THE ADOPTION OF NEW CROPPING TECHNOLOGY IN NORTHERN PAKISTAN

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ABSTRACT

This paper is a preliminary investigation of the adoption process for high yielding varieties of wheat in Gilgit District, Northern Areas of Pakistan and of the farmer's relationship to his socio-economic environment. By viewing the farm-household as a producer, consumer and resource owner, it becomes possible to enhance knowledge of the characteristics of the farm-household which influence the adoption rate of HYVs. A simultaneous equation model was developed and estimated. The results are consistent with the view that farm-household decisions about the degree of adoption of high yielding varieties are closely linked to decisions regarding levels of family labour used, off-farm income, and planting time in wheat production.

I. THE PROBLEM — SLOW GROWTH AND 'NEQUITY

1.1 Introduction

In developing countries, there is growing concern about issues relating to the failure to achieve the potential for growth , resulting from the adoption of high yielding varieties (HYV) and technology transfer and the likelihood of inequity in the distribution of attendant benefits. The problems faced by policy-makers promoting adoption are further compounded when the community under investigation has a low literacy rate, strongly imbedded traditional agricultural practices and socio-economic configurations which may be inimical to technological change.

In a number of studies researchers have examined the impact of adoption of HYV on productivity and output in different environments. In most of these analyses, the authors assert a high rate of return to the adoption of high yielding varieties, and there is strong advocacy for an increased agricultural extension effort (Ruttan, 1982, Ayer and Schuh, 1972). While many of these studies have made valuable contributions to our understanding of the processes of adoption or non-adoption of high yielding varieties, the kind and quality of information, generated from these analyses remain inadequate as practical bases for policy-makers in their design and implementation of polices.

The deficiencies of these studies are two-fold. First they fail to address the basic question, "Why is the diffusion of HYV slow, compared with the rapid diffusion of other agricultural technologies, such as fertilizers, tractors and threshers?" Second, most of these studies fail to provide insights into the mechanisms of linkages between the adoption process and the relevant economic entities of the farm household (Pradhan and Quilkey, 1983).

The aim of this paper is to attempt to explain these lacunae in understanding the adoption process and to improve understanding of the adoption of new wheat cropping technology in the farm economy of developing countries, in particular, in the Northern Areas of Pakistan.[1]

1.2 The Study Area

Gilgit District, the area under study in Northern Pakistan, is a mountainous region (Figure 1) and wheat is the major crop. The average land-holding is about 1.08 hectares (ha) of which one half is normally planted to wheat, between November and March and harvested from

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1 Northern Areas of Pakistan (Northern Pakistan) is comprised of three districts: Gilgit, Chitral and Baltistan. The region has a special status and is under the direct control of the Federal Government of Pakistan.

the middle of June to mid July, depending on the crop variety[2] and climatic conditions (Mir, Beg, 1986). Wheat is of critical importance. It is the staple food of the people, supplying 72 per cent of calories and proteins in the average meal, principally in the form of chappati and nan[3] (CIMMYT, 1989). Wheat is important not only because of its contribution to human consumption, but because of its role in the crop livestock interaction (Ahmad, et.al, 1988) through the use of the wheat-straw[4] or 'bhusa' as fodder and the use of farmyard manure which is applied to improve the flexibility and texture of the soil of the region. Hence there exists a significant interaction between wheat and the rest of the farmer's subsistence system.

In the last two decades the Northern Areas of Pakistan, have been introduced to many technologies including HYVs of wheat. However, the adoption rate of these HYVs has been relatively slow, in sharp contrast to the rate of adoption of the fertilizer component of the technological package (Figure 2). The hypotheses addressed in this paper have emerged from this single key question: Why has the adoption of HYVs proceeded so slowly, relative to that of fertilizer? This question led to hypotheses about specialisation in either traditional or high yielding varieties. In explaining specialisation by farmers across wheat varieties, one can argue that the availability of information on the new technology, in particular, high yielding varieties, and the household ability to process that information significantly affects the rate of adoption. A further argument considered as one of the hypotheses to be tested is that, male-out migration for off-farm employment in winter has substantially retarded the adoption rate of HYVs.

The preliminary analysis of this study indicates that the opening of the paved Karakoram Highway (KKH)[5] between Gilgit and the rest of Pakistan, on the one hand improved input availability and enhanced the efficiency of agricultural marketing. On the other hand it facilitated the transport of wheat, flour and other items of daily use (Hussain, 1988) from the plains to Gilgit. Simultaneously, the opportunities for employment in non-agricultural activities have multiplied. This reflects improved supply conditions (for all inputs) which dominated the period between the opening of KKH in 1978 and the current survey in 1990, while the declining relative profitability of wheat farming since then has affected investments in all innovative decisions including those concerning adoption of HYVs.

1.3 Organization Of The Paper

The discussion in Section 1, helps set the stage for the theoretical and empirical parts of the paper. Section 2 gives a brief overview of the theory of agricultural household models. In Section 3, the empirical model is specified and its parameters are estimated. The summary and conclusions are presented in the last section of the paper.

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2 Crop variety: (i) High yield variety are normally planted after mid-December and harvested by June. HYV have a short maturing period. (ii) Traditional varieties require a long maturing duration, they are planted in September/October and harvested in June/July.

3 Chappati and nan: two unleavened bread products.

4 Wheat-straw (bhusa) is the major feed for livestock, particularly over the winter-spring period in the Northern Areas of Pakistan. Manure is used as fertiliser and animal draft power is used for wheat growing, ploughing and theshing respectively.

5 KKH: Karakoram Highway also known as friendship highway, links China and Pakistan. This highway was opened for traffic in 1978.

