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THREE ESSAYS ON NEPALESE DEVELOPMENT:

TECHNOLOGY ADOPTION, AGRICULTURAL RISK AND THE EFFECTS OF REMITTANCES ON RECIPIENT HOUSEHOLDS

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Abstract

This dissertation addresses the empirical issues pertaining to technology adoption decisions, agricultural commodity price volatility and the effects of remittances on recipient households combined with the motivation of migration decisions in low-income countries such as Nepal under the theories of incomplete and imperfect markets. This dissertation contains three substantive essays applying a number of econometric models to test a number of the hypotheses using both panel and cross-section data from the Nepal Living Standard Surveys and time series data for commodity prices and farm yields. Summaries of these essays are presented as follows.

The first paper examines factors affecting the adoption of improved seeds and inorganic fertilizers. I consider the adoptions of both these technologies as a joint decision and estimate over two repeated cross-section data from NLSSs. Both probit GMM with the moment restrictions and Linear Probability Models for period 2 (2004) combined with reduced form probit models for both periods and Tobit models were applied to control for plot level, household characteristics, and other factors. The result weakly favours the hypothesis of joint decision. The results show significant effects on adoption decisions for farm technologies from four variables: the factor markets for credit and for labour, agricultural extension services, and household labour endowment. Proximity to road transport and access to markets also increase the adoption rate of improved seeds and inorganic fertilizers. Positive effects were associated with the increasing age and education of household heads with some exceptions. The results from Tobit models were also consistent with the reduced form and structural models with some exceptions. Well-functioning factor markets and well-developed infrastructure emerge as the precondition for agricultural-led growth in Nepal.

The second paper explores how price shocks affect the stability of farmers' income at different levels across different regions of Nepal, using a recent theoretical model that allows examination of the household income variance through combination of household datasets with price and yield time series under the scenarios of actual, full and no exposure to Indian markets. Agricultural income variability is found to be higher among the farmers with higher share of agricultural products (more than 65 percent) in the total household income, followed by 30 to 65 percent share of agricultural products. The results show relatively high income variability in the poor than the non-poor farm households, but their difference is low. The increased income variability of agricultural households, observed in almost all belts and regions, and at all income levels, is attributable to the domestic shocks. In general, the degree of market integration with Indian prices seems to be widely affected by the geographical heterogeneity in Nepal. Granger-causality tests show a higher integration between border markets of both countries, revealing that Nepalese commodity prices follow Indian prices with the exception of some commodities in some border markets.

Finally, the third paper analyses the effect of remittance income on the hours of work in remittance-receiving households using panel data from the Nepal Living Standard Surveys. The study applies a number of econometric models to explain the impact of remittance income on the hours of work in different sectors (i.e. on-farm, self-employment, off-farm and hired labour) taking into account various methodological issues (endogeneity and selection bias) for migration decision and remittances. I first use a Zero Inflated Poisson model to examine the factors motivating migration. I then apply random effects model and instrumental variable Tobit models for estimating the impact of remittances on the household work hours both for different sectors and separately for working age men and women. Evidence shows that rural people with larger family size and higher per capita income without remittances have higher probability to go migrate. Remittances decrease work hours in a number of sectors, but increases work hours of hired labour in remittance-receiving households. Remittance income seems to be a substitute of non-labour income for remittance-receiving households. No significant effects on off-farm and self-employment activities were observed in the sample households. In contrast, non labour income appears to increase work hours of household members. Moreover, demographic characteristics seem to be an influential factor for the allocation of household work hours, implying that higher family size leads to higher work hours, and a larger number of children leads to a reduction of work hours of females, but not of males. Educated people are also more likely to increase their work hours.

Keywords: farm technology, commodity price fluctuations, remittances, farm households, labour supply, Nepal

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

Nepal, predominantly an agrarian country, is one of the least developed and poorest countries in the world. The country is situated between two giant Asian countries viz. Tibet region of China in the north and India in the east, west and south. Before 1951, Nepal was under 104-year feudalistic Rana oligarchy and economy was in terrible condition. The revenue base was so narrow due to the absence of major industries and related infrastructures. Nepal initiated five-year development plans under the guidance of the Colombo Plan for Cooperative Economic and Social Development in Asia and the Pacific in 1956 and the economic system evolved to be one of mixed economy that allows with limited access to private sectors in development activities. Development efforts were mostly undertaken on the basis of planned projects, particularly giving more priority on infrastructure and agriculture in which the expenditure on such sectors were being met by foreign aid in the form of grants and loans.

Nepal initiated economic reform agendas in the early 1990s in order to accelerate the pace of economic development and reduce poverty in the country. However, the progress of policy reform has been geared up after the political change (i.e. multiparty system with constitutional monarchy) in 1990 which implemented economic liberalization programmes. Despite a number of economic reforms, nearly a third of the country's 26.4 million citizens are still below the national poverty line-with less than $0.25 per day- and another third living on less than $2 per day. Due to economic stagnation and other social and economic disparities among the rural and urban people as well as among the caste and the ethnic groups, Nepal faced a decade–long armed conflict (1996-2006) which further caused much damage to the social, economic, and natural environment of the country. Presently, Nepal is declared as federal republic country and is in process of making new constitution based on a federal system that emphasizes the integration of cross-cutting themes such as youth engagement, community participation, market strengthening, and social inclusion. Though there are tangible changes in political system, Nepal's economy is still dominated by agriculture sector and agro-based industries. Rural development through agricultural modernization and commercialization is still in the priority list of the country's development plans.

Nepalese agriculture that accounts for 40.2 percent of total GDP and more than 73 percent of total employment (WB, 2006), and the bulk of the country's export earnings (WB, 2005) with a sizeable share of agro-based industries (38.79 percent) in the total share of industrial GDP (MOF, 2006), remains the most important sector for achieving economic growth. Recognizing the largest source for broad based economic growth, high priority has been given to this sector with a significant amount of the Government's budget being allocated to it during the last decade. Rapid growth in agriculture has been emphasized as having the potential to reduce poverty, which was the single most important objective of the current Tenth Five-Year Plan of Nepal (NPC, 2002).

Despite these endeavours, the agricultural sector has not really been successful in making any substantive change in the structure of poverty and deprivation. As a result, Nepal is still one of the poorest countries in the world with a GNP per capita of US$270 in 2006 (WB, 2006a), in which more than 31 percent people still live below poverty line (CBS, 2004). Thus, an interest arose to study some challenges in the agricultural development and to identify the impact of the growing size of remittances on household investment and consumption in order to enhance the agricultural growth in Nepal.

As a backbone of Nepalese economy and the primary means of livelihood, agricultural sector influences other spheres of rural development including migration, forestry resource management, energy consumption, and pollution. The government has identified the agricultural sector as a key area for the achievement of development goals. Thus, the success of overall development is an outcome of what happens in agriculture (Addison, 2005). However, the current trend in this sector does not seem satisfactory to achieve the targeted growth rate to reduce poverty and raise employment opportunities, particularly in rural areas. Commercialization and modernization of the agriculture have yet to occur in a substantive manner. Hence, shifting from subsistence to a commercial economy is still a central challenge for rural development in Nepal (World Bank, 2006_N).

It is widely discussed in the development literature that as economies grow, households shift the farming system away from traditional self-sufficiency goals and towards profit and income oriented decision making (Pingali and Rosegrant, 1995). An understanding of factors encouraging the agricultural sector towards market oriented farming systems through the adoption of new technologies and high value crops could be interesting for designing further policies and programs. However, a small number of studies in one particular area may not precisely be enough to understand the overall problems. Further study seems desirable to get better insights of the overall challenges in this sector that could enable to address the problems.

Nepal has been engaged in various policy reforms to continue development and adjusting country's economy to meet its growth potential. The country has initiated the economic liberalization programs since mid-1980s, but bold measures of economic restructuring took place after the commencement of trade reform policy in 1992, that included tariff cuts, abolition of import license auction, subsidies' removal, improvement of export incentives, deregulation of foreign investment and reformulation of the tax system (MOC, 1992). However, these new policies have not increased output of food grain at the same rate as population growth. Production increases have come mainly from area expansion rather than improvement in productivity. In Nepal, the scope for further expansion of area is limited; the only feasible option for increasing agricultural production now is to apply more advanced technology. Several studies have indicated the potential for a significant improvement in productivity through an appropriate policy thrust, supported by technical backstopping and a reliable supply of farm inputs, including credit (NRB, 1994). Moreover, after implementation of trade liberalization programs, domestic markets also expose producers to increased risk due to the greater volatility in world prices that might also be a possible obstacle to shift traditional farming system in the commercial path at least in the short run. This could have serious implications for sustainability of the agriculture.

Agricultural commercialization[1] that shifts the farmer from subsistence to market oriented farming, has been considered as a characteristic of agricultural change. The adoption of technologies in terms of using tradable inputs, such as improved varieties of seeds and inorganic fertilizers in particular, is regarded as an indication of the agricultural change towards the commercialization path. However, in many low-income countries, farmers are constrained with access to various resources in order to adopt new

[1] Pingali and Rosegrant (1995) categorized three levels of market orientation as characteristics of food production systems with increasing commercialization: subsistence systems with household generated inputs, semi-commercial systems with the mix of traded and non-traded inputs and commercial systems with predominantly traded inputs.

technologies resulting from high transaction costs and price volatility (Yesuf and Kohlin, 2008). It is also discussed in the literature that farmers are risk averse due to absence of credit and insurance markets and only economically secure farmers that are in possession of sufficient defence against down side risk will undertake profitable capital investments and innovations, while the majority of the poor remains under risk-induced poverty trap (Rosenzweig and Binswanger, 1993). It is necessary, for policy, to identify such factors that affect farmers to adopt new technologies in farming systems.

Agricultural commercialization and economic development are linked to each other. This linkage can enable both to foster the agricultural commercialization process with its development effects and reduce the risks of commercialization. Improved economic condition of households through alternative sources can also relax the liquidity constraints and permit an opening up toward commercialization options. Diversification of income may help to loosen the financial constraints and to manage risk. Non-farm sectors of the rural economy are inextricably tied to agriculture through input and output markets and as a source of employment for displaced agricultural labour (Boisvert and Raney 1990). It is widely explained in the literature that, in rural areas of low-income countries, market oriented production and income diversification can change not only food intake and nutrient adequacy, but also help to cope with risk in the agricultural production (Braun, 1992).

In Nepal, the trend of seeking alternative sources of income to maintain household livelihoods, even in rural areas is now increasing. Remittance income mostly from abroad is the main source of non-farm income. The data show that remittances from those working more than six months away from home contribute over 25 percent of total household income to nearly a quarter of all rural households (CBS, 1996). Policies influence the strength and direction of theses linkages (e.g., farm and non-farm incomes) and welfare outcomes.

To conclude, the traditional vision of rural economies as purely agricultural needs to assess both its challenges and alternative opportunities. Many low economic countries are emphasizing income diversification and as a result, the share of non-farm income is also increasing. Thus, the study aims to identify the factors affecting the adoption of technology and risk in the agriculture as challenges, and to find out the impact of remittances on household labour allocation as non-farm income for the improvement of household welfare.

1.2 Motivation

In Nepal, agricultural development is widely acknowledged as a critical component in a strategy to boost livelihoods of the people mostly living in rural areas and is now seen as an important part of any development strategy. Realizing this fact, the Government of Nepal has accorded top priority to agricultural growth for the improvement of living standards since the inception of a planned economy in 1956 (Aryal, Gautam and Thapa, 1999). Several policies were formulated and implemented in order to boost this sector. However, desirable progress has not yet achieved, leading the country from food self-sufficiency to food deficit in the 1990s (Banskota, 1992). The Agricultural Perspective Plan (APP)[2] is the latest policy attempt to stimulate economic and agricultural growth. The data show that Nepal's agricultural sector grew at roughly 3 percent per year from 1993 to 2003; slightly higher than the comparable population growth of 2 percent per year (WB, 2005). This sluggish performance of the dominant agriculture sector both constrains improvements in food security and reduces the overall economic growth. The country's dependence on agriculture therefore makes the sector critical to the overall economic growth and poverty alleviation goals. An understanding of the factors that lead to the failure of past efforts and programs to boost the agricultural sector is likely to be critical in the formulation and implementation of agricultural policies.

Although new opportunities have opened for Nepal after the country's recent entry into the World Trade Organization[3] (WTO) as an LDC member, the agricultural sector faces new challenges to meet food safety rules, animal health regulations, and quality standards, together with re-evaluating domestic support programs, price controls, and comparative advantages. Moreover, farm producers are exposed to several risks both market related such as price variation, and non-market related such as weather variabil-

[2] Agricultural Perspective Plan (1997-2017) is long term vision to increase agricultural productivity that stresses priority inputs (irrigation. rural roads, fertilizer and agricultural technology) to achieve priority outputs (increased production of fruits, vegetables, livestock, forestry and promotion of agri-business). The APP was designed to promote about 5 percent annual agricultural growth in order to achieve poverty alleviation goals set by the Government of Nepal.

[3] Nepal applied to join the WTO in May 1989 and was admitted WTO member in September 11, 2003. Nepal is the second least-developed country (LDC) to join the WTO.

ity, where fluctuations of commodity prices and weather can have an effect on domestic products. Hence, risk and price risk in particular, will most probably be at the core of the problems associated with the implementation of policy reform packages (Quiroz and Valdès, 1995). Such price risks may affect relatively more the poor/small producers in developing countries. The impact of price risks on domestic producers could be crucial for the formulation of risk coping strategies in new WTO member countries.

The existence of well-functioning product and factor markets is often considered as a prerequisite for the commercialization and modernization of the agricultural sector. If these markets do not function well, regional disparities are likely to persist or worsen with region specific commercialization (Pingali and Rosegrant, 1995). The literature often indicates that, if diversification provides an important means by which small-holders self-insure against risk, seize income earning opportunities, or accumulate capital for investment, then the effects of policy on diversification patterns do matter for household welfare and merit investigation (Barrett et al., 2001). In addition, a number of studies conclude that income diversification is positively related to farm productivity and contributes to poverty alleviation (Lanjouw and Lanjouw, 2001; Ellis and Mdoe, 2003). Remittances from abroad in many developing countries such as Nepal have recently emerged as supplementary income in order to insure against negative income shocks both at the macro and at the household levels. Remittance income can also play an important role in gaining access to capital, especially among lower-income households. Income diversification could help to manage risk, cope with shocks, or escape from agriculture in stagnation or in secular decline (Reardon et al., 2006). The study on the impact of remittance income on domestic factor markets could provide some insights for policy assessment in the low income countries. Besides the agricultural sector, alternative sources of income such as remittances are also important both for modernization of agriculture and for rural development: raise non-farm income through job creation, rural industrialization, and the increased provision of education, health, and nutrition, housing, and the variety of related social and welfare services.

The interpretation of this complexity, especially in the Nepalese agricultural sector, is crucial for the achievement of the dual goals of economic growth and poverty reduction. In Nepal, the factors that lead to the failure of agricultural efforts to increase productivity are often analysed with falling average farm size and land fragmentation leading to growing poverty which in turn constrains farmers' ability to invest from their own resources (FAO, 2003). A number of efforts towards commercialization and modernization of the agricultural sector have failed due to a poorly developed road network that restricts access to markets, constraining agricultural growth and diversification into higher value added and non-farm activities (WB, 2005). Poor people and those from food insecure areas are mostly restricted by the access to both technology and technical knowledge. Several experts and policy makers summarize the slow growth rate in agriculture due to the absence of incentives to farmers, weak institutional mechanisms and insufficient resources. It is often discussed in the literature that rural markets in developing countries are generally poorly developed and characterised by high transaction costs, arising from transportation costs, high search, recruitment and monitoring costs, and limited access to information, capital, and credit (de Janvry, Fafchamps and Sadoulet, 1991; Sadoulet, de Janvry and Benjamin, 1998). Poorly developed factor markets may also affect farmers' risk attitudes, because adoption decision may depend on farmers' attitudes toward risk. The literature shows that farmers in the resource poor economies are risk averse and the difference in risk preferences affects the farm investment decision-making (Binswanger, 1980). For instance, risk averse farmers in the presence of poorly developed credit markets may delay in technology adoption. Farmers' risk attitude in the presence of poorly functioning rural factor markets seems to be important for agrarian reforms. Therefore, revitalising economies by promoting growth and rebuilding the models for agricultural development are great challenges for the policy makers and economists.

