1}), V_{t}(W_{t+1})]$ (6)

where for risk averters, F is an increasing function of the mean and a decreasing function of the variance. The first-order condition is:

$$F_1 W_t E_t R_{t+1} + 2F_2 W_t^2 \Omega x_t = 0$$
 (7)

Define the coefficient of relative risk aversion $\rho = -W_t \frac{2F_2/F_1}{r_1}$ and assume it to be constant. The first order condition can then be solved for x_t to give:

$$\mathbf{x}_{t} = \frac{1}{\rho} \quad \Omega^{-1} \mathbf{E}_{t} \mathbf{R}_{t+1}$$
(8)

Equation (8) is a matrix equation which defines the demand for each asset, relative to total wealth, as a function of the expected returns on all assets. Thus, for example, the share of total wealth held in the real asset K would be a function not only of the real returns to real and financial assets, but also of the real return to human wealth. If the demand is expressed as an absolute rather than relative demand, with the wealth divisor transferred to the right hand side and proxied by real income, the functional form is similar to that estimated in the text. Two further implications of equation (8) which derive explicitly from the framework of uncertainty have been ignored in the estimation. The first is that demands depend on expected rather than actual returns, and the second is that the coefficient estimates should themselves bear some relationship to the variances and covariances of returns about their expected values.

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