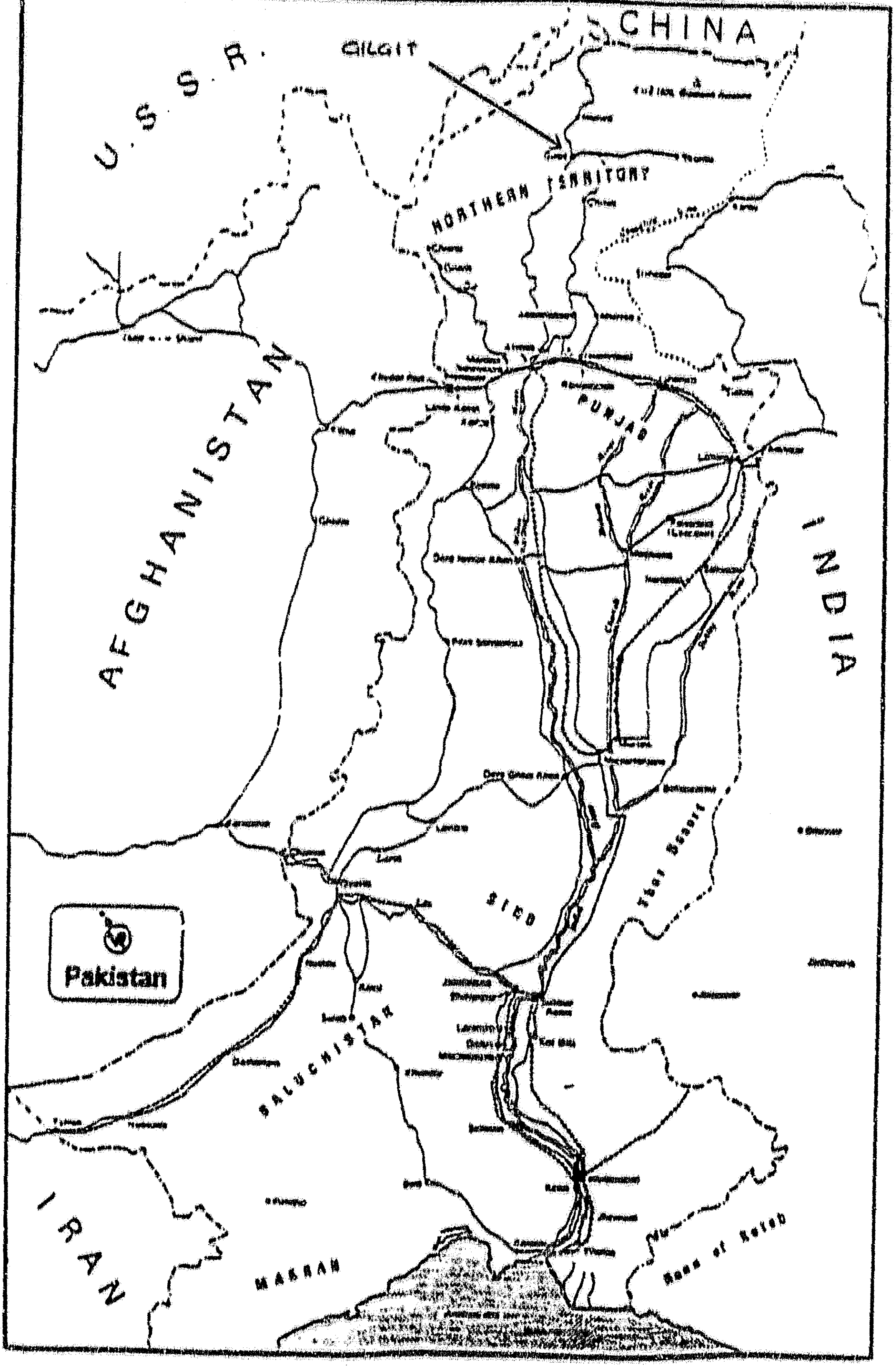

FIGURE 1: Map of Pakistan

Source: Pakistan Tourism Development Corporation, Government of Pakistan.

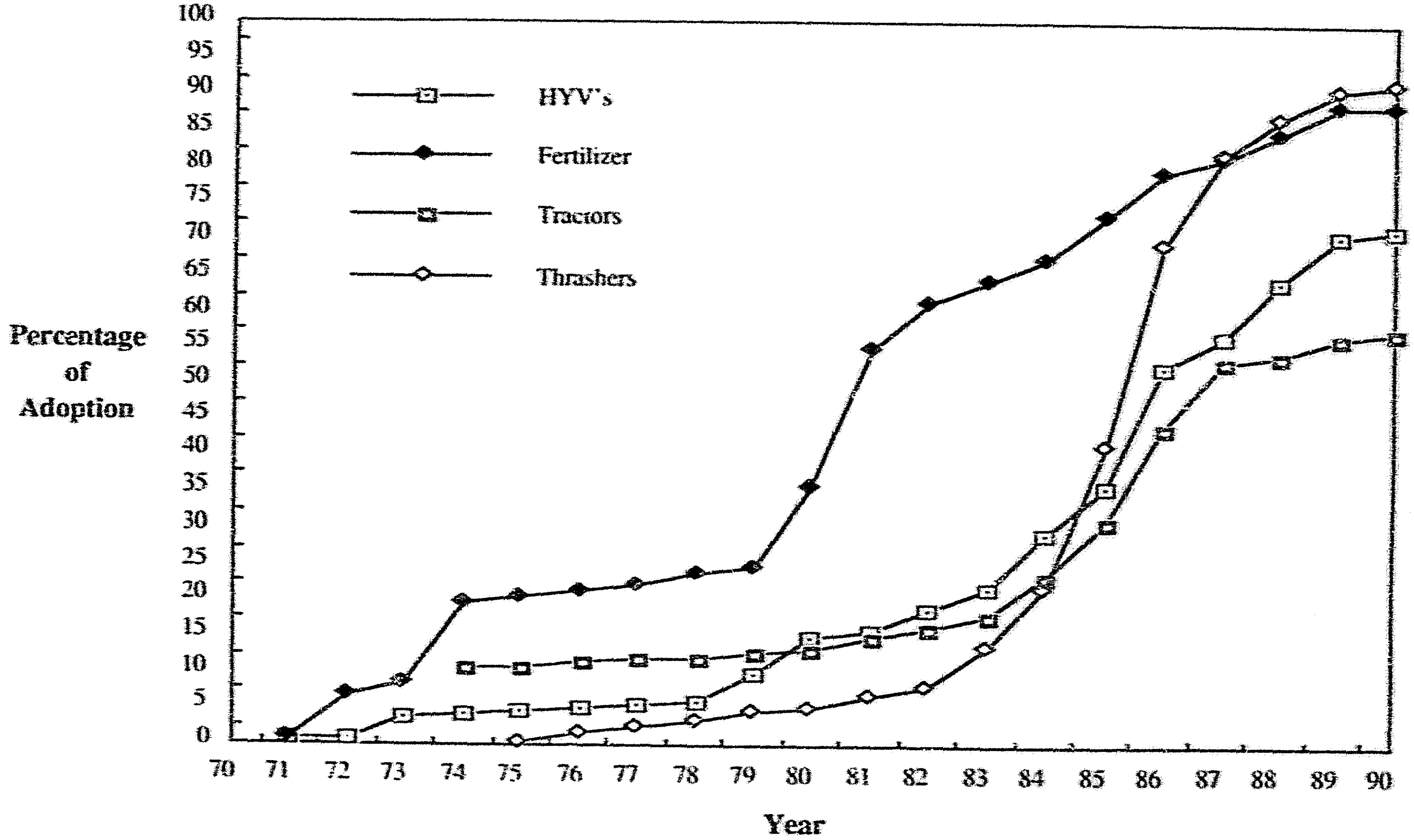

FIGURE 2: Trend of Technology Adoption in Gilgit

Source: Survey (1990) conducted by the senior author

2. THEORY AND THEORETICAL MODEL

2.1 Overview of Agricultural Household Models – The Theory

Analysis of choice between work and leisure in terms of subjective equilibrium as the base for the integration of production and consumption has its origins with Chayanov (1925) and a succession of later works by Tanaka (1962), Nakajima (1957), Mellor (1963, 1969), and Fisk and Shand (1969) and the reinterpretation of Chayanov's work by Millar (1970).

Subjective equilibrium theory embodies the notion that block recursive production and consumption decisions cannot be inferred in general without ignoring the dual role of time endowment as a commodity which is utility yielding and as a productive factor, labour. The appropriate perspective is that adopted by Thurow (1983) who points out that unlike other factors of production labour cannot be separated from its supplier. In addition, certain kinds of labour are preferred to others. Consequently, labour's productivity is determined not only by technology but is influenced by motivation and preferences. With such a view of labour, it may be argued strongly that separation of production and consumption is not valid and that 'where there is motivation for holding resources as other than productive factors non-joint production and consumption is untenable' (Pradhan and Quilkey, 1991).

The rationale for both the subjective equilibrium approach and neoclassical theory is utility maximisation. In Chayanov's work, however, the opportunity set has as a characteristic a non-linear constraint in the form of a production function. Whereas in the neoclassical model prices are fixed, in the subjective equilibrium model prices are set by usage levels so that commodity non-market (shadow prices) are dependent not only on factors on the supply side such as land, capital and information but, as well, on factors such as family size and composition.

Household behaviour, according to subjective utility theory, is considered to be an interaction between a production function and a utility function. In an environment in which exchange prices are poor determinants of household behaviour and, where shadow prices are determined by usage levels of commodities, household behaviour with respect to production and consumption is properly regarded as interdependent.