Most economic analysis in developing countries and Nepal in particular, presupposes a Western-style agrarian system that assumes perfect input and output markets with zero transaction costs. However, the literature is often discussed that rural households are systematically exposed to market imperfections and constraints, referred to as "failures", and their behaviour can not be understood without reference to the specificity of these failures (Thorbecke, 1993). Under missing and incomplete markets, farmers may not enable to employ all factor inputs optimally even if adopting all inputs which could be beneficial in production. This could happen when a farmer faces a binding resource or liquidity constraint in his/her investment decisions (Feder, Just and Zilberman, 1985). In addition, risk can play an important role in the choice of production inputs and the technology adoption, especially in a situation where insurance markets function so poorly, that it is difficult to pass the risks to a third party (Rosenzweig and Binswanger, 1993). Hence, the assumption of perfect markets in this context may lead to misguided analysis and policy. There is also growing consensus in the literature that these factors tend to be physical manifestations of underlying market and institutional failures (Bojo and Cassells 1995). Moreover, missing or incomplete markets for output and inputs, including labour and capital, result from high transaction costs endemic to poor economies (Taylor and Adelman, 2002). A pragmatic theoretical approach to address this complexity of rural market structure is always desirable for formulation of policies.

During last few decades, agriculture has provided a fertile soil for the application of theories of incomplete and imperfect markets to economists and other scholars, particularly in developing countries. Farm household models are the conventional method to test various theoretical approaches. The empirical studies on farm households in most developing countries were initially based on the assumption of independence between farm household production and consumption decisions (Barnum and Squire, 1979; Rosenzweig, 1980). They assume perfect substitutability of factor inputs such as labour and capital as well as family and hired labour in production, and no disutility is associated with working off the farm i.e. utility is maximized from the consumption side, production and consumption decisions of farm household models are taken simultaneously using a two-stage model (Strauss, 1986; Benjamin, 1992). However, these studies are silent as regard to the relative efficiencies of family and hired labour inputs, and hiring-in and off-farm employment constraints, which often prevail in rural settings. Violation of any of these conditions generally breaks down the separability assumptions of the farm household model. Moreover, these studies do not incorporate an integrated structure of the farm household model where the implications of factor input of the observed heterogeneity have also been derived in a consistent manner and verified empirically. Thus, such models are important in evaluating the effects of policies directed at this poorest segment of the population (Jacoby, 1993).

To summarize, this dissertation assesses the agricultural technology adoption decisions. Based on the available literature, the analytical approach for the dissertation has been set up under the assumption of market imperfections that constrain farmers as regards commercialization and modernization of farming system. Due to pervasiveness of market failures in Nepal, farmers are more risk averse in adoption of new technology and this may lead them to remain in subsistence farming.

The study also assesses the impact of economic liberalization on Nepalese agriculture after entering WTO as a LDC country. This segment of the dissertation explores the impact of price risks both domestic and international on agricultural income instability, especially under three scenarios such as full, partial and no exposure to international markets.

Finally, the study seeks to find out the impact of remittance income on labour supply responses in remittance-receiving households of Nepal. This objective deals with the effect of remittance income in household labour allocation, assuming the relationship between remittance income and work hours of remittance-receiving households depends on the type of good and constraints such as labour and liquidity faced by the particular household.

This analysis has important implications for policy. If the reduction of transaction costs and relaxation of factor input constraints are found to be a real economic factor, their simple abolition, as demanded by economists and policy makers, without adequately addressing the factors that accelerate agricultural growth, may simply worsen the position of a lot of intended beneficiaries. In addition, if income diversification through remittance or other sources of income are found to be more positive for adopting new technology in agriculture by reducing credit constraints and insuring against negative income shocks, the result can be helpful to explain their persistence. The findings can also have policy implication at micro, meso and macro levels for the improvement of overall agricultural growth in Nepal.

1.3 Aim and scope of the study

The overall aim of this dissertation is to understand better the challenges in rural development of Nepal with particular attention to the issue of low productivity and increasing risk in the agricultural sector which are the underlying issues in this stage. Persistent low performance of Nepalese agriculture needs to stimulate through transformation of technology. Moreover, increase in agricultural risk both domestic and world prices, as well as yields may face shrinking returns and high risk which may further lead to negative effects on the income of farmers and the macroeconomic health of the country. Policy makers need to address these issues by exploring the degree of market integration and the impact of price and yield variability on both agricultural producers and consumers in order to formulate risk coping strategies and reduce volatility. The growing importance of remittances with an increase in the flow of migration is emerged as an alternative source of non-farm income that may support to raise the standard of living through smoothing income, easing liquidity constraint for small business, and financing on education and health expenditure in Nepal. The effect of remittances on recipient households is therefore likely to be critical to measure household welfare.

The theoretical basis for the dissertation is the recent development in microeconomics of theories of incomplete and imperfect markets, which allow the application of agricultural household models. Agricultural household models are a staple of micro-level research on less-developed country (LDC) rural economies. Household-farm models are a useful tool to study how household specific transaction costs shape the impacts of exogenous policy and market changes in rural areas (Taylor and Adelman, 2002). However, other regression analyses will also be taken into account to some parts of the dissertation. The specific objectives of the dissertation are following;

- ❖ to explore the factors affecting the adoption of improved seeds and inorganic fertilizers,
- ❖ to assess the commodity price risk and its impact on agricultural income instability under the scenario of full, partial and no exposure with international markets, and
- ❖ to find out the impact of remittance income on household labour allocation in remittance-receiving households in Nepal.

A sequence of research questions aim at clarifying the above mentioned objectives. The research questions set up here deal with each objective. However, some research questions may seek to answer from more than one objective. The following research questions guide this dissertation;

1. In what way rural factor markets contribute to the adoption of new technologies in agriculture in resource poor economies?
2. What are the factors that determine the adoption of new technologies in agriculture, use of improved seeds and inorganic fertilizers in particular?
3. Do Nepalese agricultural commodity prices follow Indian and world prices?

4. How do Indian price fluctuations affect the income of agricultural households in Nepal?
5. What are factors affecting to take migration decisions in Nepal?
6. What is the impact of remittance income on labour allocation of remittance-receiving households?

The size and diversity of the agricultural sector have led to this dissertation being focused on technology adoption decisions with particular attention to the use of improved seeds and inorganic fertilizers, assuming that the use of such inputs is an initial step in shifting from subsistence to commercialized farming.

Fluctuations in Indian (or world) agricultural commodity prices in the context of implementing Nepal's national economic liberalization programs affect the domestic markets and increase risks that can also influence the agricultural income instability. The analysis focuses on the impact of price fluctuations in major agricultural commodities (e.g., rice, maize, wheat, mustard oil and chicken meat) of Nepal.

Remittance income is often discussed in the literature that it has impact on different segments of the domestic economy such as consumption patterns and other social sectors. However, the study focuses on how remittance income affects labour supply decisions of remittance-receiving households in Nepal. The study thus highlights the challenges in agricultural development and the impact of major alternative sources in rural livelihoods and factor markets.

Modernization of the agricultural sector may evolve in two ways. The first is the large scale commercialization that consists of mechanizing the farming system derived from purely market-oriented purposes as well as the objective of profit maximization. The second way is the small holder and small scale plantation deriving from the objectives of both household food security and market oriented commercialization. This dissertation concentrates only on small holder commercialization which seems to be plausible in Nepal.

1.4 Description of data set

The dissertation uses both panel and cross section data of Nepal Living Standards Surveys (NLSS) conducted by Central Bureau of Statistics, Government of Nepal with technical and financial assistance from the World Bank. Nepal Living Standards Surveys

(NLSS I and II) were conducted in 1995/1996 and 2003/04 using the methodology of a household survey approach developed by the World Bank and applied in more than 50 developing countries in the world. The data set provides the agricultural and other household activities covering consumption, income, assets, housing, education, health, fertility, migration, employment and child labour. These data sets are supposed to be the best and most reliable data set available in Nepal covering all agro-ecological regions as well as administrative units both in urban and rural areas.

Table 1.1: Primary sampling units of NLSS II by region and zone

Ecological zones	Development Region					Total
	East	Central	West	Mid-west	Far-west	
Cross section	**75**	**126**	**65**	**39**	**29**	**334**
Mountains	9	11	1	6	7	34
Hills	22	68	45	18	11	164
Terai	44	47	19	15	11	136
Panel	**23**	**39**	**19**	**11**	**8**	**100**
Mountains	3	4	0	2	3	12
Hills	7	23	12	6	3	51
Terai	13	12	7	3	2	37
Combined	**98**	**165**	**84**	**50**	**37**	**434**
Mountains	12	15	1	8	10	46
Hills	29	91	57	24	14	215
Terai	57	59	26	18	13	173

NLSS II 2003/04 is the second survey, where the first NLSS was conducted in 1995/96. NLSS II was designed with similar approach adopted in NLSS I, but this survey includes both cross-section and panel samples. The following tables show the primary sample, sampling households and its distribution of sample households by region, zone and urban/rural residence.

Table 1.1 shows the distribution of primary sampling units by region and zone both cross-section and panel. As presented in the table, administratively, Nepal is divided into five development regions (i.e. Eastern, Central, Western, Mid-western and Far-western) with three agro-ecological zones (Mountains, Hills and *Terai* i.e. plain and low land in southern part of Nepal). Among five development regions, the central region where capital city is located, has the highest numbers of sampling units both in cross-section and panel units, and the hilly region occupied relatively higher percentage of land area in Nepal, covers 164 sampling units both in cross-section and panel units.

Table 1.2: Number of sample households of NLSS II by region and zone

Ecological zones	Development Regions					Total
	East	Central	West	Mid-west	Far-west	
Cross section	**900**	**1512**	**780**	**468**	**348**	**4008**
Mountains	108	132	12	72	84	408
Hills	264	816	540	216	132	1968
Terai	528	564	228	180	132	1632
Panel	**276**	**468**	**228**	**132**	**128**	**1232**
Mountains	36	48	0	24	48	156
Hills	84	276	144	72	48	624
Terai	156	144	84	36	32	452
Combined	**1176**	**1980**	**1008**	**600**	**476**	**5240**
Mountains	144	180	12	96	132	564
Hills	348	1092	684	288	180	2592
Terai	684	708	312	216	164	2084

Table 1.2 shows the number of sample households by region and zone. The sample households are relatively higher in central (1980) and eastern (1176) than other regions both in cross section and panel due to higher population density. Among ecological

Table 1.3: Distribution of sample households of NLSS II by region, zone and urban/rural residence

Ecological zones	Development Region					Total
	East	Central	West	Mid-west	Far-west	
Mountains	**108**	**132**	**12**	**72**	**84**	**408**
Urban	12	-	-	-	-	12
Rural	96	132	12	72	84	396
Hills	**264**	**816**	**540**	**216**	**132**	**1968**
Urban	48	480	168	24	24	744
Rural	216	336	372	192	108	1224
Terai	**528**	**564**	**228**	**180**	**132**	**1632**
Urban	156	120	48	48	36	408
Rural	372	444	180	132	96	1224
Total	**900**	**1512**	**780**	**468**	**348**	**4008**
Urban	216	600	216	72	60	1164
Rural	684	912	564	396	288	2844

zones, hilly region has the highest number of sample households (2592) followed by *Terai* (2084) and mountain (564) regions respectively.

Table 1.3 shows the distribution of sample households by region, zone and urban/rural residence. The distribution of sample households for urban areas is almost nil for mountain regions due to poorly developed infrastructure in the region.

Table 1.4: Enumeration status of primary sampling units and households in the NLSS II[4]

Sample		**Enumerated**			**Not enumerated**
	sampled	**Originally**	**Replaced**	**Total**	
Cross-section	4008 (334)	3493	419	3912 (326)	96 (8)
Panel	1232 (100)	962	198	1160 (95)	72 (5)
Combined	**5240** (434)	**4455**	**617**	**5072** (421)	**168** (13)

Table 1.4 reveals the enumeration status of primary sampling units. A total of 96 households were not enumerated in cross-section sampling, while 72 households were dropped from interview in panel sampling.

Though the NLSS covers wider level of data, the study concentrates more on NLSS panel and NLSS II data related to agricultural activities and remittance earned from abroad. Remaining data will also be used in order to support the result whenever necessary.

The dissertation also uses Nepalese commodity price data collected from the office of Agricultural Information and Extension, Ministry of Agriculture and Cooperative, Government of Nepal and Indian price data adjacent to Nepalese border from the Nepal Rastra Bank (i.e. the National/Central Bank of Nepal) and the International Monetary Fund, and yield data from the Food and Agriculture Organization (e.g., FAOSTAT).

1.5 Outline of the study

The dissertation is composed into six chapters. Chapter one consists of the introduction, motivation, aims and scope of the study and data set under the heading of general introduction by giving the overview of development challenges in the Nepalese agri-

[4] Figures represent the number of households; figures in parentheses represent the number of primary sampling units

culture sector, especially that of a transformation of subsistence and semi-subsistence to commercialized farming. Chapter two reviews the existing literature that covers the evolution of theoretical approaches, particularly focusing on the developing world.

Chapter 3 deals with the first objective of the dissertation. This part analyses the decisions of more advanced technology adoption in the agricultural sector. The analysis intends to explore the factors determining the adoption of agricultural technologies in Nepal and considers as driving force for the transformation of subsistence and semi-subsistence agriculture to commercialized farming. For this, it applies farm household models using equations of both improved seeds and inorganic fertilizers under the new economic paradigm of market imperfections. The study argues that under market imperfections, farmers face many constraints (i.e., cash income, family time, endowment of fixed productive assets, and production technologies), and it assumes that the production decision is derived by the consumption decision and not by the motive of profit maximization. The presence of missing and incomplete markets may disrupt the process of agricultural commercialization.

Chapter 4 addresses the second objective that assesses the impact of the price risk in agriculture. This part sheds light more on the impact of Indian agricultural commodity price fluctuations in domestic agricultural producers of Nepal. This part argues that in many low income countries, domestic prices are highly volatile due to poorly developed private sector, weak market infrastructure, and incomplete or poorly functioning financial and risk markets.

Chapter 5 analyses the impact of remittance income on household labour supply decisions in different sectors such as on-farm, off-farm, self-employment activities and hired labour in Nepal. It examines the assumption that an increase in the household income through remittances may increase household leisure and reduce working hours, if remittance is a normal good. Moreover, remittance income may loosen the liquidity constraint and then increase farm investment that may lead to higher work hours on farm sector because of the presence of missing and incomplete labour markets.

The final chapter provides the detailed information of major findings, summary and conclusion of the study. This chapter deals more specifically with the synthesis of findings and requirements for further studies on the technology adoption and risks in agriculture, Nepal in particular.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews the economic theory in relation to the risk and technology adoption in agricultural households and the effects of remittances on recipient households, particularly dealing with the context of low income countries as the study analyses the data from Nepal. During the last two decades, there have been a large number of studies on the issues of rural development with particular focus on the theory of incomplete and imperfect markets. It is therefore important to distinguish the different factors involved in rural economies. This chapter covers the role of factor markets in rural economies and the theoretical framework used in these studies, mostly applied in micro level studies in low income countries like Nepal.

2.1 Factor markets and their role in rural economies

In many agrarian countries like Nepal, agriculture is the main engine of economic development in rural areas, and the growth in agriculture is important for the improvement of rural livelihoods. Development practitioners and economists commonly emphasize that productivity growth in agriculture is required for a transformation out of the subsistence, low-input, low productivity production systems that characterize most of the developing world (Pingali, 1997; Doss, 2006). Due to the broader linkages of the agricultural sector, several factors are needed to be taken into account during the transformation of traditional agriculture system, especially in low income countries. The role and status of factor markets (e.g., labour, land, capital and insurance) are generally considered as the deriving factors for the commercialization and modernization of agriculture, because the transformation of the subsistence economy to a market oriented one by promoting commercialization in agriculture production may be determined by the nature of factor markets in the particular region. Indeed, the commercialization of agriculture is not only the marketing of agricultural output, but also the fact that the purchase of inputs and product choice are done based on the principles of profit maximization. The substitution of non-traded inputs in favour of purchased inputs, the specialization of farms and the declining proportion of farm income in total household income as labour is allocated somewhere else are all signs of transformation of subsistence agriculture (Pingali, 1997). Agricultural transformation is also necessary for the development of factor markets in developing countries. Because, for instance, by promoting market demand for inputs, the use of modern varieties of inputs may induce private sector investment which improves the availability of key inputs that can be used on a wide range of crops. In addition, commercialization may support private investment in infrastructure and human capital development that leads to broader benefits for other economic activities.