The theoretical and methodological precursor to the model employed in this study is that proposed by Pradhan and Quilkey (1991). The base theoretical model they propose is presented below.

2.2 Pradhan and Quilkey (PQ) Model[6]

The base theoretical foundation of PQ models is the three functional relationships which characterises farm-household decision-making process in developing countries.

The first functional relationship is the farm output function which is implicitly specified, to characterise farm-household in developing countries as:

$$q_p = q + q_m = F(l_{fs}, l_{hd}, C_f, \pi, xi) \qquad (2.1)$$

where q_p is the level of production; q is the level of consumption; q_m is the marketed surplus; l_{fs}, l_{hd} are labour supply and hired labour demand, C_f represents the cash inputs, π is the extent of new technology adoption as measured by the proportion of land allocated to the new technology and xi are other relevant exogenous variables. While F stands for an output function combining two separate technologies which is different to the concept of a production function.

[6] Pradhan and Quilkey (PQ) model is presented here keeping the notations unchanged.

The second relationship is the utility function which is specified as:

$$U = U[q, M, l_{fs}(s_i), l_{ms}(s_j), C_f(s_k)] \tag{2.2}$$

In this utility function an additional factor M is included to take account of all other consumption goods besides the subsistence good which is produced and consumed by the farm household, and s_i, s_j, s_k are i, j and k specifications of variables associated with on-farm labour supply, l_{fs}, off-farm (market) labour supply, l_{ms}, and cash inputs used in farm activities, C_f. No distinction is made as to the sources of C_f which may be funded by borrowing or 'own cash' generated from liquid assets. The PQ model assumed that lending activities are not important in the empirical context.

The specification variables, in effect, represent the sources of resource endowments, their allocations and product characteristics of relevant endogenous variables. By definition, these are exogenous variables which determine the values of the respective endogenous variables by mechanisms other than those explained by the current model. One can, however, identify reasonably well what these specification variables are in particular contexts.

The variables, s_i and s_j may stand for such factors as family size and composition which largely account for variation in the time endowments among farm households. Family size and compositional factors are to be considered as exogenous variables since they determine, without themselves being determined by, current decision related variables such as on-farm and off-farm labour supply. Similarly, specification variables s_k accompanying cash inputs are likely to be asset and liquidity related variables such as income and wealth, and credit market related variables such as credit-acquisition-time, interest rates and sources of credit.

The third relationship is the real balance constraint that integrates the production and consumption sectors of the farm household and is defined as:

$$p_s q_m + y_n + w_m l_{ms} - w_f l_{hd} - M - C_f - V = 0 \ , \tag{2.3}$$

where p_s is the price at which marketed surplus, q_m of farm produce (rice) is sold, w_f and w_m are the on-farm and off-farm wage rates, y_n is nominal unearned income, M is the market value of non-rice consumption commodities, C_f is the use of cash inputs in the farm-firm, and V is the saving of cash that may be carried over from year to year.

The empirical optimisation problem of a semi-subsistence agricultural household implies maximising the utility function (2.2) subject to the production function (2.1) and the cash-flow identity (2.3).

To derive the empirical model, the familiar constrained optimisation technique of model solution was applied to the problem defined in the previous section. Instead of the usual case of a single linear constraint which is so often encountered in economics texts, here there are two constraints, one of which is non-linear. The general methodology, however, applies yielding the Lagrangrian function:

$$\begin{aligned} L = {} & U[q, M, l_{fs}(s_i), l_{ms}(s_j), C_f(s_k)] - \\ & \lambda_1[q + q_m - F(l_{fs}, l_{hd}, C_f, \pi; x_i)] - \\ & \lambda_2(p_s q_m + y_n + w_m l_{ms} - w_f l_{hd} - M - C_f - V) \ , \end{aligned} \tag{2.4}$$

where λ_1 and λ_2 are Lagrangian unknowns.

By differentiating (2.4) partially with respect to the unknown variables q, M, l_{fs}, l_{ms}, C_f, q_m, l_{hd}, π, λ_1 and λ_2, the following first order conditions can be obtained. Thus:

$$L_q = U_q - \lambda_1 = 0 \ , \tag{2.5}$$

$$L_M = U_M + \lambda_2 = 0 \ , \tag{2.6}$$

$$L_{l_{fs}} = U_{l_{fs}} + \lambda_1 F_{l_{fs}} = 0 \ , \tag{2.7}$$

$$L_{l_{ms}} = U_{l_{ms}} - \lambda_2 w_m = 0 \ , \tag{2.8}$$

$$L_{C_f} = U_{C_f} + \lambda_1 F_{C_f} + \lambda_2 = 0 \ , \tag{2.9}$$

$$L_{l_{hd}} = \lambda_1 F_{l_{hd}} + \lambda_2 w_f = 0 \ , \tag{2.10}$$

$$L_\pi = \lambda_1 F_\pi = 0 \ , \tag{2.11}$$

$$L_{q_m} = -\lambda_1 - \lambda_2 p_s = 0 \ , \tag{2.12}$$

$$L_{\lambda_1} = -(q + q_m) + F(l_{fs}, l_{hd}, C_f, \pi; x_f) = 0 \ , \tag{2.13}$$

and

$$L_{\lambda_2} = -(p_s q_m + y_0 + w_m l_{ms} - w_f l_{hd} - M - C_f - V) = 0 \ . \tag{2.14}$$

where the subscripted L's, U's and F's are partial derivatives of the relevant functions with respec to the indicated subscript variables.[7]

From equation (2.5) which provides the linkage between the consumption sector (the f... n family) and the production sector (the farm-firm) of the farm household,

$$\lambda_1 = U_q \ . \tag{2.15}$$

Using the value of the numeraire λ_1 from (2.15), the relative prices of other consumption goods can be obtained from the linkage equation (2.12) between the real and nominal sectors as:

$$\lambda_2 = -\frac{\lambda_1}{p_s} = -\frac{U_q}{p_s} \ . \tag{2.16}$$

The Lagrangian unknowns can be removed from the rest of the first order system of equations by using their values from (2.15) and (2.16). The resulting system of equations defined in implicit form may be treated as the structural relations of the farm household model.

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[7] The problems of the reduced-form behavioural equations and the problems of non-lineary are explained in PQ (1991).

The PQ model names the transformed first-order conditions after the variables with respect to which the Lagrangian function is differentiated. Thus, the transformed first-order condition is (2.6) written as:

$$U_M - \frac{U_q}{P_s} = 0 \ , \tag{2.17}$$

and called the **'other consumption goods function'** since its origin can be traced back to partial differentiation of L with respect to other consumption goods, M. Similarly, equations (2.7) through (2.11) transformed into the implicit **family labour supply equation:**

$$U_{l_{fs}} + U_q F_{l_{fs}} = 0 \ , \tag{2.18}$$

the off-farm labour supply equation:

$$U_{l_{ms}} + \frac{U_q}{P_s} w_m = 0 \ . \tag{2.19}$$

a cash-input function:

$$U_{C_f} + U_q F_{C_f} - \frac{U_q}{P_s} = 0 \ , \tag{2.20}$$

a hired labour demand equation:

$$U_q F_{l_{hd}} - \frac{U_q}{P_s} w_f = 0 \ , \tag{2.21}$$

and a rice-technology adoption equation:

$$U_q F_\pi = 0 \tag{2.22}$$

respectively. To measure the output equation (2.13), the variable representing total production q_p is used in place of $(q + q_m)$ so that **the total output equation is:**

$$q_p = F(l_{fs}, l_{hd}, C_f, \pi; x_i) \ . \tag{2.23}$$

The equations (2.17) through (2.23) along with the identities, **the output and disposal identity**

$$q_p = q + q_m \ , \tag{2.24}$$

the real balance identity

$$p_s q_m + y_n + w_m l_{ms} - w_f l_{hd} - M - C_f - V = 0 \ , \tag{2.25}$$

In their study these constitute the structural farm-household model consisting of a system of nine equations in nine endogenous variables.