It is often discussed in the literature that technological change and agricultural commercialization are interconnected with the development of the factor markets such as rise in wage labour, land lease, and large-scale loans and investments, and on the other hand, failure of such factor markets may lead to large inefficiencies in resource allocations (Binswanger and Braun, 1991). Agricultural commercialization may have linking power between input and output sides of a market. For instance, demand for new technologies promotes the input sides of production and facilitates the development and advancement of technological innovations. The use of new technologies can also lead to higher productivity and then can induce output markets. On the other hand, in the absence of the market for outputs, farmers have to be self-sufficient in basic staples (de janvry, Fafchamps, and Sadoulet, 1991). Technological change may also be affected by the factor markets functioning in the particular region. For instance, land rights and security of land tenure influence farmers' investments via the incentives and the constraints. Farmers may have higher incentives to invest on their own farm, if they have secured property rights on land. Secured land rights may also enable liquidity-constrained farmers to use their land as collateral for obtaining credit, allowing them to increase investment. Moreover, in the presence of incomplete labour markets, household labour endowments may also determine farm investment decisions, if the new technology is more labour intensive. It is therefore a general convention that the pattern of technological choice may deviate from an efficient path in the presence of incomplete factor markets such as land, labour and credit.

Farmers' risk attitudes related to the rural factor markets are also crucial for agricultural transformation in the developing world. Because new technology is often regarded as high-risk high return activity and the adoption decision may be affected by the farmer's attitudes toward risk. Many empirical evidences show that farmers in the rural sectors of developing countries are more risk averse arising often from the incomplete and missing factor markets such as credit and insurance (Newbery and Stiglitz, 1979; Binswanger, 1980; Fafchamps, 2003). For instance, in the absence of insurance market, farmers are willing to avoid new technologies (Feder et al., 1985). In other words, exposure to risk is likely to affect the *ex ante* production choice (Fafchamps, 1992). Therefore, an understanding of the role of factor markets towards farmers' risk attitudes is likely to be critical for agrarian reforms.

However, in many developing countries, farmers encounter with many constraints in relation to each of labour, capital and land due to poorly developed factor markets. These binding constraints which may be the result of factor market imperfections, may limit the adoption of new technologies in agriculture. It is widely discussed in the literature that market imperfections arising from high transaction costs are common in rural markets in developing countries (Hoff, Braverman and Stiglitz, 1993). It is the rule rather than the exception that there are market imperfections in rural economies in developing countries (Holden, Taylor and Hampton, 1998). Market imperfections in this context imply missing markets (absence of particular market such as output or factor), partly missing markets (rationing, seasonality), thin markets and interlinked markets (land market with labour market, credit market with land) (Holden and Binswanger, 1998). Market imperfections prevail due to high transaction costs that include not only the transportation costs but also the consequences of imperfect and asymmetrical information leading to adverse selection and moral hazard as a consequence of the opportunist behaviour it allows; shallow local markets (high negative co-variation between household supply and effective prices); and price risk and risk aversion (i.e, influence the effective price used for decision making) (Sadoulet and de Janvry, 1995).

The pervasiveness of market imperfections in many developing countries varies across time and countries and these include: (i) monopoly, or imperfect competition in land markets that leads to monopolistic and monopsonistic behaviour, (ii) incomplete credit markets and land with credit contracts, or interlinked markets[5] (iii) imperfect (non-clearing) labour markets and conditions of "surplus labour", which make household labour utilization dependent on land ownership, and (iv) underdeveloped insurance markets, which make land ownership the key to food security and a source of insurance against food-price shocks that is unavailable to landless households (Benjamin and Brandt, 1997).

Holden, Taylor and Hampton (1998) have developed a typology of villages in the context of market imperfections, which are characterised along with two main domains in relation to transaction costs or isolation from the outside world and to the degree of internal differentiation of access to resources. These types of farm households are characterised by a number of market failures for some products (e.g., some foods, particularly the most perishable or bulky, or those with high price risk) and for some factors (e.g., child or family labour with low access to the labour market or facing price discrimination) (Sadoulet and de Janvry, 1995). This may cause the factor markets non-tradable or locally tradable. For instance, in the absence of labour market, household composition is an important determinant of farm labour use (Benjamin, 1992), where the labour time cannot be purchased and valued (Ellis, 1993). In this context, the result may be endogenous village prices, perhaps observed in local markets or be in shadow prices and are internal to households and various contractual arrangements (Holden and Binswagner, 1998).

Nepal is facing many development challenges for the improvement of living standard of the people. The central challenge is now to shift from subsistence to a commercial agriculture, because

[5] Binswanger and Rosenzweig (1984) also termed it as interlinkages market.

agriculture is the main source of food, income and employment for the majority, particularly in rural areas. The history of economic development in Nepal indicates that agricultural productivity has been the major source of sustained improvements of rural livelihoods. It is often discussed at the policy level that the commercialization of agriculture, which mostly relied on imported agricultural technologies, including improved seeds, chemical fertilizers and pesticides, will enhance productivity growth. Adoption of such agricultural technologies can only be possible when the input and output markets are functioning well in all agro-ecological zones in Nepal. The small number of studies relating to Nepal show that proximity to markets and the size of cities are strongly associated with different patterns of agricultural production (Jacoby, 1998). Participation of markets both input and output varies with distance as well road access and level of infrastructure development. Another study done by Asian Development Bank (2004) explores the argument that the commercialization of high value agricultural products is constrained by lack of access to adequate credit in rural areas of Nepal. So policy needs to address the importance of input and output markets to encourage a transformation out of subsistence oriented farming in Nepal. In the perspective of many development economists, missing or imperfect markets constitute the crucial step in our understanding of the economic problems of developing countries (Ray, 1998).

The impact of modernization of agriculture, particularly on small farm holders has been discussed for decades as being a driver for reducing poverty and hunger. However, pervasive market failures often create undue risks for farmers to engage in significant commercialization activities (Dorward et al., 2004). Such market failures that lead to factor market imperfections resulting mostly from high transaction costs is widely recognized as an obstacle to transformation of agriculture in many low-income countries such as Nepal. Reduction of transaction costs through the policy reforms and infrastructure development in all ecological belts now seems inevitable for the significant achievements of rural development and agricultural commercialization programs, because efforts made to boost this sector in the past could not materialize due to physical constraints as a land-locked country and mountainous terrain with poorly developed infrastructure that limited the opportunities of agricultural marketing in Nepal (see, World Bank reports). A report prepared by the World Bank[6] mentions that limited access to resources, weak and poorly integrated institutions and inadequate technical support for supply chain development are the major constraints towards the agricultural commercialization in Nepal. Development of rural factor markets for labour, land, and credit is necessary to increase the access to resources, especially for small-holders and to facilitate a transformation in agricultural production.

[6] This information is drawn from the assessment report prepared by World Bank under the heading of Agricultural Development in Nepal: Challenges and Opportunities.
http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/EXTSAREGTOPAGRI/0,,contentMDK:20273771~menuPK:548215~pagePK:34004173~piPK:34003707~theSitePK:452766,00.html

2.2 Theoretical framework for rural economies

A key to an investigation of rural economics is to develop a theory for the behaviour of the farm household, which is the elementary unit of analysis in modelling the rural economy. This theory must cover farm production, the marketing of agricultural commodities, and the demand for food, the performance of product and factor markets, the linkages between agriculture and other sectors of the economics, and the rest of the world. An understanding of household behaviour is important to analyze the effects of government interventions (e.g., pricing policies, investment) and external changes in market conditions on the rural economy, rural livelihoods, poverty and household decisions (e.g., production and consumption). Agricultural households, particularly in resource-poor economies, are faced with a complex set of issues that influence, to a very large extent, their livelihoods and livelihood strategies (Ellis, 1993; Caillavet, Guyomard and Lifran, 1994; Carney, 1998). Their behaviour of rural households needs to be analyzed in terms of production and consumption decisions that are taken simultaneously. This is because, rural households often consume at least a small portion of the output of their own product, and household labour is often an important input into the production process of the enterprise[7] (Bardhan and Udry, 1999). In other words, most rural households in the developing world are characterised by the mixture of both production activities (the level of output, the demand for factors and the choice of technology) and consumption activities (labour supply and commodity demand). Agricultural households make joint decisions over consumption, production, and time (labour/leisure) allocation for work[8]. The agricultural household model provides a framework for analyzing such household behaviour that integrates these three decisions and it is considered as a staple of micro research on less-developed country rural economies (Taylor and Adelman, 2003). Moreover, agricultural household models are microeconomic models of household behaviour which are built theoretically and applied empirically. Conventional models of agricultural households often neglected the interdependences of consumption and production decisions (Lopez, 1987).

Agricultural household models were initially developed and applied by Chayanov (1920) and Nakajima (1957) who believed that the behaviour of farm households was best understood in a household-firm framework. Later, this model is formalized by Becker (1965) in the "new home economics", in which the author explained the time allocation of household members when labour has an opportunity cost and the utility of household is not only derived by market goods but also by household produced goods and total household time endowment. The model took its full shape by

7 Bardhan and Udry (1999) explain that the insights of agricultural household model can also apply in the households that operate enterprises such as small-scale trading or petty manufacturing that often uses a certain percentage of households' labour and other inputs.

8 Farm households or agricultural households that imply the same meaning in this thesis are used interchangeably. Hence there would not have been any confusion using both terms frequently.

Barnum and Square (1979) and was further elaborated by a series of articles in a book entitled "Agricultural Household Models: Extensions, Applications, and Policy" edited by Singh, Squire and Strauss (1986). This book, one of the most widely referred books for agricultural household models, is known as the new-classical farm household model in the academic arena. The model was further developed under missing or incomplete markets by de Janvry, Fafchamps and Sadoulet (1991). The section below first deals with the agricultural household model under the assumption of perfect markets and then elaborates under missing or incomplete markets.

2.2.1 Household models with perfect markets

The simple agricultural household model, followed by Singh, Squire and Strauss (1986) is a combination of consumer and producer model into a single model, in which the model typically assumes that households maximize its utility subject to a budget constraint, which incorporates production on assets owned by the household. In other words, households take the decisions of production, consumption, and labour supply separately with the following setup:

- the household produces one food crop (Q_a), one cash crop (Q_c) using labour and one purchased input,
- the household consumes the food crop (C_a), one non-food good (C_m),
- the household allocates time endowment between farm labour (L_H) and leisure(ℓ); labour can be sold off-farm and can be hired in, meaning that there are no efficiency differences, and
- the model excludes non-farm labour earnings as these make no difference to the analysis.

The model assumes perfect markets for production, consumption and labour, and supposes that prices are exogenous to the household. The model also assumes perfect credit and insurance markets. Consider a farm household in which adult male and female jointly choose their decisions of consumption of both agricultural goods (C_a) and non-agricultural or market goods (C_m) and their time endowment (T) between household work (L_H) and leisure (ℓ). The model can be written as follows:

(2.1) $$\underset{\{C_a, C_m, \ell\}}{Max} \quad U\{C_a, C_m, \ell\}$$

Subject to following constraints;

(2.2) Production: $g(Q_a, Q_c, L_T, x) = 0.$

(2.3) Time endowment: $T = L_H + \ell.$

(2.4) Income: $P_a(Q_a - C_a) + w(L_H - L_T) + P_cQ_c = P_xQ_x + P_mC_m.$

Where L_T is total labour both household and hired used in production, and x is factor input for production, and P_i is the prices of agricultural goods (a), market goods (m) and inputs (x). w is the wage of labour. The term (Q_a - C_a) will be positive, if the household is net seller and negative if the household is net buyer. Likewise (L_H- L_T) is positive if the household is net seller of labour time and negative if the household is net buyer of labour time. After combining (2.3) and (2.4), the full income budget constraint is expressed as:

(2.5) $$P_aC_a + P_m C_m + w\ell = P_a Q_a + P_C Q_C - P_X x - wL_H + wT \quad (\equiv y^*),$$

the left hand side of the constraint represents the value of all consumption, including own produced food and leisure, while the right hand side of the constraint is the value of full income. The term "($P_a Q_a + P_C Q_C - P_X x - wL_H$)" is farm profit (π^*) and wT is the full value of time. Using Lagrange multiplier (λ), the first order conditions are:

(2.6) $$\frac{\partial U}{\partial C_a} - \lambda P_a = 0,$$

(2.7) $$\frac{\partial U}{\partial C_m} - \lambda P_m = 0,$$

(2.8) $$\frac{\partial U}{\partial \ell} - \lambda w = 0, \text{ and}$$

The equations (2.6 -2.8) show that marginal rate of substitution equals the price ratio of any two goods. Moreover, if γ is the Lagrange multiplier for production constraint (i.e. 2.2), then the first order conditions are:

(2.9) $$P_a + \frac{\gamma}{\lambda} g_a = 0,$$

(2.10) $$P_c + \frac{\gamma}{\lambda} g_c = 0,$$

(2.11) $$w - \frac{\gamma}{\lambda} g_c = 0,$$

(2.12) $$P_x - \frac{\gamma}{\lambda} g_x = 0, \text{ and}$$

where the equations (2.9-2.10) imply that marginal rate of transformation equals to price ratio for any two outputs, and the equations (2.11) to (2.12) also imply that value of marginal product equals the factor price.

These results imply that production decisions over x and L_T affect consumption decisions via farm profit in the full income constraint. However, consumption decisions do not affect production decisions, implying that production is independent of household preferences and income.

Comparative statics: As we discussed earlier, this model gives a useful benchmark to study the household's response to price changes.

A. *Demand for food*

Based on the above household model, the demand for food at the optimum level can be written as:

(2.13) $C_a = C_a (P_a , P_m, w, y^*)$,

this equation implies that demand for food is the function of the prices of food and non food goods, wage rate, and the household full income ($y^* = P_a Q_a^* + P_c Q_c - P_x x^* - wL_H + wT$). This demand function is different than usual demand function because here prices have an added effect on income through profits.

Differentiating C_a with respect to P_i, then the result follows as:

(2.14) $$\frac{\partial C_a}{\partial P_a} = \left.\frac{\partial C_a}{\partial P_a}\right|_{\pi^* constant} + \frac{\partial C_a}{\partial y^*}\cdot\frac{\partial y^*}{\partial P_a}\left(=\frac{\partial C_a}{\partial \pi^*}\cdot\frac{\partial \pi^*}{\partial P_a}\right),$$

the first term on the right side is standard Slutsky equation, while the second term on the right hand side is income effect ($\frac{\partial C_a}{\partial y^*}\cdot\frac{\partial y^*}{\partial P_a}$) or profit effect $\left(=\frac{\partial C_a}{\partial \pi^*}\cdot\frac{\partial \pi^*}{\partial P_a}\right)$. The first term on the right can also be decomposed into substitution and income effect using the Slutsky equation.

(2.15) $$\frac{\partial C_a}{\partial P_a} = \left.\frac{\partial C_a}{\partial P_a}\right|_{U \text{ constant}} + (Q_a - C_a)\frac{\partial C_a}{\partial y^*},$$

the first term on the right is the substitution effect and is negative, implying that an increase in the price of food decreases the consumption of food item. If food is normal good, then $\frac{\partial C_a}{\partial y^*}$ is positive, while the sign of this term $(Q_a - C_a)$ is determined by the household status as a net seller, $(Q_a - C_a) > 0$ or a net buyer $(Q_a - C_a) < 0$ of food. The net term can provide more information regarding the household response. For net buyer of food, the sign of $\partial C_a / \partial P_a$ is unambiguous. If the household is large enough marketed surplus, then $\partial C_a / \partial P_a$ can be positive, particularly if income elasticity is large.

B. *Demand for leisure*

The demand function for leisure (or home time) at optimum is:

(2.16) $\ell = \ell(P_a, P_m, w, y^*)$.

Differentiating the demand function for leisure with respect to wage, and decomposing as before, yields:

(2.17) $$\frac{\partial \ell}{\partial w} = \left.\frac{\partial \ell}{\partial w}\right|_{U=constant} + (T-\ell)\frac{\partial \ell}{\partial y^*} = \left.\frac{\partial \ell}{\partial w}\right|_{U=constant} - (T-L_T)\frac{\partial \ell}{\partial y^*}.$$

The first term on the right hand side is negative, if the household is net purchaser of labour. This implies that an increase in wage rate will reduce leisure time and increase work hour. On the other hand, if the household is net seller of labour (e.g., landless workers and small farmers), the elasticity can be either sign. For them, wage is revenue. Income elasticity of leisure is likely to be high at low income level, so the consumption of leisure will be low. However, it depends on the size of income elasticity and market surplus of labour.

C. *Marketed surplus*

(2.18) $MS_a = Q_a - C_a$, where MS is the market surplus of food.

If marketed surplus of food ($Q_a - C_a$)>0, then the response of marketed surplus to price can be expressed as:

(2.19) $$\frac{\partial MS_a}{\partial P_a} = \frac{\partial Q_a}{\partial P_a} - \left.\frac{\partial C_a}{\partial P_a}\right|_{U=constant} - (Q_a - C_a)\frac{\partial C_a}{\partial y^*}.$$

As we know, the first term on the right hand side is positive because this is supply response of production. The second term is also unambiguously positive, an implication of the standard theory of consumer demand. However, the third term depends on the type of good. If the good is normal, then this term is negative. If marketed surplus (MS_a) is large enough, it is possible that the consumption response of households may outweigh its output response giving an overall negative response. More normally, we would expect the first two terms to dominate so that markets surplus responds positively to the traded good price.

Farm household theoretical literature has recognized that marketable surplus supply response is influenced by the price and income elasticities of own-consumption (Strauss, 1984; Davis and Zong, 2002). However, the response of price change depends on whether the farmer is a net seller or buyer matters. The study on the market surplus households in 6 countries (Japan, Korea, Malaysia, Nigeria, Sierra Leone, Taiwan, and Thailand) shows a positive response of price change in different crops such as rice in Korea, Malaysia, and Sierra Leone, sorghum in Nigeria, and farm output in Japan, Taiwan, and Thailand (Sadoulet and de Janvry, 1995) and rice in Madagascar (Barret and Dorosh, 1996).

2.2.2 Household models with market failure

The agricultural household model mentioned in the previous section is based on the assumption of perfect markets called as separable (or recursive) household model, implying that production decisions are independent from consumption decisions of the farm household. Under this assumption, all products and factors are tradable and the opportunity cost of any product or factor held by the household is its market price. However, rural households of developing countries are systematically exposed to a number of market failures due to high transaction costs (e.g., high transportation costs because of distance to markets, high marketing margins because of poor infrastructure, merchant with local monopoly, high search and recruitment costs because of imperfect information, and supervision and incentive costs of hired labour); price risks and risk aversion (e.g., risk averse households calculate with low sales prices and high purchase prices); limited access to credit (e.g., low collateral and seasonality of agricultural expenditures). More specifically, a market fails when the cost of a transaction through market exchange creates disutility greater than the utility gain that it produces, such that no market transaction occurs (de Janvry, Fafchamps and Sadoulet, 1991). The extreme case of market failure is nonexistence of a market (Sadoulet and de Janvry, 1995). However, in general case, the market exists but the gains for a particular household may be below or above the cost under which conditions some households may participate and some may not participate in the markets. The market definition is therefore household specific but not commodity specific (de Janvry, Fafchamps and Sadoulet, 1991).

With market failure, the particular good or factor becomes nontradable in which prices are no longer determined by the market. Under the presence of market failure, the separability assumption breaks down and consumption decisions are affected by the production decisions of the household[9]. In real life, rural households may face various kinds of market failures (e.g., missing markets, partly missing markets, and thin markets) for some goods but not all, resulting in a mixture of tradables and nontradables (Taylor and Adelman, 2003). The study of the agricultural household therefore needs to include both tradables and nontradables goods in the model. The agricultural household model with market failure follows the procedure developed by de Janvry, Fafchamps and Sadoulet (1991) and mentioned by de Janvry and Sadoulet (1995). The model is presented below in detail.

The household's optimization problem is to solve:

(2.20) $$\underset{\{c, \ell, q\}}{Max} \quad U\{C_a, C_m, \ell\},$$

Subject to the budget constraint:

(2.21) $$\sum_{i \in TR} P_i C_i = \sum_{i \in TR} P_i (Q_i + T_i),$$

[9] A number of literatures on market imperfections focusing in low income countries can be found. Some noted papers are: Stiglitz (1986, 1989), de Janvry, Fafchamps and Sadoulet (1991), Bejnamin(1992), Thorbecke (1993), Jacoby (1993), Skoufias (1994), de Janvry and Sadoulet (1995), Bardhan and Udry (1999), and de Janvry and Sadoulet (2006).

where P_i is the price of good *i*[*i*= agricultural goods(P_a) and non food or market goods(P_m) in consumption; and food crop (P_a) and cash crop (P_c) in production], C_i is the quantity consumed of good *i*(i.e. C_a and C_m), Q_i is the quantity of good *i*[*i*=food crop (Q_a) and cash crop (Q_c)] in production, T_i is the total household initial labour endowment. The term TR stands for the set of tradable goods. Production function of the household is:

(2.22) $g(Q_i, L_T, x) = 0$, where outputs both food crop and cash crop (with positive values; Q_a, Q_c>0) and inputs (with negative values; L_T, x <0),

and a self-sufficiency constraint for nontradable goods (i.e. equilibrium for nontrabables):

(2.23) $Q_i + T_i = C_i, \quad i \in NTR$ (nontradable goods),

the model assumes exogenous market price for tradable goods referred as:

(2.24) $P_i = \overline{P}_i, \qquad i \in TR$,

reorganizing the above constraints and using the Lagrange multiplier, the maximization problem is:

(2.26) $$L = U(C_i, \ell) + \lambda \left[\sum_{i \in TR} \overline{P}_i (Q_i + T_i - C_i) \right] + \mu g(Q_i, L_T, x) + \sum_{i \in NTR} \phi_i (Q_i + T_i - C_i),$$

first order conditions with respect to consumption and production are:

(2.27) $U_i^{'} - \lambda P_i = 0, \qquad i \in TR,$ consumer goods,

(2.28) $\mu g_i^{'} + \lambda P_i = 0, \qquad i \in TR,$ producer goods,

(2.29) $U_i^{'} - \phi_i = 0, \qquad i \in NTR,$ consumer goods, and

(2.30) $\mu g_i^{'} + \phi_i = 0, \qquad i \in NTR.$ producer goods

To simplify the notation, the prices of tradables and nontradables are presented by the first order conditions of constrained maximization problem in which the price of nontradable commodity is converted into an endogenous price which is written as:

(2.31) $$P_i \equiv \frac{\phi_i}{\lambda} \qquad \text{for all } i \in NTR,$$

the model can be solved by defining endogenous decision prices for nontradable goods and exogenous prices for tradable goods, which are as follows:

(2.32) $P_i^* = \overline{P}_i, \qquad i \in TR$ (Tradable), and

(2.33) $P_i^* = \phi_i / \lambda, \qquad i \in NTR$ (Nontradable), where P_i^* in nontradable is called as shadow price.

It is noteworthy to mention that market prices for tradable commodities are common across households and exogenous to individual households while shadow prices are endogenous and household specific and are obtained by the equilibrium between production and consumption of goods (2.23).

The reduced form of the model can be shown after the calculation of first order condition in which production decisions of all tradables and nontradables are represented by a system of input demand and output supply in the decision price P_i^*:

(2.34) $$Q_i = Q_i(P_i^*),$$

on the production side, the household is assumed to maximize profit with shadow prices (P_i^*), where the maximum profit at optimum levels of products and factors can be written as:

(2.35) $$\pi^* = \sum P_i^* Q_i \,.$$

On demand side, the household also makes decisions based on shadow prices (P_i^*), the full income constraint using shadow prices (P_i^*)from (2.21) to (2.33) follows as:

(2.36) $$\sum_i P_i^* C_i = \pi^* + \sum_i P_i^* T_i = y^*,$$

and the demand system is:

(2.37) $$C_i = C_i(P_i^*, y^*)\,.$$

In this model, the demand for consumption is determined by the shadow prices (P_i^*) and income (y^*).

Comparative statics:

The market response of agricultural household models under missing markets with the change in market conditions is different than the conventional models under the assumption of perfect markets that allow only exogenous prices for all production and consumption goods. For this, let us take a simple case with a single nontradable good and let us analyze what is the response of the household to a change in price of an unconsumed output, say a cash crop. Consider now that there is absence of market for cash crop, indicated by the shadow price (P_c^*) and exogenous price ($\overline{P}_c$) for a tradable cash crop. Total differentiating supply equation (2.34) with respect to price in logarithmic form (for global elasticities), then the result is:

(2.38) $$\frac{d\ln Q_c}{d\ln \overline{P}_c} = \left.\frac{d\ln Q_c}{d\ln \overline{P}_c}\right|_{dP^*_c=0} + \frac{\partial \ln Q_c}{\partial \ln P_c^*} \cdot \frac{\partial \ln P_c^*}{\partial \ln \overline{P}_c},$$

this equation reveals that the effect of a change in the price of the cash crop can have two effects: a direct output response and an indirect output response because of the possible effect of the change in market price on the endogenous shadow price of the cash crop. If we assume there is no change in this shadow price ($dP_c^* = 0$), then the first term on the right hand side will be positive

$\left[\frac{d\ln Q_c}{d\ln \overline{P}_c} > 0\right]$. This would be the case if the cash crop had a clear market price. Instead, in the absence of market for cash crop, the second term on the right hand side will be negative $\left[\frac{d\ln Q_c}{d\ln P_c^*} < 0\right]$, because the indirect effect of the external price via the internal price change would have opposite to the direct effect. In the absence of market, market price is more likely to be higher than the shadow price, if the household is a net purchaser and lower if the household is a net seller of food. So the supply response of the market price to the shadow price may be opposite. The third term will be positive $\left[\frac{d\ln P_c^*}{d\ln \overline{P}_c} > 0\right]$, implying that an increase in the price of cash crop raises the shadow value of food. In other words, cash crop supply elasticity will be smaller when we include missing market in the model.

The market response of the agricultural household can also be analyzed in demand function. Consider now that there is absence of market for food, marked by the shadow price (P_a^*), and that one market price $\overline{P}_m$ changes, then totally differentiating the demand function with respect to prices, gives:

(2.39) $$\frac{d\ln C_m}{d\ln \overline{P}_a} = \left.\frac{d\ln C_m}{d\ln \overline{P}_a}\right|_{dP_a^*=0} + \frac{\partial \ln C_m}{\partial \ln P_a^*}\cdot\frac{\partial \ln P_a^*}{\partial \ln \overline{P}_m},$$ where $\overline{P}_a$ is exogenous price for food commodity.

As discussed in the literature, supply and demand elasticities do not simply have unambiguous signs (de Janvry, Fafchamps and Sadoulet, 1991). However, the response to a change in the price of food and non-food goods could be interesting under missing markets of some commodities. In equation (2.39), the first term on the right hand side is positive because of cross price elasticity with respect to other goods and the second term is also positive because of two effects: substitution and income. In this case, the income effect is positive, if employment in production is smaller than the total income available to the household. However the sign may be negative in the case of a household having very large area in which labour costs reduce the household's income dramatically. Moreover, if the shadow price of good, say food, increases, then the household's income would increase through the higher income of shadow price, which also increases the consumption of the household, i.e. $\frac{d\ln P_a^*}{d\ln P_m} > 0$. The overall effect is positive, implying that non food/market good cross-price demand elasticity becomes larger when the effect of missing market is accounted in the model.

It is noteworthy to say that the agricultural household model is a useful vehicle for rural policy assessment, allowing to analyze the effect of demands for all sorts of commodities and labour supply via cross price effects and it is potentially important for policy design and the assessment for policy impact. This model provides a description of the effect of policy changes in the agricultural sector not only in production, but also in consumption and labour supply and demand. Due to its significance in empirical application, a number of studies are also found to extend this model in other fields such as health and nutrition, rural energy consumption, fuel wood and fodder collection, storage, and human resource development.

2.3 Conclusions

This chapter reviewed the literature related to the theoretical framework applied in the rural economy, particularly in the context of developing countries. The chapter examined the literature critically both theoretical approaches and applied studies in which agricultural household models that capture households both as producers and as consumers, as well as under perfect markets and under missing or incomplete markets in the model are found to take into account both household and local characteristics of the rural economy.

CHAPTER 3
ADOPTION OF IMPROVED SEEDS AND INORGANIC FERTILIZERS

3.1 Introduction

Agriculture is the main source of food, income, and employment for the majority of low income households in Nepal, most of which are rural. Growth in agriculture is, therefore, critical for reducing poverty and hunger in the country because the majority of the poor are small-holders (NPC, 2002). The conventional wisdom in Nepal is that the low productivity in agriculture is primarily due to subsistence-oriented farming that applies traditional technologies for cultivation and the wide use of low yield varieties of seeds[10]. Technology transfer in this regard seems to be a precondition for increasing productivity, as well as for shifting from subsistence to commercial farming. This transformation encourages the adoption of more advanced technologies such as high yield varieties of seeds and inorganic fertilizers. Many studies have viewed technology as a means to end poverty (Besley and Case, 1993). It is often claimed in the literature that the transfer of technologies through the adoption of modern varieties of seeds and fertilizers can substantially provide an opportunity to increase productivity and income (Feder, Just and Zilberman, 1985) [11]. The contribution of technological change to agricultural productivity in developing countries has been extensively documented (see, Sunding and Zilberman, 2000; Doss, 2006). In other words, technological change can have enormous effects in many respects such as income increases, creation of labour opportunities for the poor, food prices, environmental sustainability, and linkages with the rest of the economy. An understanding of adoption decisions of new technology in agriculture is therefore crucial for formulating effective policies.

Recognizing the importance of the agricultural sector in the national economy, the Government of Nepal has made numerous efforts such as the distribution of intermediate inputs, improved seeds, and inorganic fertilizers to enhance agricultural-led growth, but past programs to increase

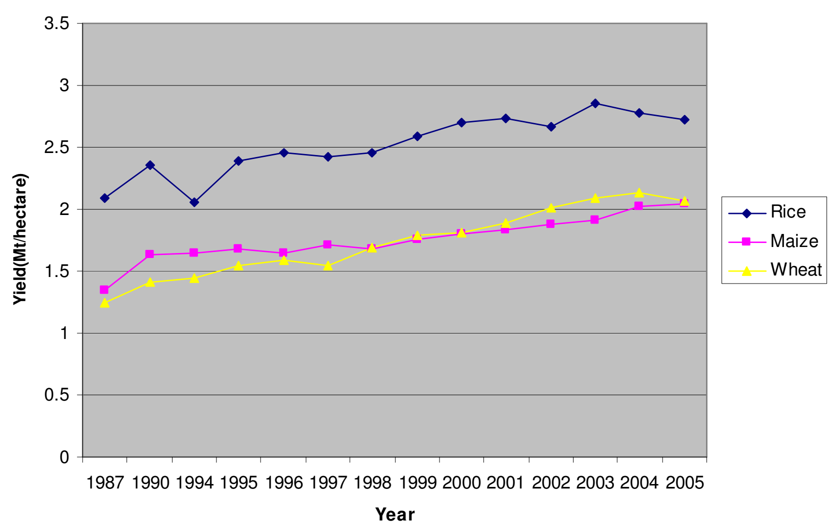
[10] Traditional technology refers to the endogenous methods of cultivation to provide subsistence using local technologies such as non-marketed of local seeds, animal traction and organic fertilizer/manure. Technology transfer refers to changes in both technology and motive for farming, e.g., use of purchased seeds such as improved seeds and fertilizers, and tractorization.

[11] Adoption of a new technology is a choice between traditional and new technology such as rice, maize and wheat. It is often believed that modern varieties of seeds lead to higher yields than the traditional varieties. For econometric analysis, the definition of adoption depends on whether the adopter is a discrete state with binary variable (use or not) or a continuous measure (e.g. proportion of land allocated to technologies as measure of adoption), as explained by Doss (2006).

productivity have mostly failed (NPC, 2002). Adoption and dissemination rates of new agricultural technologies are relatively lower than in other South Asian countries, especially India, Pakistan, Sri Lanka, and Bangladesh due to Nepal's late participation in the Green Revolution (Herath and Jayasuriya, 1996). Inorganic fertilizers are used on about 50 percent of total farmland in Nepal, and most predominantly in paddy farming. However, the use of improved seeds is much lower covering about 30 percent of farmland on average. The average level of fertilizer use is 100 kg per household and 56 kg per hectare (AFCI, 2003). The percentage of land area planted with modern seed varieties is about 40 percent for paddy (Herath and Jayasuriya, 1996) and 54-58 percent for maize, including both improved varieties and those seeds recycled for one or more seasons (Adhikary et al., 2001; Aquino et al., 2001; Ranson, Paudyal and Adhikari, 2003); these rates are lower than 15 percent in remote areas. The Nepal Living Standard Survey (NLSS; CBS, 2004) shows that the percentages of households using improved seeds in selected crops are 20.7 percent for winter vegetables, 17.8 percent for onions, 16.3 percent for winter potatoes, 11.9 percent for summer vegetables, 5.6 percent for wheat, 5.4 percent for paddy, and 4.3 percent for summer maize[12]. Likewise, the percentage of households using inorganic fertilizers are 66.4 percent for paddy, 56 percent for wheat, 34 percent for summer maize, 21.6 percent for winter potato, 8.1 percent for winter vegetables and 3.7 percent for summer vegetables. The adoption rate of both improved seeds and inorganic fertilizer is higher in urban and semi-urban areas as well as in *Terai* (southern plain land) than in mountain and hilly regions (CBS, 2004).