2.3 The Equations and Their Empirical Background

The model presented here follows the PQ pattern but in a somewhat truncated form. In this study, an application of the model over a crop year in Gilgit, Pakistan entailed estimation of the parameters of five behavioural equations and two identities. A number of elements of the specification problem require attention before the parameters of an empirical model can be estimated.

The appropriate set of equations for this study are presented below. Compared with the Pradhan and Quilkey (PQ) model there are two less equations, some additional exogenous variables, have been used and some variables included in their system have been dropped.

In addition to the two labour supply equations, the PQ model included a hired labour demand function. The determinants of the demand for hired labour were specified as farm-size, rate of adoption, farm family consumption levels and the conditions of the existing exogenous factor markets. In this study, hired labour as a factor of production, has not been included in the analysis for the following reasons:

1. The use of hired labour by the farmer in the study area is rare and in preliminary analysis appeared to have no effect on wheat output.

2. Because of small farm-size, farmers in Gilgit (Northern Pakistan) usually rely on family labour supply, which is readily available.

3. Since there is little demand for hired labour, the manpower surplus to farm requirements, usually engage in off-farm employment in the plains, with higher wages and better working conditions.

The cash-input equation used in the PQ model was initially included in the analysis, but the impact was not significant, because in Gilgit, chemical fertilizer (F_1) is the only cash-input. All other inputs are either free of charge as is water, or exchanged with neighbours, such as seeds and farm-yard manure (F_2). Hence chemical fertilizer (F_1) has been used in the total farm output of wheat (TFOW) equation.

To elaborate the dimensions of the model, each behavioural equation has been explained in implicit form:

The total farm wheat output equation:

$$TFOW = F(FL, RNVWA, VTTG, F_1, F_2) \quad (2.26)$$

where TFOW is the total farm wheat output measured in maunds (mds) (1md = 37.38 kg).

FL is the amount of on-farm family labour supplied to the farm-firm for wheat cultivation and is measured in man-days of eight hours

RNVWA is the ratio of the area sown to high yielding varieties of wheat to total wheat area.

VTTG is the investment in modern technology, used in cultivation of wheat by the farmer, measured in Rupees (Rs) [1 U.S.$ = 22 Rupees (approximately) at the time of the survey].

F_1 is the amount of chemical fertilizer (Nitro-phosphate), measured in kilograms (kg)

F_2 is the amount of farm-yard manure used, measured in number of baskets (1 basket = 20.33 kg).

The model includes an on-farm family labour supply equation, representing the supply of labour to the farm-firm. This equation is given by:

$$FL = G(TWA, VTTG, TOFL, RNVWA, TFMA, PTP) \quad (2.27)$$

where TWA is the total wheat area measured in kanals (k) (1 hectare (ha) = 19.76 kanals).

TOFL is the total off-farm income measured in Rupees (Rs) representing income from family members engaged in seasonal or regular off-farm employment.

TFMA is the total number of family members above the age of 10, measured in numerical value representing those members of the family capable of contributing to the farming activities.

PTP is the planting time, used es a dummy variable for early planting which has the value 0 from October to mid-December and 1 from mid-December to March for late planting.

Other variables of the equations are as defined previously.

Total off-farm income represents the additional family income earned from off-farm employment. This equation is expressed as follows:

$$TOFL = H(FL, ICAW, TFE, RDM, TQ, FWC, VTTG) \quad (2.28)$$

ICAW is the income from the three crops: wheat, maize and potatoes and additional income generated as a result of women's activities such as embroidery, sewing. This income is measured in Rupees (Rs).

TFE is the total family expenditure measured in Rupees (Rs).

RDM is the ratio of dependents (children up to 10 years of age) to the total number of family members.

TQ is the total savings of the farm family measured in Rupees (Rs) representing the financial position of the individual household.

FWC is family wheat consumption measured in maunds (mds).

Other variables have been explained previously.

The model also includes a commodity demand function for the agricultural household, which represents the impact of consumption and income on the farm family expenditure. This equation is written as follows:

$$TFE = T(FWC, QWS, ICAW, TQ, TFMA, TOFL, RDM) \quad (2.29)$$

where QWS is the amount of surplus wheat sold by the household, measured in maunds (mds). All other variables are defined earlier.

Finally, the adoption behaviour of the farmer concerning the high yielding wheat varieties (RNVWA) is explained with the help of the adoption equation (2.5). The behavioural equation for the adoption model of the agricultural household depends on the supply inputs and the wheat output achieved from HYVs. The equation is also influenced by other factors such as investment in extension services, level of education and experience of the farmer in dealing with HYV's. The adoption equation is formalised below as:

$$RNVWA = R(TFOW, FL, LITR, ENT, PUP, PTP, EXCT) \qquad (2.30)$$

where

LITR is a dummy variable representing the level of education of the farmer (o) for illiterate and (l) for literate.

ENT is the level of experience of the farmer in dealing with HYVs and measured as the number of years.

PUP is the price of chemical fertilizer (nitro-phosphate) (F_1) measured in Rupees (Rs).

EXCT is the investment of extension services measured in Rupees (Rs) and represents the amount spent by the farmer in gaining access to the service and the amount contributed by the extension office in imparting the service.

All other variables have been discussed previously.

The model has two additional equations which represents the equilibrium condition of the agricultural household in a given period, where total income (TOFL + ICAW) minus total farm expenditure (TFE) and the total savings (TQ) just exhausts the family financial resources. This condition has been defined by two identities as follows:

$$(ICAW + TOFL) - (TFE + TQ) = 0 \qquad (2.31)$$

$$FWC = TFOW - QWS \qquad (2.32)$$

All these variables have been defined previously.

As shown in equation (2.6) total income including income from crops (wheat, maize, potatoes) and activities of the women (sewing, knitting, embroidery) (ICAW) and total off-farm income from off-farm employment, will identically equal the aggregate expenditure of the farm household (TFE) and their savings (TQ). Equation (2.7) states that the family wheat consumption (FWC) equals the total farm wheat output (TFOW) minus the quality of surplus wheat sold (QWS).

3. THE EMPIRICAL MODEL

3.1 Introduction

The theoretical and empirical apparatus of this paper has the following properties:

(1) the farm household data are cross-sectional;
(2) the farm-level determinants of adoption are classified as technological and socio-economic;
(3) the farm household is viewed as a producer, consumer and resource-owner.

The model investigated in this paper is essentially an input demand model that is constrained by exogenous (including supply) factors. Both demand and supply are assumed to be observable at the village level. Within a village, farmers differ from each other in their demand for an input, but face essentially a common set of supply considerations. Villages differ from each other in terms of the supply curves they face, and each farmer's relationship to the supply factors is characterized by his location within a well-defined village situation.

The behavioural equations help in explaining the model in explicit terms. Each equation has an endogenous variable which determines its relationship with the systematic pre-determined variables. The structural linkage in these equations and the model estimation which attempts to establish the realistic specifications of the explanatory variables is given below.

3.2 The Estimates and Model Evaluation

The estimates resulting from the use of OLS, 2SLS and 3SLS are now presented following specification of individual equations in explicit form, embodying the decisions about which explanatory variables are to appear in each equation. The predicted signs of the coefficients are presented along with the estimates in tabular form following the individual equations of the model.

ON-FARM LABOUR SUPPLY EQUATION (FL)

$$FL = b_{1.1} + b_{1.2}\,TWA + b_{1.3}\,VTTG + b_{1.4}\,TOFL$$

$$+ b_{1.5}\,RNVWA + b_{1.6}\,TFMA + b_{1.7}\,TWA^2 + b_{1.8}\,PTP \qquad (3.1)$$

where $TWA^2 = TWA \times TWA$

In the equation (3.1) the variable total family members (TFMA) is expected to have associated positive coefficients due to its direct relationship with on-farm labour supply. Because of complementarity between the factor input and the scale of operation it is also anticipated that any increase in total wheat area (TWA) will require additional labour. However, in the absence of a hired labour component, farmers rely on on-farm labour supply. Therefore TWA is expected to have positive coefficients.

Late planting is normally favoured for higher altitudes, where maize is planted immediately following the harvest of wheat crops in the same field. The harvesting of wheat and planting of maize in a short turn-around period is expected to increase the work-load, hence additional on-farm labour is likely to be utilized. Therefore the sign of the coefficient of planting time (PTP) is expected to be positive.

Where there is less investment in technology (VTTG) the results are expected to show that wheat farming relys more on on-farm labour supply (FL). Therefore, VTTG is included in the equation, cosidering a possible relationship between FL and VTTG. The field duration and planting time of HYVs of wheat in general are different from those of the traditional varieties. As mentioned in section (1.2) HYV wheat are preferably planted late because of their short growing period. This characteristic is expected to have a negative impact on the on-farm labour utilization due to an increase in the ratio of HYVs area. For traditional varieties, family labour have limited scope to seek off-farm employment, because of their increased involvement on the farm throughout the crop duration are in sharp contrast to the HYVs. Hence the coefficient of RNVWA in the equation is expected to carry a negative sign.

If there is more off-farm employment, it is anticipated that less on-farm labour will be available. Therefore, one would expect a negative relationship between on-farm labour supply and total off-farm income (TOFL).

As mentioned above the coefficient of total wheat area (TWA) is expected to have a positive sign because of complementarity between the factor inputs and the scale of operation. However, the sign of the coefficient of the squared term (TWA^2) may either be positive or negative depending on the income effect of farm size on family labour, for other factors such as cash-input. However in the rational zone of the production function the coefficient of TWA^2 is expected to be negative.

The parameter estimates of the on-farm labour supply equation from all three methods of estimations in Table 1, show that all signs of the coefficients are as predicted and the explanatory variables are highly significant. The analysis reveals that a decrease of every one rupee from off-farm income (TOFL), the on-farm labour supply would increase by .004 man-days. A decrease in off-farm income is consistent with more family labour being employed on the farm. The negative coefficient of RNVWA demonstrated that, as the ratio of HYVs area is reduced by one kanal (k), the on-farm family labour being used for traditional varieties is increased at the rate of 15 mandays per kanal, as traditional varieties have a longer crop duration compared with the HYVs.

Finally, planting time (PTP) was positively related to FL, justifying the shift to planting maize and harvesting of wheat in a short period, requiring a considerable increase in utilization of family labour.

The production function which explains the adoption behaviour is explained in the total farm wheat output (TFOW) equation (3.2) and Table 2.

TOTAL FARM WHEAT OUTPUT (TFOW)

$$TFOW = b_{2.1} + b_{2.2}\,FL + b_{2.3}\,RNVWA + b_{2.4}\,VTTG + b_{2.5}\,F_1 + b_{2.6}\,F_2 + b_{2.7}\,FL^2 + b_{2.8}\,PTP \qquad (3.2)$$

where $FL^2 = FL \times FL/TWA$

Equation (3.2) reflects the production activities of the farm household, from which it appears plausible that all coefficients should be positively related to total wheat output, due to the expected direct relationship of the factors of production with wheat output. Planting time, (PTP), in normal circumstances, will have a positive coefficient because HYVs are preferred for late planting and HYVs are expected to produce more than the traditional varieties, Saleem, *et.al.* (1987), Longmire (1989).

As mentioned earlier, investment in technology (VTTG), chemical fertilizer (F_1) and farmyard manure (F_2) are expected to show positive signs due to complementarity among the factor inputs and the scale of operations. It is also assumed that use of HYVs would increase the output of wheat, hence any increase in the ratio of high yielding area (RNVWA) is expected to be associated with a positive coefficient.

This equation also explains the relationship between on-farm family labour supply (FL) and the total farm output of wheat (TFOW). It is anticipated that, because of small farm size, after a certain level, the on-farm family labour supply would have a diminishing effect on farm wheat output, if farmers attempt to increase production of wheat by switching to HYVs. The results in Table 2 show that all signs are according to expectations, except planting time (PTP). The current situation shows a negative relation of PTP with respect to TFOW. This outcome could be due to planting mixed seed (traditional and HYVs) instead of high yielding variety seed, as discussed in section (1.2). This results in a semi-ripe crop at harvest time, thus the output is lower than expected from a HYV crop.

Similarly, the analysis show that the sign of the explanatory variable RNVWA is positive as predicted, but not significant. This further leads us to believe, that mixed seed planted by the household, is not giving the expected output of a HYV crop. The estimates also reveal that on-farm family labour (FL) was very productive with respect to total wheat output (TFOW). An increase of one manday in FL led to an increase in the total farm output of wheat by 13 maunds hence FL carries a positive coefficient and is highly significant.

TABLE I: Parameter Estimates of the "On-Farm Family Labour Supply" (FL) Equation (3.1)

Descriptive Names Explanatory Variables	Variable Code Name	Expected Directional Effect	Method of Estimation		
			OLS	2SLS	3SLS
Constant term	C	?	8.8408 ** (1.57)	11.6194 ** (1.92)	11.7104 *** (1.96)
Total wheat area	TWA	+	20.5535 *** (21.21)	20.1607 *** (20.01)	19.9911 *** (20.35)
Investment in technology	VTTG	-	-0.0531 *** (-2.90)	-0.0535 *** (-2.81)	-0.0457 *** (-2.41)
Total off-farm income	TOFL	-	-0.0014 *** (-3.05)	-0.0035 *** (-4.43)	-0.0040 *** (-5.15)
Ratio of HYVs area to total wheat area	RNVWA	-	-8.7126 *** (-2.77)	-11.7148 *** (-2.50)	--10.7077 *** (-2.36)
Total family members above 10 yrs ago	TFMA	+	2.2572 *** (3.59)	3.5247 *** (4.73)	3.8239 *** (5.16)
Square term of total wheat area	TWA2	?	-0.2373 *** (-6.36)	-0.2294 *** (-5.95)	-0.2362 *** (-6.33)
Planting time	PTP	+	11.4834 *** (4.02)	13.5098 *** (4.31)	12.7958 *** (4.14)

Equation fit measures

R^2 : 0.88			
$\bar{R}^2$: 0.88			
F : 7.299	317.044 ***		
D.W.	1.52	1.63	1.66
RMSE	22.29	23.01	34.52

Note: Figures in parentheses are calculated t-values.
*** significant at 1 per cent.
** significant at 5 per cent.
RMSE: stands for root mean square error.