The Green Revolution, introduced in the late 1960s in South Asia, is considered to be the evolution of new technology comprising high yielding varieties of seeds in association with inorganic fertilizers (Farmer, 1986). However, Nepal was slow to adopt these technologies in comparison to other South Asian countries, and thereby benefited less from the Green Revolution than its neighbours. The yields per hectare of major crops such as

Figure 3.1: Yields of major crops



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[12] NLSS II (2003/04) report explains improved seeds as high-yielding varieties (HYV) of crops (in Nepali language called as *bikase biu*) introduced more recently than the existing improved seeds (e.g. improved recycle seeds). This study includes both newly introduced improved seeds and recycled improved seeds.

rice, maize, and wheat have not significantly improved even after adopting new technologies (see Figure 1). The data show that rice productivity increased from 2.09 to 2.72 metric ton per hectare from 1987 to 2005. Likewise, in the same year, the productivity of maize increased from 1.34 to 2.04 and of wheat from 1.25 to 2.07 metric tons per hectare. Such sluggish performance in the agriculture sector has raised a number of important questions about the policies adopted by the Government for improving the agriculture sector. It is also widely recognized that most low-income countries are confronted with multiple constraints due to inadequate capital, poor road and communication networks that often negatively influence the timely distribution of farm inputs such as improved seeds, inorganic fertilizers, and farm credit, thereby reducing the probability of adopting new farm technologies. Thus, understanding the adoption processes in rural settings is a high priority for improving the living standards of rural people.

In addition to the studies related to output variability and technology adoption in the agricultural sector, a number of studies have also raised issues relating to the theoretical implications of models in which the adoption decisions about improved seeds and inorganic fertilizers are often estimated as a single equation assuming that the adoption decision about improved seeds is different than the adoption decision about inorganic fertilizers. The literature shows that a single equation approach may cause bias, inconsistency, and inefficiency in parameter estimates if simultaneity in decision making is detected and/or unobserved heterogeneities are correlated for these decisions (Maddala, 1983; Greene, 2003). On the other hand, bivariate probit models can capture the interrelation between the two decisions as opposed to the situation in which two separate probit (or logit) models are estimated. Numerous factors can affect joint decisions of technology adoption such as improved seeds and inorganic fertilizers. For instance, it may occur due to interlinakges and synergies in farm production. Adoption decisions about inorganic fertilizers are more likely to occur when farmers decide to adopt improved seeds, but not necessary the other way round. It may be possible that farmers in low income countries decide to adopt new technologies as a package, including for example, improved seeds with other supplementary components like inorganic fertilizers and pesticides (Kaliba et al., 2000). If it can be shown that joint decisions are indeed made, then policy makers need to give more emphasis to the adoption of improved seeds. If the findings support joint technology adoption, then policy should focus on a package program of technology adoption. An understanding of the factors affecting the adoption decisions of technologies in Nepal is likely to have policy implications for other countries at similar levels of development.

The analysis of adoption behaviour of farm technologies with the application of both single and simultaneity decisions using panel data may give better insights about the adoption behaviour of farmers in Nepal. This study intends to capture the underlying characteristics of farm households, such as simultaneity decisions in technology adoption and prevalence of missing and incomplete markets, which are often neglected in the past studies. Such characteristics may be crucial for policy implications. The use of panel data is also an important contribution, enabling to capture changes in the adoption decision over time which may not be possible in the conventional static models. The study thus aims to add to the literature on the adoption of new farm technologies and examines the policy implications for Nepal.

The purpose of this paper is to examine the factors affecting adoption decisions about improved seeds and inorganic fertilizers under the assumption of incomplete and missing markets, where both decisions are considered to be interdependent. This paper is organized as follows: Section 3.2 reviews the literature on technology adoption and diffusion; Section 3.3 outlines the theoretical framework; Section 3.4 presents the data and descriptive statistics; Section 3.5 specifies the econometric models; Section 3.6 presents the findings; Section 3.7 discusses the results; and Section 3.8 concludes.

3.2 Literature on farm technology adoption and diffusion

In most developing countries of the world, agriculture is considered as the backbone of country's economy and the livelihoods of the majority of people, who live rural areas. Increase in the productivity of agricultural sector is critical to improve livelihoods of poor people as well as to economic growth and development (Datt and Ravallion, 1996). An understanding of the sources of agricultural productivity is thus important for these countries. The adoption and diffusion of agricultural innovations are widely regarded as the way to transform traditional agricultural systems to enhance agricultural productivity. A substantial number of studies on the adoption and diffusion of agricultural innovations have been done extensively over the last 50 years. The major challenge is to understand the farmers' perception towards new technology and its impact on farm production (Doss, 2006).

Everett Rogers (1983), considered by many as pioneer in adoption and diffusion research since publishing the widely cited book "Diffusion of Innovation" in 1962 defined adoption as, "the mental process an individual passes from first hearing about an innovation to final adoption". The term "adoption" refers to the stage in which a technology is selected for use by an individual (farmer) or decision making unit (farm household), while diffusion is the process in which the technology spreads to general use and application. Innovation is often used with the nuance of a new or innovative technology (e.g., high yielding varieties of seeds) being adopted. In other words, the innovation systems' concept refers as "the network of organizations, enterprises and individuals focused on bringing new products, new processes and new forms of organization into social and economic use, together with the institutions and policies that affect their behaviour and performance" (World Bank, 2007).

However, there is growing concern regarding the definition of adoption and the analysis of adoption behaviour and particularly regarding the application of empirical approaches due to variation of the definition of adoption across regions. For instance, adoption can be measured both in the timing and extent of new technology utilization by individuals (Sunding and Zilberman, 2001). In this case, it will be difficult to capture the adoption behaviour of farmers without uniform definition of adoption. It is also the fact that the adoption of new technologies in the agricultural sector is complicated to define. Farmers can adopt only one improved variety of seed, or many improved varieties of seeds, or partially both traditional and improved varieties of seeds (Doss, 2006). In empirical research, the analysis of adoption behaviour is often applied by a discrete choice (e.g., adoption or no adoption), or by a continuous variable (e.g., percentage of land planted new variety of seed). As in the analysis of the adoption behaviour, diffusion can also have several indicators for a specific technology. One possible way to measure may be the percentage of farming population using new technologies, or the share of land using new technologies in total land (e.g., Sunding and Zilberman, 2001). This section intends to shed lights on the adoption decisions of new farm technologies with particular attention to micro studies in the developing world.

3.2.1 Technology adoption behaviour: early approaches

The literature shows that the study of adoption and diffusion is initiated by sociologists. Ryan and Gross (1943), two prominent rural sociologists analyzed the switch to hybrid corn seeds among farmers in two communities in Iowa state of the United States, focusing on the importance of communication process on technology adoption. Their motivation on diffusion research was guided by the improvement of extension services and the marketing of new seeds and technology. Another prominent sociologist (Rogers, 1962) also conducted studies on the diffusion of hybrid corn in Iowa and compared diffusion rates in different counties. The general outcome of the results on diffusion rates was S-shaped[13] function of time. Most rural sociologists also highlighted the socio-psychological factors that determine individual adoption that focused on the individual attitude, education, and economic status on adoption behaviour.

The empirical model developed by Griliches (1957) for diffusion of agricultural innovations is another milestone in the literature of technology adoption and diffusion. This model was novel

[13] In S-shape diffusion curve, early adoption rates will be relatively low and will take high adoption rates called as take-off periods. In this period, marginal rate of diffusion increases and the diffusion curve is a convex function of time. After takeoff periods, the diffusion rates reach a peak (i.e. saturation), then fall down. Finally new technology will be replaced the old one after declining diffusion rates.

and original in every respect and it still remains a prime example of powerful, thorough, and original empirical research. The basic model of diffusion is:

$$(3.1) \qquad Y_t = K\left[1 + e^{-(a+bt)}\right]^{-1},$$

where Y_t is diffusion at time t (i.e. percentage of land for farmers adopting an innovation), K refers as long-run upper limit of diffusion, *a* is the diffusion at initial period, and *b* measures the pace of diffusion.

The study of the diffusion of agricultural innovations in developing countries is found to be influenced by Griliches (1957, 1960, and 1962) in which the author explained that the adoption behaviour was largely affected by the profitability of innovation and other economic variables, rejecting the explanations made by rural sociologists. Griliches's use of S-shaped diffusion curve has become widespread in several areas, such as in marketing to depict diffusion patterns in many products. Diffusion studies have become a foundation for economic literature for quantitative research in developing countries. Often in these theoretical and empirical works, farmers were assumed to behave as profit maximizers including other determinants of diffusion patterns such as the heterogeneity of attributes and resource endowments among individuals in which the profit maximization problem depends on the utility of adoption for farmers. A number of studies have been carried out under the basic idea of Griliches with further elaborating and revising the numerous factors affecting the adoption behaviour of individuals, deriving the insights and policy recommendations that were basic for the design of most technological change efforts implemented as part of the Green Revolution and agricultural development programs (e.g., Falcon, 1970; Bell, 1972; Perrin and Winkelmann, 1976; Ruttan, 1977; Feder et al., 1985; Byerlee and Hesse de Polanco, 1986; Smale et al., 1995; Kaliba et al., 2000; Sunding and Zilberman, 2001; Smale, 2005; Dixon et al., 2006; Doss, 2006; Monge et al., 2008).

The analytical approach of agricultural innovation processes has been divided into two distinct areas such as in the field of economics (individualistic and profit-maximizing approaches) and in the field of sociology (socio-psychological approach), particularly after 1970. These two approaches encounter a number of issues regarding the analysis of agricultural innovations. Since then, the analytical approach of agricultural innovations has been spurred in economics with more emphasis on the methodological aspects, in which the adoption behaviour of farmers is often considered as rational decision markers (Feder, Just and Zilberman, 1985; Gladwin, 1989b; Reardon, 1989). The paper on the adoption of agricultural innovations in developing countries, reviewed by

Feder, Just and Zilberman[14] (1985), one of the widely cited articles, has raised several issues on methods and modelling, comparing the work conducted on the Green Revolution technologies. These authors highlighted five areas in which we need to focus on innovation research, which are: (i) examining the intensity of adoption; (ii) addressing the simultaneity of adoption of different components of a technology package; (iii) analyzing the impact of incomplete markets and policies of adoption decisions; (iv) contextualizing adoption decisions within social, cultural, and institutional environments; and (v) paying attention to dynamic patterns of changes in landholdings and wealth accumulation among early and late adopters. Their studies show that the adoption decisions are mostly influenced by the costs of the technology, farm size, farmer's human capital, labour availability, membership in an extension services, and liquidity constraints (Feder, Just, and Zilberman, 1985; Feder and Umali, 1993). The literature also shows that over the past two decades, a large number of studies focusing on the introduction of new inputs such as high-yielding varieties, fertilizers, pesticides, or machinery are undertaken focusing on the first two issues (Doss, 2006).

3.2.2 Technology adoption behaviour: present trends

The current literature on theoretical innovation systems has undertaken a significant change from the conventional, linear perspectives on agricultural research and development (Spielman, 2006). According to Doss (2006), the present literature on technology adoption decisions focuses on three main areas: (i) innovative econometric and modelling methodologies, (ii) examinations of the process of learning and social networks, and (iii) continuation of micro-level studies based on local data collection with an aim to shed light on local contexts for policy purposes.

The application of econometric methodologies and modelling has been spurred in the recent studies on technology adoption behaviour due to use of sophisticated econometric techniques, focusing on the issues of endogeneity and simultaneity. Besely and Case (1993) who provided a brief overview of technology adoption modelling in developing countries, describe that the empirical approach for modelling technology adoption should be consistent with an underlying theoretical model of optimizing behaviour. They raised a number of issues pertaining to the methodological application such as the simultaneity in decision making. The conventional model used in the technology adoption behaviour was mostly based on binary choice (whether or not to adopt), and a functional relationship between the probability of adoption and a set of explanatory variables estimated using the logistic distribution for the logit procedures and the normal distribution for the probit procedures. However, such estimates may not capture farming decisions on sequential adoption

[14] They also distinguished individual adoption (farm level) from aggregate adoption. Individual adoption refers as the degree of use of a new technology in the long-run equilibrium if farmers have full information about new technology and its potential, while aggregate adoption is the process of spread of a technology within a region.

components of a package of technology improvements and the intensity of the use of new technologies. There has been a growing body of literature on econometric modelling, taking into consideration the simultaneity in the decision making. For instance, Smale et al. (1995) applied adoption decisions as three simultaneous choices: the adoption choice of the components of the recommended packages, allocation decisions of different technologies across the land area, and the decision on the quantity of inputs such as fertilizers. Others investigated the models accounting for the interrelationships among adoption decisions, causing selectivity biases (Roberts et al., 2002; Fernandez-Cornejo et al., 2001; Khanna, 2001; Napier et al., 2000; Traore et al., 1998; Dorfman, 1996). In addition, Pitt and Sumondiningrat (1991) used both seed-variety-specific profit functions and a meta-profit function which allow for the effect of risk preferences, uncertainty, and schooling on the cultivators' seed variety choice. Kaliba et al. (2000) applied adoption of improved seeds and inorganic fertilizers, where the authors assume that farmers first decide to allocate land for improved seeds and then decide to use inorganic fertilizers. Yesuf and Kohlin (2008) estimated simultaneous decisions of new farm technologies and soil conservation using the bivariate probit model.

A number of researches (in a second strand) have attempted to model the effect of the learning and social networks on adoption decisions of farm technology, where Benerjee (1992) and Bikhchandani et al. (1992) are early contributors in this field. Studies carried out by Besely and Case (1994) and Forster and Rosenzweig (1995) investigated the importance of learning in the dynamic adoption process. Besely and Case (1993) applied the model farmers as being uncertain about profitability of the new seed compared to the known ones and simulated the sub-game perfect number of plots to be planted to the new seed. Their model assumes that farmers learn about the profitability of the new seeds through experience. On the other hand, Foster and Rosenzweig (1995) modelled the optimum input use as being unknown and stochastic. These studies show that farmers learn about the optimal combination through their experience and from the experience of their neighbours. There are a number of studies using learning models to test the effects of social interactions, continuously refining the specification of social learning effects (e.g., Pomp and Burger, 1995; Fischer et al., 1996; Henrich, 2001; Marra et al., 2003; Munshi, 2004; Alene and Manyong, 2006; Monge et al., 2008). Moreover, Besely and Case (1993) and Cameron (1999) applied panel data in order to analyse the dynamic model instead of static model that allows to address the adoption decisions over time on the same farmers. The literature also includes some models build up on Bayesian approaches combined with the assumption of free access of information from individual and social networks (Conely and Udry, 2004; Bandiera and Rasul, 2006).

The literature on the third strand focuses on a particular technology in a particular location or region with an aim to support agricultural technology policy. These studies are primarily undertaken with the collaboration of international organizations such as the International Centre for Wheat and Maize Improvement (CIMMYT) and International Rice Research Institute (IRRI). For instance, Singh et al. (2006) analyse the adoption pattern and constraint of Basmati rice in north India. Mendola (2007) modelled the adoption of rice varieties on poverty reduction in rural Bangladesh applying a propensity-score marching analysis. Likewise, Minten and Barret (2008) examined rice technology adoption and studied the link between agricultural performance and rural poverty in Madagascar, using spatially-explicit dataset. Samaddar and Das (2008) investigated ecological differences between the drought-prone and wet zones affecting the adoption of rice technology in two villages of West Bengal, India. Likewise in Pakistan, Iqbal, Khan and Ahamad (2002) analysed the adoption of recommended wheat varieties in irrigated Punjab province using the probit model. In Nepal, Ransom et al. (2003) used the adoption of maize varieties in the hills of Nepal. Joshi and Pandey (2006) examined farmers' perceptions and adoption of modern rice varieties in two districts of southern Nepal. In Africa, CIMMYT with collaboration of national research institutes conducted 22 micro-level studies on adoption of improved varieties of wheat and maize, as well as chemical fertilizers in Ethiopia, Kenya, Tanzania, and Uganda. In America, Mather et al. (2003) analysed the adoption of disease resistant bean varieties in Honduras.

3.2.3 Analyses of adoption behaviour in Nepal: current status and research gaps

Studies on the adoption and diffusion of agricultural innovations begin after the Green Revolution, South Asia in general and Nepal in particular. However the pace of research on adoption and diffusion of agricultural innovations conducted by economists and other researchers in Nepal is found to be slow as in the case of the implementation of Green Revolution. Though the literature shows that studies on technology adoption and diffusion were carried out on staple food crops such as rice, wheat and maize, mainly as parts of the project reports. However, some studies show that the research on maize in an organized way was initiated in 1965 (Paudyal and Poudel, 2001). Based on the information available in journals and other publications, the adoption studies started in the beginning of 1980. For instance, Upadhaya et al[15]. (1983) examined the adoption and impact on productivity of modern varieties of rice in Nepal using a Tobit model. They found low irrigation level and poor irrigation facilities as constraints to adopt high-yield modern varieties. Malla (1983) applied the logit model to analyse the adoption of modern varieties of rice and fertilizers in Dhanusa district of Nepal, in which the factors affecting adoption decisions were schooling, family size, farm size, proportion of irrigated land, and extension services. Another study conducted by Khadka

[15] This paper was based on the data G.B. Thapa's PhD dissertation entitled "The impact of new agricultural technology on income distribution in the Nepalese Terai" (submitted to Cornell University in 1989) and H.K. Upadhaya's PhD dissertation entitled "Labour market effect of modern rice technology and its implications on income distribution in Nepal" (submitted to University of Philippines in 1988).

(1983) on factors influencing the adoption of modern rice varieties and fertilizers in the south-eastern part of Nepal applying both multivariate probit and Tobit models, shows that higher frequency of irrigation, tenure status and access to credit significantly influenced the adoption decisions. These factors are also found influential in the adoption decisions of improved maize varieties in Chitwan district (Paudel and Matsuoka, 2008), in *Terai*, the southern part of Nepal (Shakya and Flinn, 2008), and in mid-hills of Nepal (Karki and Bauer, 2004).

Pachico and Ashby (1983) examined the study of the diffusion of new rice varieties among small farm holders in Nepal and recommended to decentralize the biological screening to small-scale site specific trials with farmers, highlighting the need of extension efforts. Floyd et al. (2002) conducted an adoption study of 15 improved technologies including agriculture, horticulture, livestock and forestry production in the western hills of Nepal. They applied both univariate and multivariate statistical methods to analyse the data suggesting that the adoption decisions are largely influenced by the extension input, ethnicity and household food self-sufficiency of the household. The result shows that only 10 percent households are multiple adaptors (of about four technologies).

Ransom et al. (2003) applied the Tobit model to analyse the adoption of maize varieties in the hills of Nepal. There are many studies conducted by Nepal Agricultural Research Council (NARC) staff in collaboration with CIMMYT in Nepal, particularly in the area of new varieties of maize and wheat and the adoption decisions of these varieties (Adhikary et al., 2001; Aquino et al., 2001; Paudyal and Poudel, 2001; Tripathi et al., 2006; Ortiz-Ferrara et al., 2007).

There are also a number of studies on the adoption of rice varieties in Nepal and these studies tried to capture the famers' perceptions on adoption decisions. For instance, Joshi and Pandey (2006) analysed the farmers' perception and adoption of modern rice varieties. The results show that in addition to farm and farmer characteristics, farmers' perception towards new technology is also important in adoption decisions. Joshi and Bauer (2007) examined the loss of Nepali rice landraces and the factors affecting the probability of cultivating the most dominant landraces. Their result shows that changes in the production environment, farmers' preferences for consumption and market integration have influenced the adoption of rice landraces. Moreover, Dusen, Gauchan and Smale (2007) examined the adoption of various rice varieties in Nepal testing for simultaneity in the decision to plant landraces or the decision to plant modern varieties, and whether their decision to plant particular landrace constituted the genetic diversity of interest for future crop improvement. Their results support the simultaneity in decisions in certain cases.

With regard to analytical models in adoption decisions of improved varieties of seeds and fertilizers, all reviewed studies except (Dusen, Gauchan and Smale, 2007[16]) used the conventional static models modelling the decision as a single equation such as logit, probit and Tobit using cross-section data. Hence the study of the adoption of improved seeds and inorganic fertilizers considering simultaneity in decisions of both technologies seems to be important to fill the gap in the research of agricultural technology adoption in Nepal. To better understand farmers' adoption decisions, one needs to assess whether farmers take adoption decisions of improved seeds and fertilizers separately or simultaneously over time.

In Nepal, many studies in the past have given emphasis on the analysis of adoption of modern varieties of seeds and other technologies such as inorganic fertilizers and land conservation practices separately without paying more attention on the simultaneity decisions of adopting more than one farm technology, while most of these studies used cross-section data. However, there is growing concern in the farm technology adoption literature that adoption behaviour of farmers using simultaneous decisions seems to be plausible, particularly in the developing world like Nepal due to pervasive market imperfections. Moreover, adoption is a dynamic process and farmers often adopt new technologies through learning process. Adoption analysis using panel data may capture the dynamic process of adoption by learning.

3.3 Theoretical framework of the study

Over the last few decades, various theories based on the foundation of microeconomics have been applied to development issues. These theoretical approaches argue that the neoclassical explanations of household responses may not capture the behaviour of economic agents in many low income countries due to pervasive market imperfections arising from high transaction costs and imperfect information. These market imperfections are particularly common in relation to land resources, labour, credit, risk/insurance, and some basic commodities (de Janvry, Fafchamps and Sadoulet, 1991). More recently, theories of incomplete and imperfect markets have been incorporated into the modelling of the agricultural household responses in various sectors such as farm technology adoption decisions in rural settings. This approach suggests that the assumption of perfectly competitive markets is not plausible in resource poor economies due to weak formal institutions (e.g., finance, public services, government) and informal problems, such as imperfect monitoring of labour or imperfect information on borrowers that contribute to incomplete or missing markets (e.g., labour, land, credit and insurance). Under this prevailing market structure, household preferences and market imperfections (e.g., in capital markets) are not independent; and lead to

[16] This study concerns more on the conservation of crop diversity of rice varieties rather than the adoption and diffusion of agricultural innovations.

non-separable household models, where production decisions are affected by the consumption decisions of the household (Eswaran and Kotwal, 1989). In this theoretical framework, technology adoption processes need to focus on the decisions making of farmers regarding the use of technologies at each point by taking into account the prevailing factor markets. The study thus aims to analyse farm technology adoption decisions under the conceptual framework of the imperfect factor markets in which the insights are mainly drawn from Feder Just and Zilberman (1985), Feder and Onchan (1987), Doss (2006), and Yesuf and Kohlin (2008).

The theoretical framework of the study is therefore based on the farm household model under incomplete and imperfect factor markets, where farmers' decisions over a given period of time are assumed to be derived from the maximization of a discounted utility of farm profit subject to labour and credit constraints. Farm profit is a function of the farmers' choice of mixed technologies, in which for a discounted expected utility maximising decision maker, adoption decisions of both technologies are taken jointly. For instance, the decision to adopt improved seeds and inorganic fertilizer is made simultaneously (Smale, Just and Leathers, 1994). In addition to the technology used for production, other factors such as household and land characteristics, *ex ante* and *ex post* risks, and subjective discount rates can also affect farm profits. However, the adoption of technologies in agricultural households depends on whether the discounted expected utility with adoption is larger than without adoption. In other words, adoption decision about new technologies compared to the traditional is primarily based on the motive of farm profit maximization.

Consider a farm household in which adult male and female jointly decide the consumption goods (C) and their time endowment (T) between work and leisure (*l*). The household produces food crops on fixed land using labour, seeds and other inputs such as fertilizers and pesticides. The household maximization problem deriving from the utility function with production, time constraint and income constraints (Fernandez-Cornejo et al., 2005) defined as:

(3.2) $$Max\ U = U(C,l)$$

subjective to following constraints:

(3.3) production: $Q = Q(L, X)$,

(3.4) time constraint: $T = L_h + l$, and

(3.5) income constraint: $P_c C = P_q Q + w(T - l) + K$.

Where Q is the quantity of output produced. L is the total labour time used for production (i.e. $L = L_h + L_m$) and L_m is hired labour and ***K*** is non-labour income (e.g., pension, interest, dividends and other social securities). P_c and P_q are the prices of consumption goods and farm outputs.

The model assumes that farmers are price taker either in the national market or in the local market. By substituting (3.4) into (3.5), household full income is obtained as:

(3.6) $$P_c C = P_q Q + w(L_h - L_m) - P_x X + K,$$

combining equations (3.6) and (3.3), the expression (3.2) can be maximized subject to full income constraint (3.6):

(3.7) $$\ell = U(C,l) - \lambda\{P_c C - P_c Q - w(L_h - L_m) - P_x X + K\} - \varphi Q(L,X)$$

where λ and φ are the Lagrange multipliers associated with full income and production constraints. First Order Conditions (FOCs) associated with consumption goods are:

(3.8) $$\begin{cases} \dfrac{\partial \ell}{\partial C} = U_c - \lambda P_c = 0 \\ \dfrac{\partial \ell}{\partial l} = U_l - \lambda w = 0 \end{cases}$$

the equations show that the marginal rate of substitution between consumption goods and leisure is equal to the ratio of the wage rate and the price of consumption goods. The FOCs for production constraint are:

(3.9) $$\begin{cases} P_q + \dfrac{\varphi}{\lambda} Q' = 0 \\ w - \dfrac{\varphi}{\lambda} Q_L = 0 \\ P_x - \dfrac{\varphi}{\lambda} Q_x = 0 \end{cases}$$

The last two equations imply that the value of marginal products is equal to the factor prices. At the optimum level, the demand for labour input on farm is:

(3.10) $L^* = L(P_q, w, P_x, K)$ and

the demand for factor input is:

(3.11) $$X^* = X(P_q, w, P_x, K).$$

These equations show that input demand functions are determined by the prices of farm output goods, factor inputs and household full income. If the optimal input demand functions are substituted in the production function, then the supply function of farm output can be written as:

(3.12) $$Q^* = F(P_q, w, P_x).$$

Finally the maximum household income may be expressed as:

(3.13) $$\pi^* = P_q F(P_q, w, P_x) + wL^* - P_x X^* + K$$

As discussed earlier, adoption of new technology is based on the expected utility of farm profit. Let A_{ij} be the adoption decision of seed *j* (equals to1 if improved and 0 traditional or local seeds) by farmer *i*. Farmer may adopt new technology (e.g. improved seeds) if the difference of expected farm profit between new and traditional or local is greater than zero, which is given as:

$$(3.14) \qquad \begin{cases} A_{ij} = 1 & \text{if } E(\pi^*_{i1}\text{-}\pi^*_{i0}) > 0, \text{and} \\ \quad = 0 & \text{if } E(\pi^*_{i1}\text{-}\pi^*_{i0}) < 0. \end{cases}$$

If the household used new technology, then it equals one otherwise zero. The term $E(\pi^*_{i1} - \pi^*_{io})$ is the difference of the expected gains in profit between improved varieties of seeds and local or traditional seeds. If the household used improved seeds, then the expected farm profit using improved seeds (π^*_{i1}) exceeds the expected farm profit using traditional or local seeds (π^*_{io}). This expression can also apply in the adoption of inorganic fertilizers in a similar way.

The theoretical framework presented here is the simple mathematical interpretation. However, on empirical application, the adoption of improved seeds ($iseed_{ht}$) and inorganic fertilizer ($ifert_{ht}$) may be influenced by the factors such as alternative technologies applied by the household *i*, the profitability index of the technology adopted on the farm land *l* ($pftl_{ht}$), the ownership of land ($ownl_{ht}$), the household's access to credit and labour markets ($clmkt_{ht}$), the household's information on new technology ($ntif_{ht}$), whether households receive any remittance income (R_{ht}), and other random factors such as μ^{isd}_{ht} and μ^{ift}_{ht}, representing improved seed and inorganic fertilizer adoption decisions respectively. These random factors are assumed to have zero mean and constant variance.

A growing body of literature defines the decision to adopt soil conserving and/or output enhancing technologies depending on the perception of soil erosion and soil fertility (Pender and Kerr, 1996; Shiferaw and Holden, 1999; Yesuf and Kohlin, 2008). This study assumes that the farmers' perception of technology adoption depends on farm/plot characteristics (lc_h) — such as plot/farm size, soil quality, irrigation facility of land, and ownership of land; human capital of the household (hc_h) as measured by family size (or number of adult members the households), gender, age and education; and agro-ecological characteristics (ac_r) — such as rainfall and temperature[17]. Although, there could also be other factors such as farmers' perceptions of adoption decisions and risks associated with new technologies, these factors are not included in this model due to lack of data availability. The functional relationship of the adoption of improved seeds and inorganic fertilizers in this study can be specified as:

$$(3.15) \qquad iseed_{ht} = f(ifert_{ht}, pftl_{ht}, ownl_{ht}, clmkt_{ht}, ntif_{ht}, R_{ht}, lc_h, hc_{ht}, ac_r, \mu^{isd}_{ht});$$

[17] This study will analyse from both plot level (GMM for reduced form GMM probit for period 1 and Linear Probability Model and structural probit model for period 2) and farm level (Tobit model) characteristics.

(3.16) $ifert_{ht} = f(iseed_{ht}, pftl_{ht}, ownl_{ht}, clmkt_{ht}, ntif_{ht}, R_{ht}, lc_h, hc_{ht}, ac_r, \mu_{ht}^{ift})$.

Market proximity and road access are often included in the model, considering as factors affecting the adoption of new technologies. The conventional argument for use of such exogenous variables is that greater access to roads and markets can promote adoption of new technologies such as improved seeds and inorganic fertilizers in farm production due to higher possibilities of access to resources in both input and output markets. In Nepal, areas located near cities have more diversified and more market-oriented activities (Fafchamps and Shilpi, 2005), and improving road access to markets confers substantial economic benefits on average (Jacoby, 2000). On the other hand, theory assumes that better road access to markets may also lead to higher off-farm employment opportunities that can take away labour from the farm sector, and then may discourage investment in the adoption of new technologies on farms, if the new technology is more labour intensive. This ambiguous effect of distance from the market and paved road needs to be taken into account while analysing farm technology adoption decisions. The study also uses extension services received by farm households as a variable for households' information about technology.

The assumption of missing or incomplete markets for inputs and output, including labour and capital, has become common in micro-level research on most developing countries' rural economies. The literature on these issues takes the view that rural households are systematically exposed to market imperfections and constraints, referred to as "failures", and their behaviour cannot be understood without reference to the specificity of these failures (Thorbecke, 1993). These failures are characterized by partial engagement in markets, which are often imperfect or incomplete (Ellis, 1992). Under these circumstances, farm households with limited access to credit and labour are relatively more affected than those households with higher access to resources. In other words, credit-constrained households adopt a more diversified crop portfolio and make less use of high yielding varieties (Morduch, 1990). In Nepal, farm credit is considered as one the constraints limiting the adoption of high yielding and high value crops (ADB, 2004). However, there are many credit programs such as micro credit, Small Farmers Development Program (SFDP) under the Agricultural Development Bank/Nepal, Intensive Banking Program under the Commercial Banks targeting small farm holders, and many saving and credit programs initiated by Non-Governmental Organizations (NGOs). However, access to these programs by small holders and poor farmers is limited. The survey report of NLSS II shows that about 69 percent of households received loans, of which only 15.1 percent got loan from banks and 2.3 percent from NGOs/Relief Agencies, while the rest of the loans were received from informal sectors (e.g., businessmen, relatives and local money lenders). The credit borrowed for the purpose of business or farm use only constitutes 24.2 percent of the total loan disbursement (CBS, 2004). Evidence from the formal sector shows that total loan charges, including interest, transactions cost, and corrupt side payments, have remained high (Adams, Brunner and Raymon, 2003). This is likely to inhibit taking loans from formal institutions for credit-constrained farmers who are keen to adopt new farm technologies. The marginal contribution of credit in farm investment is more likely to be high in households that have a higher binding constraint than in those of that are less-constrained (Simtowe and Zeller, 2006). Under prevailing market conditions, the theory hypothesizes that credit-liquidity constraint affects the adoption decision about new farm technologies, implying that liquidity less-constrained households have higher probabilities of adopting new farm technologies than liquidity constrained farmers. In addition, it is also hypothesized that seed-fertilizer technologies associated with the Green Revolution are relatively more labour-intensive than traditional varieties and practices (Farmer, 1986). Adoption of improved seeds and fertilizers can be influenced by the prevailing labour market and household labour endowment. In other words, households with higher number of family members can have more possibilities to adopt external inputs than lower number of family members, particularly under missing or incomplete labour markets.