TABLE 2. Parameter Estimates of the "Total Farm Wheat Output" (TFOW) Equation (3.2)

Descriptive Names Explanatory Variables	Variable Code Name	Expected Directional Effect	Method of Estimation					
			OLS		2SLS		3SLS	
Constant term	C	?	0.5043	(0.24)	2.2809	(0.426)	0.9758	(0.42)
On-farm family labour supply	FL	+	0.1210 **	(4.41)	0.1277 ***	(4.54)	0.1291 ***	(4.60)
Ratio of HYVs area to total wheat area	RNVWA	+	3.4529 ***	(2.22)	2.7172	(1.23)	2.6686	(1.21)
Investment in technology	VTTG	+	0.0147 *	(1.68)	0.0135	(1.53)	0.0129	(1.46)
Use of chemical fertilizer	F_1	+	0.0495 ***	(4.83)	0.0491 ***	(4.78)	0.0491 ***	(4.78)
Use of farm yard manure	F_2	+	0.0090 **	(1.56)	0.0090	(1.54)	0.0085	(1.45)
Squared term of on-farm family labour supply	FL2	?	-0.0014	(-1.21)	-0.0016	(-1.41)	-0.0016	(-1.40)
Planting time	PTP	+	-4.6877 ***	(-2.93)	-4.4109 ***	(-2.59)	-4.3611 ***	(-2.56)

<u>Equation fit measures</u>

R^2 : 0.47

$\bar{R}^2$: 0.46

	OLS	2SLS	3SLS
F : 7.299	37.90 ***		
D.W.	1.99	2.00	2.01
RMSE	10.94	10.95	11.68

Note: Figures in parentheses are calculated t-values
*** significant at 1 per cent
* significant at 10 per cent
RMSE: stands for Root Mean Square Simulation Error

The total off-farm income (TOFL) which depends on the availability of on-farm family labour for off-farm employment is specified in equation (3.3).

TOTAL OFF-FARM INCOME (TOFL)

$$TOFL = b_{3.1} + b_{3.2}\ FL + b_{3.3}\ ICAW + b_{3.4}\ TFE + b_{3.5}\ RDM$$

$$+ b_{3.6}\ TQ + b_{3.7}\ FWC + b_{3.8}\ VTTG \qquad (3.3)$$

In this equation one would expect that on-farm family labour (FL) would be negatively related to off-farm income (TOFL). If the total off-farm income (TOFL) increases, it is likely that less labour is being employed on farm and more members of the farm family are working off-farm. This is expected to have a negative impact on income from other crops and womens' activities (ICAW). The situation envisaged, in which less family labour is used on-farm will reduce the involvement of women in other income generating activites on the farm, and thus reduce farm income.

As a traditional practice, only male members of the farm family migrate to other parts of Pakistan for employment, in such circumstances, their female countrparts are expected to increase their working hours on the farm, at the cost of their other productive activities, such as sewing, embroidary and craft-work. This suggests that investment in technology (VTTG) and accordingly its use would decrease, thus giving a negative coefficient.

An increase in income from an increase in off-farm employment is expected to improve the standard of living of the farm household. This would also improve their total savings (TQ) and consumption patterns, indicating that the coefficients of total family expenditure (TFE) and family wheat consumption (FWC) will have predicted positive signs.

Table 3 reveals that the directional effect of all explanatory variables are according to expectations. On-farm family labour (FL) has a negative relation to total off-farm income which suggest that, less family labour working on the farm, is possibly increasing the participation rate in off-farm employment. The parameter of FL reveal that a decrease of one man-day from FL leads to an increase of RS.12.52 in off farm income.

The male-out migration for off-farm employment is likely to have some effect, on the adoption rate of HYVs. As explained in section (1.2), the opening of Karakum Highway has not only created new job opportunities in the plains, but also facilitated the transportation of wheat flour, on cheap rates from other cities. It appears, such changes have diverted the farmers from seeking the benefit of adoption of HYVs, to the pursuit of economic benefits which are more readily available.

The specification of total family expenditure (TFE) which has been affected by the household decision concerning adoption and off-farm employment is presented in the next equation (3.4) TOTAL FAMILY EXPENDITURE (TFE)

$$TFE = b_{4.1} + b_{4.2}\ FWC + b_{4.3}\ QWS + b_{4.4}\ ICAW$$

$$+ b_{4.5}\ TQ + b_{4.6}\ TFMA + b_{4.7}\ TOFL + b_{4.8}\ RDM \qquad (3.4)$$

In this equation it is expected that the quantity of wheat sold (QWS) will have a positive coefficient. Any increase in total savings (TQ), resulting from farm income (ICAW) and off-farm income (TOFL) will improve the spending power of the household. Hence TQ, ICAW and TOFL are expected to be positively related to TFE. Similarly, adult family members (TFMA) and dependent members (RDM) are expected to increase the total family expenditure

TABLE 3: Parameter Estimates of "Total Off-Farm Income" (TOFL) Equation (3.3)

Descriptive Names Explanatory Variables	Variable Code Name	Expected Directional Effect	Method of Estimation		
			OLS	2SLS	3SLS
Constant term	C	?	-344.20 (-0.64)	-705.022 (-1.24)	-264.9319 (-0.47)
On-farm family labour supply	FL	-	-6.0262 *** (-2.60)	-8.9769 *** (-3.53)	-12.577 *** (-4.98)
Income from crops and women's activities	ICAW	-	-0.8006 *** (-10.46)	-0.8216 *** (-10.42)	-0.7803 *** (-10.04)
Total family expenditure	TFE	+	0.6650 *** (8.73)	0.5144 *** (4.87)	0.5798 *** (5.53)
Ratio of dependent members	RDM	+	1748.42 ** (1.67)	1318.06 (1.22)	783.5618 (0.78)
Total savings	TQ	+	0.3250 *** (3.09)	0.3614 *** (3.28)	0.2935 *** (2.74)
Family wheat consumption	FWC	+	128.62 *** (2.34)	343.28 *** (3.60)	297.4434 *** (3.14)
Investment in technology	VTTG	-	-3.3203 ** (-1.89)	-3.5362 ** (-1.96)	-1.6955 (-0.95)

<u>Equation fit measures</u>

		OLS	2SLS	3SLS
R^2	: 0.52			
$\bar{R}^2$	: 0.51			
F	: 7,299	45.54 ***		
D.W.		1.85	1.91	1.93
RMSE		2116.88	2171.92	6669.00

Note: Figures in parentheses are calculated t-values
*** significant at 1 per cent
** significant at 5 per cent
RMSE: stands for Root Mean Square Error

(TFE), if the numbers increase. Finally, it is also anticipated that if additional wheat is consumed by the farm family, family expenditure will increase accordingly, hence FWC is likely to have a positive coefficient.

In Table 4, the estimates are shown together with the signs of the explanatory variables which are as predicted.

Quantity of wheat sold (QWS) has a positive relation, however the result is not statistically significant. A plausible explanation is that if the household markets surplus wheat, this is likely to increase their purchasing power and ultimately the farm family can expect to spend more, which could increase the total family expenditure (TFE).

The coefficient was statistically highly significant in the OSL estimation, but this was not so for the 2SLS and 3SLS estimates of total off-farm income (TOFL). However, the coefficient of TOFL remains positive. As income increases the demand for market goods is likely to be generated. This could ultimately lead to an increase in family expenditure.

The estimates for the adoption model (RNVWA) expressed in equation (3.5) are presented in Table 5, depicting the adoption behaviour of the farmer with respect to HYVs.

ADOPTION EQUATION (RNVWA)
RATIO OF HIGH YIELDING VARIETIES AREA (HYV) TO TOTAL WHEAT AREA

$$RNVWA = b_{5.1} + b_{5.2}\,TFOW + b_{5.3}\,FL + b_{5.4}\,LITR + b_{5.5}\,ENT + b_{5.6}\,ENT2 + b_{5.7}\,PUP + b_{5.8}\,PTP + b_{5.9}\,EXCT \quad (3.5)$$

where ENT2 = ENT x ENT

As discussed in the previous equations total farm wheat output (TFOW) is postulated to increase with the increase in the ratio of high yielding varieties area RNVWA, thus total farm wheat output (TFOW) is expected to have a positive coefficient. However, on-farm family labour (FL) is expected to have a negative sign, since it is anticipated that HYVs are planted late, and require less family labour because of their early maturing quality. The price of the input chemical fertilizer (PUP) is expected to show a negative sign, indicating that if the price of chemical fertilizer (F_1) is reduced, its application would increase accordingly.