The literature also explained that non-farm income such as remittances can have impact on farm investments. It is discussed in the literature such as “The New Economics of Labour Migration” that migrants can play the role of financial intermediaries, enabling rural households to overcome credit and risk constraints on their ability to achieve the transition from subsistence to commercial production (Stark, 1991). However, the effect of remittances can be ambiguous. Remittances can have positive effect on farm technology adoption, particularly on credit constraint households; on the other hand, the effect may be negative for labour constraint households because of loosing a family member due to migration, especially under the incomplete and missing markets.

Adoption decisions about new farm technologies are also associated with property rights over farmland. A substantial number of studies explore the condition that farmers are more willing to invest in land improvement under which they have security of land tenure (Feder, Just and Zilberman, 1988; Basely, 1995; Deininger and Jin, 2006). The rationale for this hypothesis can be analysed in terms of three positive effects (Basely, 1995): (i) security-induced demand for investment; (ii) collateral availability; and (iii) the potential for gains-from-trade. However, there are two specifications in the context of Nepal: first, land rights are fully secured in terms of buying and selling, collateral for loan, and production decisions; and second, the adoption of improved seeds and fertilizers is more likely to be a short-term phenomenon (e.g., at least for one crop cycle), which may not be affected even if farmers do not have property rights (e.g., sharecroppers or renters). In Nepal, sharecropping is quite common and the contracts for sharecropping are usually for a minimum of one crop cycle. New farm technologies, the cost and benefit streams of which are very short duration, will be less affected by property rights than those with lengthier benefit streams (Place and Shallow, 2000). Nevertheless, credit-constrained farmers may be affected by the ownership of land, implying that the adoption decisions about new farm technologies are likely to be lower in share-cropping land, because land ownership is often considered as prerequisite for obtaining credit (Doss, 2006). Land ownership also enhances capital formation by providing better incentives and improved access to credit (Feder and Onchan, 1987). Hence, the relationship between new farm technology adoption and land ownership may depend on the liquidity availability to individual farmers. If farmers are liquidity-constrained, then land ownership increases the probability of farm technology adoption.

The impact of farm size on the technology adoption decisions is one of the key issues in most developing countries. It is often hypothesized that small farms could limit adoption due to high fixed costs especially for tractors, tubwells and oxen and tend to adopt more slowly than large farms. The relationships between farm size and intensity or farm size and technology adoption are still debated on the academic arena. Two paradigms address this issue (Yesuf and Kohlin, 2008): one is Boserupian theory, which argues that due to population pressure, small farms lead to intensive use of land through adoption of new technologies; and the second is new-Malthusian group, which argues that population pressure leads to the cultivation of marginal lands, and then degrade the land. The impact of farm size on respect to technology adoption can be positive or negative.

The impact of access to information on the adoption decision is one of the policy variables (Doss, 2006). Several studies have shown that adoption decisions are likely to be dependent on information about new technologies (Zhao, 2005), since farmers do not adopt new technologies without adequate information. Increased information about new technologies is likely to increase adoption decisions, when new technologies are profitable to farmers. In other words, the variable (i.e. access to information) can show some indications regarding the government performances in disseminating information to the farmers about new technologies. To operationalize this variable, extension services are often used as a measurement (Doss, 2006). One way to measure the variable of access to information is a binary one, which is based on whether farmers receive any extension services from the government offices. However, there are other ways to measure the variable of access to information such as the number of extension services received by the farmers (Herath and Takeya, 2003), and whether or not they received any extension services during a particular period (Ranson, Paudyal and Adhikari, 2003). Other approaches to measuring access to information could be farmers' perceptions about the particular technology. This study includes only the dummy variable whether or not farmers received any extension services.

Regardless of the many factors affecting technology adoption decisions, development economists often believe that the slow diffusion of new technology could be the key to understanding the persistent poverty of subsistence farmers in low income countries, as slow diffusion may reflect individual risk attitudes and social learning processes. These determinants can not be observed or assessed directly from standard household surveys. However, these factors are often captured in models by the variable of access to credit due to the existence of interlinked markets in rural settings. For instance, liquidity-constrained households use credit as insurance. The literature shows that poor and small farm holders have high consumption smoothing problems and therefore high subjective discount rates, which in turn discourage land investment decisions (Holden, Taylor and Hampton, 1998; Yesuf and Kohlin, 2008). Moreover, farmers' risk preferences may also affect the adoption decisions of new technologies. A number of studies have empirically investigated technology adoption taking into account farmer's perceptions about the degree of risk concerning future yields (Feder and Umali, 1993). This study does not include any individual risk preference variable in the model due to unavailability of data. However, microeconomic theory often shows that under missing or incomplete markets, access to credit is often used as a proxy for risk preference, particularly risk-averse farmers who may use credit as an insurance that may also reduce the subjective discount rate and consumption risk of the farm households. In addition, some authors also use wealth as a proxy for risk aversion (Erin et al., 2001).

3.4 Data set and descriptive statistics

The data used in this paper are the part of Nepal Living Standard Survey (NLSS) panel data compiled during surveys conducted in 1995/96 and 2003/04 covering almost all parts of the country. These were nationally representative surveys of households and communities undertaken by the Central Bureau of Statistics with technical and financial assistance from the World Bank. The panel data include 952 households in each survey, covering both rural and urban households as well as farm and non-farm activities. The analysis is based on households having some sort of activities on farms: owned, rented or sharecropped. Since the main objective of the study is to explore the determinants of technology adoption decisions, the data cover plot level information on the adoption of improved seeds for rice, wheat, maize, seasonal vegetables, and other crops and inorganic fertilizers. However, the data do not cover the intensity of new technology used on the plot.

The data include the characteristics of sampled households, farm and non-farm activities, adopters and non-adopters, socioeconomic and locational characteristics covering all agro-ecological zones and all regions of Nepal. The data also cover plot level characteristics such as size, irrigation facility and soil quality. A total of 4352 farm plots[18], including both owned and share-cropped plots, are reflected in the data, where the average plot size is 1.16 hectares. Table 3.1 further shows that about 68 percent of plots and 65 percent of farm households used inorganic fertilizers and the use of improved seeds both new and recycled is about 43 percent of the total plots and 34 percent of total farm households. The survey also provides the information on the amount spent on the adoption of improved seeds and inorganic fertilizers, including other information such as farm credit, labour status (hired or family) and extension services from the Agriculture Development Office.

3.5 Econometric specification

This study examines factors affecting the adoption decisions about improved seeds and inorganic fertilizers considered as new farm technologies, under the assumption of incomplete or imperfect markets. The basic assumption is that farmers make adoption decisions about improved seeds and inorganic fertilizer jointly. A single equation approach to determine whether improved seeds affect fertilizer use is subject to simultaneity bias. The bivariate probit model, which is a natural extension of the probit model, enables us to control for the simultaneity problem as suggested by Maddala (1983). However, in this paper, I use a Generalized Method of Moments (GMM) procedure as an alternative due to some identification problems in the bivariate probit model. Identification problems possibly arise in the simultaneous equations such as bivariate probit models, if the exogenous variables included in the second equation are exactly the same as in the first equation. Parameters that are not identifiable cannot be estimated and there need to have exclusion restrictions if there is no variation of the exogenous regresssors (Wilde, 2000). As the main purpose of the paper is to explore technology adoption decisions, other non-technology variables which can have effects on technology adoption decisions are assumed to be exogenous. The structural equations are as follows:

$$(3.17) \qquad \begin{cases} iseed_{it}^{*} = \alpha_1 ifert_{it}^{*} + \alpha_2^{'} x_{it} + \varepsilon_{\mathrm{it}}^{1} & \mathrm{iseed}_{\mathrm{it}} = 1\,(\text{if } \mathrm{iseed}_{\mathrm{it}}^{*} > 0,\ 0 \quad \text{otherwise}) \\ ifert_{it}^{*} = \beta_1 iseed_{it}^{*} + \beta_2^{'} x_{it} + \varepsilon_{\mathrm{it}}^{2} & \mathrm{ifert}_{\mathrm{it}} = 1\,(\text{if } \mathrm{ifert}_{\mathrm{it}}^{*} > 0,\ 0 \quad \text{otherwise}), \end{cases}$$

where $iseed_{ht}^{*}$ and $ifert_{ht}^{*}$ are latent dependent variables referring the household's adoption decisions about improved seeds and inorganic fertilizer respectively. x_{it} is the vector of explanatory variables, α and β vectors of unknown parameters, and ε_{it}^{1} and ε_{it}^{2} are the error terms of respective equations. The model has the following characteristics: the first is that the dependent variables are binary; the

[18] This study is based only on same plot repeated in the period 2 of the two-year panel data. Those plots which are not matched in the both year are deleted from the analysis.

second is that the binary dependent variable of first equation is entered as covariate in the second equation and vice versa; the third is that the unobserved heterogeneities of the two decisions are assumed to be correlated i.e. $E[ifert_{it}, \varepsilon_{it}^{1}] \neq 0$ and same for the $E[iseed_{it}, \varepsilon_{it}^{2}] \neq 0$.

The econometric literature also shows the frequently used two-stage for the probit and logit models with endogenous regressors, as suggested by Maddala (1983), to be inconsistent – see Dagenais (1999). The two-stage logit or probit approach is often problematic due to possible complexity arising from the external (i.e. direct effect through exogenous variables) and the internal (i.e. indirect effect through the same exogenous being as an endogenous variable) validity of instrumental variable interpretation. Consistency of two stage estimators depends on their allowing the interpretation of instrumental variables. The nonlinearity of the logit and probit estimators prohibits an instrumental variable interpretation of the corresponding two stage estimator. It is therefore no basis for asserting these estimators to be consistent. By contrast, the Linear Probability Model (LPM) can be consistently estimated either by two stage least squares or instrumental variables and gives consistent parameter estimates. However, the LPM fitted values lack a probability interpretation (since they can lie outside the zero-one interval). Using GMM, the LPM can give consistent estimates of the average impact of exogenous variables on the dependent variables (e.g., adoption of improved seeds and inorganic fertilizers), as a function of the observed variation. LPM may also provide good estimates of the partial effects on the outcome probability close to the centre of the distribution of exogenous variables.

Moreover, Generalized Method of Moments (GMM) gives estimates that are both consistent and allow probability interpretation (Dagenais 1999; Wilde 2008). GMM can also exploit the sample moment counterparts of population moment conditions of the data generating process and it has large sample properties which are easy to characterize in ways that facilitate comparison and can also be constructed without specifying the full data generating process. In addition, GMM is found to be relevant in various reasons: (a) many estimators (e.g., OLS, IV) are special cases of GMM; and (b) GMM is often possible where a likelihood analysis is extremely difficult. The method needs only a partial specification. GMM also provides a means for testing over identifying restriction on which the structural parameters estimates are based (Newey, 1985). GMM model fits the probit models applying maximum likelihood by methods of moments. In addition, GMM is also common approach to apply in case of facing problem of heteroscedasticity, because it makes use of the orothgonality conditions to allow for efficient estimation in the presence of heteroscedasticity (Baum et al., 2003). GMM is usually applied method for the estimation of instrumental variables.

Since the main purpose of this study is to examine the factors affecting adoption of new technologies and to test whether farmers take adoption decision jointly, the bivariate equations without exclusion of some variables either of the equation may create the problem of identification which is common problem in simultaneous equations. Due to absence of instrumental variables in this data set, the study uses GMM in lieu of bivariate probits, incorporating the predicted values ($\hat{iseed}_{i1}, \hat{ifert}_{i1}$) of reduced form probit models[19] obtaining from the period 1 (1996) as instruments for period 2 (2004). In the second stage, this paper estimates Linear Probability Model (LPM) structural equations using predicted values of period 1 and other variables such as $iseed_{i1}$, $ifert_{i1}$, and the proportion of household using improved seeds and inorganic fertilizers in the sample unit as instruments. Finally, this exercise estimates the structural GMM probit with moment restrictions. The estimates derived from the probit models for period 1, combined with period 2 are also discussed as supporting evidences. In addition to this, I also estimate both random effects and simple Tobit models from panel data based on the household level data in order to test some consistency and robustness in the results. The econometric models applied in this study presented from the period 1 probit model to the period 2 LPM and GMM probit models and then Tobit models follow as:

Probit model for period 1

Probit estimation is based on underlying latent variable of $iseed^*_{i1}$ and $ifert^*_{i1}$ (adoption of improved seeds or inorganic fertilizers respectively) with the explanatory variables x_{i1}. The vector β contains K deterministic coefficients and ε_{i1} denotes error term. The model is expressed as (cf. Bertschek and Lechner, 1998; Greene, 2004):

(3. 18) $$\begin{cases} iseed^*_{i1} = x_{i1}'a_1 + \varepsilon^1_{i1} \\ ifert^*_{i1} = x_{i1}'b_1 + \varepsilon^2_{i1} \end{cases},$$

where $iseed_{i1} = 1\left(iseed^*_{i1} > 0\right)$,and $ifert_{i1} = 1\left(ifert^*_{i1} > 0\right)$ i= 1, ….,n and *iseed*= improved seeds, *ifert*=inorganic fertilizers. $iseed = (iseed_1^{'},......,iseed_N^{'})'$ and $ifert = (ifert_1^{'},......,ifert_N^{'})'$ are $N\times 1$ vectors and $X_1 = (x_{11}^{'},....x_{N1}^{'})'$ is an $n\times K$ matrix of regressors. Latin letters (a, b) denote reduced form coefficients and Greek letters (α, β) the corresponding structural coefficients. Coefficients are allowed to differ across the two periods. The error terms $\varepsilon_i^m = (\varepsilon_1^{'},....,\varepsilon_N^{'})'$ (m=1,2) are assumed to be jointly normally distributed with zero mean and diagonal covariance matrix Σ . Errors are taken to be independent across the two periods. These assumptions imply that I can set the error variances to unity without loss of generality. The explanatory variables should be independent with Σ that implies strict exogeneity.

[19] In the case of simple binary equation, probit model performs better results in terms of the smallest standard errors and high adjustment R.-square and also solve the problem of the LPM (lying outside zero-one interval), while in the case of simultaneous equations, LPM performs better than probit model.

The conditional expectation of $iseed_{i1}$ given x_i is;

(3. 19) $$\begin{aligned} E[iseed_{i1}|x_i] &= \Pr(iseed_{i1}=1|x) = \Pr(iseed^*_{i1}>0|x_{i1}) \\ &= \Pr(\varepsilon^1_i > -x_{i1}'a_1 \\ &= 1-\Phi[-(x_{i1}'a_1)] \\ &= \Phi(x_{i1}'a_1) \end{aligned}$$

$\Phi(.)$ is the standard normal cumulative distribution function. Likewise, the conditional expectation of $ifert_{i1}$ given x_{i1} can be calculated in the same way because of same exogenous variables and the standard normal cumulative distribution function for $ifert_{i1}$ is $\Phi(x_{i1}'b_1)$.

The typical approach to deal with probit models is to apply maximum likelihood (**ML**) based on single cross-sections (cf. Maddala, 1983);

(3.20) $$\begin{cases} \ln L(a_1 | X_1) = \sum \ln \Phi(x_{i1}'a_1) + \sum \ln\{1-\Phi(x_{i1}'a_1)\} \\ \ln L(b_1 | X_1) = \sum \ln \Phi(x_{i1}'b_1) + \sum \ln\{1-\Phi(x_{i1}'b_1)\} \end{cases},$$

this model is appropriate under the assumption that the error variance matrix is diagonal.