The investment in extension effort (EXCT), the education level of the farmer (LITR) and experience in dealing with HYVs (ENT) are likely to have a positive impact on adoption. Accordingly, they are expected to carry a positive coefficient. However, the experience variable (ENT) which is measured by the number of years the farmer has been associated with HYVs of wheat is specified in quadratic form and is expected to reflect diminishing returns to experience with HYV. The estimates in Table 5, reflect that, both exogenous and endogenous variable have some degree of influence on the decision making process of the farm-household, concerning allocation of wheat area to the HYVs. On-farm family labour supply (FL) indicates that farmers decisions to adopt was linked to the level of on-farm family-labour available as an input to the farm household. For a 0.1 per cent increase in RNVWA the utilization of on-farm family labour is likely to decrease by 100 man-days. This is consistent with our earlier proposition that family labour becomes surplus during the early period of cultivation from September to December, due to late planting of HYVs.

The estimates show that experience in the use of HYVs was of statistical significance in boosting the adoption of wheat technology. The analysis in this study shows that for every year of experience gained dealing with HYVs, farmers were otivated to increase the wheat area of HYVs by 0.15 per cent. These findings are in-line with Pradhan's (1991) study of Orissa,

TABLE 4: Parameter Estimates of "Total Family Expenditure" (TFE) Equation (3.4)

Descriptive Names Explanatory Variables	Variable Code Name	Expected Directional Effect	Method of Estimation					
			OLS		2SLS		3SLS	
Constant term	C	?	90.1738	(0.50)	130.491	(0.68)	169.495	(0.88)
Family wheat consumption	FWC	+	37.5662 ***	(2.09)	23.2875	(0.75)	15.6392	(0.50)
Quantity wheat sold	QWS	-	4.1609	(1.05)	-1.9105	(-0.31)	0.4966	(0.01)
Income from crops and women's activities	ICAW	+	0.0383	(1.24)	-0.0171	(0.29)	0.0470	(0.80)
Total savings	TQ	+	0.1968 ***	(5.80)	0.2183 ***	(4.95)	0.1992 ***	(4.53)
Total family members above age of ten	TFMA	+	725.5177 ***	(29.88)	754.617 ***	(19.87)	739.0083 ***	(19.53)
Total off-farm income	TOFL	+	0.0691 ***	(3.52)	0.0395	(0.64)	0.0739	(1.21)
Ratio of dependent members	RDM	+	2310.8188 ***	(6.50)	2468.43 ***	(5.90)	2360.7949 ***	(5.63)

Equation fit measures	OLS	2SLS	3SLS
R^2 : 90			
$\bar{R}^2$: 89			
F : 7,299	375.755 ***		
D.W.	1.73	1.71	1.75
RMSE	722.94	729.15	1054.00

Note: Figures in parentheses are calculated t-values
*** significant at 1 per cent
RMSE: stands for Root Mean Square Error

TABLE 5: Parameter Estimates of the "Wheat Technology Adoption" (RNVWA) Equation (3.5) (Ratio of High Yielding Varieties Area (HYVs) to total wheat areas)

Descriptive Names Explanatory Variables	Variable Code Name	Expected Directional Effect	Method of Estimation		
			OLS	2SLS	3SLS
Constant term	C	?	0.3071 *** (4.45)	0.3094 *** (4.40)	0.3051 *** (4.36)
Total farm wheat output	TFOW	+	0.0026 * (1.74)	0.0001 (0.04)	0.0021 (0.49)
On-farm family labour supply	FL	-	-0.0010 *** (-3.03)	-0.0007 (-1.02)	-0.001 (-1.55)
Level of education	LITR	+	0.0362 (1.01)	0.0413 (1.11)	0.0389 (1.05)
Experience in HYVs	ENT	+	0.1615 *** (14.90)	0.1631 *** (14.48)	0.1605 *** (14.29)
Squared term ENT	ENT 2	?	-0.0074 *** (-11.66)	-0.0075 *** (-11.49)	-0.0074 *** (-11.35)
Price of chemical fertilizer	PUP	-	-0.0004 * (-1.71)	-0.0004 * (-1.71	-0.0003 * (-1.69)
Planting time	PTP	+	0.0590 * (1.43)	0.0459 (0.97)	0.0690 (1.29)
Extension effort	EXCT	+	0.0024 (1.03)	0.0024 (0.99)	0.0031 (1.29)

<u>Equation fit measures</u>

	OLS	2SLS	3SLS
R^2 : 0.56			
$\bar{R}^2$: 0.55			
F : 8.299	47.79 ***		
D.W.	1.36	1.34	1.35
RMSE	0.29	0.29	0.29

Note: Figures in parentheses are calculated t-values
* significant at 1 per cent
*** significant at 10 per cent
RMSE: stands for Root Mean Square Error

in India, where, however, the magnitude of increase was 6 per cent for every year of experience with HYVs. In both cases experience with HYVs were subject to diminishing returns.

Late planting was found to be significant to adoption. The outcome suggesteds that farmers opting for late planting were being induced to increase the ratio of land to HYVs, possibly because of their late planting and early maturing characteristic. The model also reflected that a decrease of one Rupee per kilogram, in the price of chemical fertilizer, is likely to encourage the farmer to increase the proportion of area to HYVs by .03 per cent. It may be noted that HYVs are expected to be responsive to chemical fertilizer. However, an increase in the purchase price of chemical fertilizer may put pressure on the limited cash available to the farm household and retard the adoption rate of HYVs.

Education level and investment in extension had positive coefficients as predicted but were not statistically significant. This result reinforced the sentiment that innovation diffusion in remote regions, such as Gilgit, can best be stimulated through the farmers own experience of dealing with HYVs. Education level seems to have no signifcant effect on adoption. Similarly, the coefficient of expenditure on extension services (EXCT) was not statistically significant. These findings support the theoretical work on Bayesian learning processes by Lindner, Fischer and Pardey, (1979), Feder and Cruava (1982), and Feder and Slade (1984). "The accumulation of information by using or observing new technology, leads to a better understanding of the parameters of new production function, and results in higher adoption rates."

4. SUMMARY AND CONCLUSIONS

4.1 Summary

The research reported in this paper emerged from the observation that the adoption of HYVs has proceeded more slowly than the adoption of fertilizers and other agricultural technology in Gilgit Districts (Northern Areas of Pakistan). The major reasons for the slow spread of HYVs appears to be:

(1) The absence of a proper seed development and marketing system for HYVs.
(2) The increase in total off-farm income resulting from increasing off-farm employment.
(3) The inability of the agricultural household to process available information on new technology because of low investment in extension services.

In general, higher growth rates in the output of foodgrain have followed the Green Revolution, as a result of the introduction of HYV seed (Alauddin and Tisdell, 1991). However, in the current study, the total wheat output of the farm (TFOW) is not a statistically significant predictor of the adoption of HYV in the (RNVWA) equation. Although the sign of the coefficient is positive as anticipated, but not significant. The same results are evident in the total farm wheat output (TFOW) equation, where an increase in the ratio of wheat area sown to high yielding varieties did not significantly increase the total farm wheat output. The causes which emerge from the current research and explain the underlying relationships, are discussed in the following sections.

During the field visits in 1990, for this survey, on the farms a remarkable mixture of plants of different heights, at the time of harvest was in evidence in each field. This heterogeneity of plant size reflected the practice of sowing mixed seed of traditional and high yielding varieties, each having a different maturing period. Farmers were of the opinion that the seeds of HYVs had been mixed with the traditional varieties during the threshing process, over time. Seed mixture through threshing has led to loss of yield advantage, (Husain quoted by Saleem *et al.* 1987). Weeding-out, a possible solution is too expensive and beyond the means of the individual household. Ever since the HYVs were released in the Northern

Region, farmers have been sewing HYV seeds mixed with the traditional varieties. Since there is no standardised marketing system for seeds (AKRSP, 1985) pure HYV seeds are not readily available to the farmers.

The mixing of seeds, has substantially damaged the various characteristics of HYVs, that have contributed to their higher grain yield, including yellow rust resistance, which affects the traditional variety seriously. The diminishing resistance of HYVs to yellow rust, which played an important part in persuading farmers to switch nominally from traditional to HYVs is to be counted as one of the reasons for their slow rate of adoption in recent years (Whiteman, 1984). Finally, at harvest time, the mixed seed gives a partially mature crop, in each field. As a result, a good part of the crop is harvested either too early or too late for maximum harvested output.

The above discussion gives ample ground to suggest that the HYV's have 'lost' their yield advantage. One could thus conclude that farmers are not interested in the HYVs, because they are not compatible with the socio-economic environment of the farm household. However, this survey suggest that, although the rate of adoption of HYVs has been slow compared with the adoption of the fertilizer technology, 62 per cent of household are classed as adoptors as shown below in Table 6.

TABLE 6.

FIELDS PLANTED TO TRADITIONAL AND HIGH YIELDING VARIETIES
(per cent of total area planted)

	Planting Time		
	Up to 15 Dec.	16 Dec. to Mar.	Total
Traditional Variety	31	7	38
High Yielding Variety	25	37	62
Total	56	44	100

Source: Survey 1990, conducted by the senior author.

In Table 6 there is some evidence that farmers perceive the suitability for late planting of HYVs as their major advantage, in particular for the period after 16 December when only 7 per cent of farmers plant traditional varieties and 37 per cent plant HYVs. This, is a superior attribute for those farmers who do not have sufficient farmyard manure for early planting, or those who choose to delay planting in favour of off-farm employment, or those who wish to stagger their harvesting over a longer period. In addition, as reported by the farmers, the HYVs planted early at the same time as traditional varieties can be harvested, on average, two weeks before the traditional varieties. This results not only in a longer harvesting period, but also in a longer turn-around time between wheat harvesting and maize planting. The advantage of having considerable time between wheat harvesting and maize planting is of significance to the farmers living on elevated parts of the region, where maize is planted side by side with wheat and is harvested in the same field. When the wheat is of the traditional variety, maize will be planted late and the crop will not ripen in time to provide feed for animals.

During the survey, farmers revealed the importance of farmyard manure to planting time. The farmers were of the opinion that if late planting is practiced, 26 per cent less farmyard manure will be used. Similarly, the survey also reflects the importance of planting date for a particular variety to male out-migration. The movement of males to off-farm employment has a significant effect on the decision-making process, at the commencement of the planting period in October. The men return in mid-December, to sow wheat. At this time, HYVs are the best choice for the farmer, because of their early maturing quality as compared to the traditional varieties.

Those men of the farm-household, who are unable to seek off-farm seasonal employment, because of age, disability or caretaking duties, stay behind to participate in wheat farming along with the females. The survey suggests (Table 6) that 31 per cent of the households plant traditional varieties during September to December, and 25 per cent are using HYVs.

It may be noted that women are highly disadvantaged in much of the developing world. Cultural and religious traditions often severely limit their education and employment opportunities. Rural women in the developing countries as a whole, account for over 50 per cent of food production -- yet their efforts are largely un-recognised and unsupported (AIDAB, 1993). The female literacy rate is extremely low in the Northern Areas. The women are given training for vocational skills and in poultry farming to encourage their participation in income-generating activities. But they are not involved with their male counterparts in the extension sessions concerning HYVs. This prevents them from broadening their knowledge and understanding about the benefits of adoption. In common with the findings of Pradhan and Quilkey experience with the new technology (ENT) was by far the most important influence favouring the adoption of HYVs. The results are consistent with the expectation that experience with modern varieties of wheat tended to increase the adoption rate of HYVs but at a decreasing rate.

These findings reinforce the emphasis on extension espoused in this paper.

4.2 Conclusions

In the paper three major conclusions are drawn. Two of them have to do with government policies and institutional support for small farmers in developing economics, such as Pakistan. The first concern is the establishment of a marketing system for modern technological inputs, the system needs to be innovative and adaptable, for farming communities. As governments cannot operate such delivery services, one low-cost alternative is to encourage the production and marketing of inputs through the private sector, ensuring the availability of quality HYVs wheat seed. This may be a widespread problem in other countries. Timely replacement of seed and variety are necessary as soon as problems such as rust affecting the seed emerge (Dalrymple, 1986).

This study highlights the immediate need for establishing a system of quality control in production and marketing of HYV seeds in the Northern Areas of Pakistan, which could be initiated by the Aga Khan Rural Support program (AKRSP).[8] Another important conclusion emanating from this paper is that the success of this program can be effectively achieved in an equitable manner by promoting, village level demonstrations of high yielding varieties. It is evident that, at least for technological innovations including HYVs of wheat, in mountainous regions, such as Gilgit, change is possible by practical demonstrations for the household as a unit. This is a significant outcome for extension work in less developed countries where literacy is a major problem among the rural communities. One possible model, which can be cited as a successful example is that of the mini-pak high yielding seed program in India, carried out by Ludhiana University (PARC/CIMMYT, 1989). A system of field days was organised jointly by the extension service and seed corporations and attended by thousands of farmers who were given small packets of HYV seed (5 kg) to take back to their villages for multiplication and sale to neighbours. A re-orientation of extension work in Northern Areas of

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[8] The Aga Khan Rural Support programme was conceived in 1982, as a catalyst for promoting equitable and sustainable growth in the Northern Areas economy. AKRSP is a private, non-profit organisation. World Bank (1990).

Pakistan, with the focus changing from individual farmers to the farm household would be another institutional innovation for development agencies, such as AKRSP. To leave some members of the household, especially women, out of the extension program is to jeopardise the gains to be made.

The above findings illustrate an important principle for policy concerning agriculture and economic development of remote areas. The supply and extension systems need to operate as complements to each other, since neither can operate in isolation. In the case of Gilgit, for instance, extension effort on HYVs is unlikely to bear fruit if certified HYV's seed is not readily available. Similarly, the availability of HYV seed will be of no significance if participation of the agricultural household is not ensured by the extension program.

The responsiveness of both the supply of inputs and extension services is intimately linked to the research that produces the new inputs and develops recommendations for their application. This study results tend to confirm that farmers in Gilgit are using HYVs for their short growing period and their late planting characteristic. By selecting HYV for these specific attributes, the farmer is transmitting the desirable agenda to policy makers. Attention to the revealed preference of the farmer, is likely to enhance the productivity of research and extension. Those concerned with policy formulation, and resource allocation decisions, need to take account of the adoption behaviour of the farmer. It may be argued that, policies based on the farmer's understanding of the new inputs, as they relate to his socio-econoic environment, help spread innovations rapidly. The innovativeness and entrepreneurial activity of small and poor farmers has often been under rated (Islam, 1987). As mentioned by Chambers (1983), "the readiness of small farmers to experiment and innovate on their own has been obscured by the preoccupation in the social sciences with the agricultural research extension and communication which are carried out through official organisations. The fact is that innovations which farmers can manage and find were good, spread very rapidly indeed through personal trials."

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