LPM and Structural GMM for period 2

The process of GMM for this analysis is described as follows. Let z_{i2} be a $(1\times G)$ vector of instruments[20] which may contain some or all of the determinants of $iseed_{i2}$ and $ifert_{i2}$. In particular, I include the period 1 reduced form fitted values of $iseed_{i1}$ and $ifert_{i1}$ as instruments. Let w_{i2} represent the vector $\{iseed_{i2}, ifert_{i2}, x_{i2}, z_{i2}\}$. Then the moment conditions can be defined as:

(3.21) $$\begin{aligned} g^1_i(w_{i2},\alpha_{20},\alpha_2) &= z_{i2}u^1_{12} = \left[(iseed_{i2} - \Phi(\alpha_{20} ifert_{i2} + \alpha_2' x_{i2}))\right] z_{i2} \\ g^2_i(w_{i2},\beta_{20},\beta_2) &= z_{i2}u^2_{12} = \left[(ifert_{i2} - \Phi(\beta_{20} iseed_{i2} + \beta_2' x_{i2}))\right] z_{i2} \end{aligned},$$

where α and β are the parameters to be estimated. It is assumed that the instrumental variables, z_i, satisfy the following orthogonality conditions:

(3.22) $$\begin{cases} E\left[g^1_{i2}(w_{i2},\alpha_{20},\alpha_2)\right] = 0 \\ \\ E\left[g^2_{i2}(w_{i2},\beta_{20},\beta_2)\right] = 0, \end{cases}$$

the corresponding sample moment conditions are

[20] Instrumental variables for improved seeds are the predicted value of period 1 (i.e. $iseed_{i1}$) for period two (i.e. 2004) and proportion of seed adoption in the particular village. For inorganic fertilizers, instrumental variables are the residual of fertilizers of period one ($ifert_{i1}$) for period two and the proportion of fertilizers adoption in the particular village.

(3.23) $$\begin{cases} g_n^1(\alpha_{20},\alpha_2) = \dfrac{1}{n}\sum_{i=1}^{n} g(w_i,\alpha_{20},\alpha_2) = \dfrac{1}{n}\sum_{i=1}^{n} z_{i2}(iseed_{i2} - \Phi(\alpha_{20}ifert_{i2} + \alpha_2^{'}x_{i2})) \\ g_n^1(\beta_{20},\beta_2) = \dfrac{1}{n}\sum_{i=1}^{n} g(w_i,\beta_{20},\beta_2) = \dfrac{1}{n}\sum_{i=1}^{n} z_{i2}(ifert_{i2} - \Phi(\beta_{20}iseed_{i2} + \beta_2^{'}x_{i2})) \end{cases}.$$

GMM estimates are obtained by minimizing

(3.24) $$\begin{cases} J_1(\alpha_{20},\alpha_2,\Lambda_1) = g_n(\alpha_{20},\alpha_2)'\Lambda_1^{-1}g_n(\alpha_{20},\alpha_2) \\ J_2(\beta_{20},\beta_2,\Lambda_2) = g_n(\beta_{20},\beta_2)'\Lambda_2^{-1}g_n(\beta_{20},\beta_2) \end{cases},$$

for arbitrary weighting matrices Λ_1 and Λ_2. The optimal GMM estimators result by choosing

(3.25) $$\begin{cases} \Lambda_1 = \hat{\Lambda}_1 = \dfrac{1}{n}\sum_{i=1}^{n}\left(z_{12}e_{12}^1\right)\left(z_{12}e_{12}^1\right)' \\ \Lambda_2 = \hat{\Lambda}_2 = \dfrac{1}{n}\sum_{i=1}^{n}\left(z_{12}e_{12}^2\right)\left(z_{12}e_{12}^2\right)' \end{cases}$$

where $e_{12}^1 = iseed_{i2} - \Phi(\hat{\alpha}_{20}ifert_{i2} + \hat{\alpha}_2^{'}x_{i2}$ and $e_{i2}^2 = ifert_{i2} - \Phi(\hat{\beta}_{20}iseed_{i2} + \hat{\beta}_2^{'}x_{i2})$, the estimated structural residuals.

The Tobit model

It has been suggested in the literature that the binary choice model seems to be more appropriate in the context of farmers growing either local varieties or improved seeds exclusively (Feder et al., 1985; Doss, 2006). On other hand, in the case of partial adoption of both improved seeds and inorganic fertilizers, a continuous measure of adoption is more appropriate (Doss, 2006), since it allows the use of the Tobit model by enabling it to capture the behaviour of adopters. The estimates compare both results (e.g., reduced form probit and structural probit using GMM and Tobit) for consistency of the outcomes. The Tobit model is used to estimate better the adoption behaviour of farm households. The model, originally developed by James Tobin (1958), is expressed as:

$Y_{it}^j = \max(Y_{it}^{j*},0)$ j= [improved seeds, inorganic fertilizers],

where the Y_{it}^{j*}'s are latent variables generated by the classical linear regression model

(3.26) $$Y_{it}^{j*} = X_{it}^{'}\delta + \gamma_i^j + \mu_{it}^j,$$

where δ is the vector of coefficients, X_{it} is the set of explanatory variables, and the error term μ_{it}^j is assumed to be independent with X_{it} and is independently and identically distributed over time and across individuals. Unobserved time invariant characteristics of the households are captured in the individual effects γ_i^j. Y_{it}^{j*} is latent variable that is unobservable, and j refers to either the adoption of improved seeds or inorganic fertilizers. If the data are above the limiting factor, then Y is referred to the proportion of farm land used for improved seeds and inorganic fertilizers and observed as a continuous variable, if Y is at the limiting factor, then it remains at zero. In other words, the mathematical presentation of this relationship can be shown as follows:

$Y_{it}^{j} = Y_{it}^{j*},\ if\ Y_{it}^{j*} > 0,\ and\ Y_{it}^{j} = 0,\ if\ Y_{it}^{j*} \leq 0$.

These two equations represent a censored distribution of the data. For this, the Tobit model is used to estimate the expected value of Y_{it}^{j} as a function of a set of independent variables (X_{it}) weighted by the probability that Y_{it}^{j} >0 (Tobin, 1958). The estimated coefficients (δ) of the Tobit model do not give the direct effect as marginal effects, but it provides the relationship between dependent and explanatory variables.

The explanatory variables for the Tobit models are the same variables used in the previous section. These models are estimated without considering simultaneity decisions. Moreover, this study also analyses the simple Tobit models for period 1 and 2 as well as pooled from both periods by using same explanatory variables (e.g. in the probit and LPM models) which are as follows:

(3.27) $$tech_i = f(fsize, irrland, hirlab, farmcredit, atmarket, distroad, aextserv, z),$$

where $tech_i$ is the proportion of farm land under the adoption of either improved seeds or inorganic fertilizers and the explanatory variables are farm size (fsize), ratio of irrigation land (irriland), hired labour (hirlab), farm credit obtained, access to market (atmarket), distance to road (distroad), receiving agricultural extension services (aextserv) and other household characteristics (z) such as age and education level of household head and total adult members in the household.

3.6 Empirical results

3.6.1 GMM structural model results

Table 3.2 presents estimates of the GMM probit models using the moment restrictions for period 2 (i.e. 2004). The results show relatively higher Pseudo R^2 for the adoption of inorganic fertilizers (0.10) compared with improved seeds (0.06), which are not so unusual in two-stage binary regressions. The interpretation of Pseudo R-square is not same as in Ordinary Least Square (OLS) method. These values, however, often interpret like in OLS as an approximation of the proportion of variance of the response variables explained by the predictors. As discussed earlier, the use of GMM can reduce the problem of heteroscedasticity by allowing orthogonality conditions for efficient estimation even in the presence of heteroscedasticity. So heteroscedasticity would not be a problem for this analysis. As the main interest of this estimation is to investigate whether farmers decide both improved seeds and inorganic fertilizers simultaneously, the result shows only weak evidence about simultaneity decisions. The estimates show that farmers are likely to use inorganic fertilizers if they adopt improved seeds, but fail to establish the reverse effect. This result may be the fact that farmers adopt new technologies in a step-wise as in the result of Byerlee and Hesse de Polanco (1986). Few exogenous variables are found to be significant. For instance, the probability to adopt improved seeds is found to be positive with the variables: the number of adult members and head's age. The result further reveals that household with more information about new technologies may have higher probability of adopting new technologies allowing us to assume that farmers want to acquire adequate information about new technology before using it. This finding also indicates that the government should expand extension services throughout the country to increase agricultural productivity through the adoption of new technologies. Moreover, the lack of adequate information about new technologies also seems to be a major factor for not adopting improved seeds, revealing that farmers do not want to take more risks by using new varieties of seeds, as in the case of the adoption of improved varieties of maize in the hills of Nepal (Ranson, Paudyal and Adhikari, 2003) and in lowland zone of Tanzania (Kaliba et a., 2000), and modern varieties of rice in the southern part of Nepal (Joshi and Pandey, 2006). On the other hand, the probability of adopting improved seeds is likely to be low, if the local market from the household is far. The results of probability of adopting inorganic fertilizers are found to be similar with the adoption of improved seeds. However, there are some exceptions, for instance, the probability of adopting inorganic fertilizers is more likely to be positive, if the households hire farm labour. No significant difference between male and female headed households is found, suggesting that gender does not matter for the adoption of new farm technology at least in this model. Moreover, age and education level of household head are also not significant in these models.

The coefficients of irrigated land are significant and negative for both technologies, which are a bit surprising at least in these estimates and are counterintuitive with our hypothesis. Possible explanation may be that the majority farmers used improved seeds for those crops which might not frequently require irrigation. For instance, out of the total improved seed adopters, about 40 percent farmers used improved seeds for the summer crops such as maize and other vegetables which are normally cultivated on rain-fed land during the monsoon season and about 50 percent of the total farmers who adopted inorganic fertilizers, also used inorganic fertilizers for the summer crops. The negative sign of irrigated land may be the higher use of both technologies for the summer crops. Another possible explanation may be due to difference between direct and indirect effects of the same exogenous variable when it becomes endogenous in the model. Because irrigated land is positive in Tobit results. However, further investigation is necessary.

The results of probit GMM structural models do not conclusively demonstrate the simultaneity of decisions to adopt both technologies, but there is some evidence of simultaneity of adopting both technologies and simultaneity can not be ruled out while using adoption decisions, particularly in low-income countries, such as Nepal.

3.6.2 LPM results for period 2

Two-stage LPM for period 2 (i.e. 2004) is presented in Table 3.2, in which the model tests the simultaneity decisions. It is noteworthy to mention that the LPM coefficients are not directly comparable in scale with the probit estimates. The estimates in the LPM models are based on the robust standard errors, because in two-stage GMM for LPM, the results are often estimated in robust standard errors. So there is no need to test about heteroscedasticity. R-square values are 0.09 for improved seeds and 0.23 for inorganic fertilizers.

The results of LPM which includes the joint decisions of adoption of improved seeds and inorganic fertilizers show that the coefficients of both endogenous variables are significant and positive in the other equation, supporting the hypothesis of simultaneity in adoption decision of new technologies. The extent of their effect on the adoption decision varies. The results show that the probability to adopt improved seeds is found to be higher when farmers use fertilizers. Moreover, few exogenous variables are found to be significant in this model, with some of estimated parameters showing surprising results. For instance, the head's age has positive impact on the adoption of improved seeds, but negative on fertilizer adoption. Likewise, the coefficients of the number of adult members in the household show positive impact on improved seeds and negative on fertilizers, followed by similarly mixed results for distance from the market and paved roads. In addition, the coefficient of hired labour is found to be significant and positive for fertilizer adoption, and the coefficient of agricultural extension services is significant and positive for improved seeds.

3.6.3 Probit model results for period 1 and 2

Table 3.3 displays the results of reduced form probit models for period 1 and 2. As the probit models for period 1 estimated to obtain the predicted values as instrument for period 2, the results can provide some insights to compare probits models with period 2, as well as with Tobit models. The values of Pseudo R-square for probit models are 0.07 (period 1) and 0.05 (period 2) for improved seeds and 0.13 (period 1)and 0.22 (period 2) for inorganic fertilizers. The LR Chi-square statistics which have the same interpretation as F-statistics in OLS showing explanatory power of the regression equation, are significant and suggest that at least one of the regression coefficients in the model is not equal to zero.

The results in the probit model for period 1 show that the adoption of new technologies is significantly affected by the factor markets such as credit and labour markets in Nepal, implying that the probabilities of adopting modern varieties of seeds and inorganic fertilizers are positive for those farmers who employ farm labourers and obtained credit, combined with receiving agricultural extension services. These outcomes are also supported by the variable of the number of adult members in the sampled households which show that those with a higher number of adults lead to a higher probability of adopting new farm technologies, probably labour-intensive technology and existence of missing labour markets. This argument is also supported by the significant and positive sign of age of household head, assuming that higher age of household head may have better experience and information about new technology than relatively younger household head, and thereby can lead to a higher probability of technology adoption, if such technology is profitable to farmers. To summarize, the results support the hypothesis of incomplete or missing factor markets as binding constraints for the adoption of new farm technologies. However, the coefficients of education level of household's head show surprising results that the probability of adoption of new technologies is low, if the household head is more educated. The reason is perhaps due to more preferences to work in the off-farm sectors by the educated people.

The coefficients of plot size are found to be significant and positive for improved seeds and inorganic fertilizers, suggesting that farmers are more likely to adopt modern varieties of seeds (e.g., rice, maize, wheat etc.) in larger plot size. This outcome is found to be similar with the adoption of improved maize varieties in the hills of Nepal (Ranson, Paudyal and Adhikari, 2003). However, the coefficients of irrigated land and soil quality show mixed results. For instance, farmers are likely to use fertilizers in non-irrigated land than the irrigated land, while the adoption of improved seeds is likely to be high on the land where the soil quality is better.

Distance from the market can also affect the probability of adopting improved seeds, but not for inorganic fertilizers. However, distance from the paved road does not show any significant impact on adoption decisions at least in this data set.

The results of probit models for period 2 are found to be compatible with the results of probit models for the period 1 with some exceptions. For example, factor markets such as hiring labour and obtaining credit have positive impact on the adoption of new technologies. In a similar line, the number of adult members in the sampled households affects the possibility the decisions to adopt improved seeds and fertilizers. In addition, the coefficient of information about the new technology is also significant and positive, suggesting that agricultural extension services need to extend throughout the country.

The coefficients of distance from the market and distance to paved roads are also found to be significant and negative with an exception of the distance to paved road for improved seeds. This result implies that the probability of adoption is more likely to increase with an improvement in infrastructure facilities.

The results of plot size contrast with period 1 results, revealing that the adoption of new technologies is likely to be high in smaller plot size than the larger plot size. In addition, the results suggest surprisingly that adoption of both technologies is likely to be high on non-irrigated land than on irrigated land. The coefficients of soil quality do not show any effect on adoption decisions.

Some coefficients related to household characteristics are found to be significant. Male headed households are likely to use inorganic fertilizers than their female counterparts. There is also a positive impact of education level on fertilizer adoptions but not on improved seeds. This result contrasts with the coefficients for the period 1 probit models. Nevertheless, the coefficients of head's age are found to be compatible with period one.

3.6.4 Tobit model results

Random effects Tobit models for the adoption of improved seeds and inorganic fertilizers are presented in Table 3.4 for the purpose of comparing consistency with the probit results. The dependent variables used in these exercises are the proportion of land using improved seeds and inorganic fertilizers by the sampled households with the same exogenous variables used in previous models[21]. The results of Wald Chi-square tests which have the same interpretation as F-statistics in OLS and LR Chi-square in probit models, are significant, rejecting the null hypothesis that exogenous variables included in the models have zero influence.

The results of the random effect Tobit models are found to be consistent with the probit models, suggesting that access to credit and labour markets and agricultural extension services increase the adoption of both technologies. Human capital (i.e., head's educational level) and labour endowment in the sampled households also have positive impact on the adoption of improved seeds. The adoption of inorganic fertilizers is likely to be high in small farms, while no significant effects are found for the adoption of improved seeds. Likewise, younger farmers are more likely to use inorganic fertilizers. However, the coefficients of head's gender do not show any effect on adoption decisions in Tobit models.

The study further estimates the simple Tobit models for period 1 & 2 and pooled from both periods (see Table 3.5 and 3.6). in which LR Chi-square tests are significant in all equations and the Pseudo R-squares are between 0.03 to 0.04 for improved seeds and 0.05 to 0.09 for inorganic fertilizers. The results show that factor markets such as hired labour and farm credit have positive impact on adoption of improved seeds, followed by agricultural extension services and household labour endowments. Adoption of improved seeds seems to be high with the education level of household

[21] In theory, there are some other exogenous variables (e.g., number of livestock, receiving remittances, and sharecrop land) which are assumed to be influential in the adoption decisions and supposed to be included in the models. But none of these variables were found significant in any of the model, so that these variables are excluded from the models.

head. However, large farm households use less improved seeds (in pooled Tobit model). The results from the adoption of inorganic fertilizers are in line with the results of improved seeds with some exceptions. The distance to paved roads and distance from the market centre seem to be constraints for the adoption of fertilizers in Tobit models, while agricultural extension services do not show any significant impact on the adoption of inorganic fertilizers in these exercises.

The results show differences of some coefficients in Tobit models in contrast to GMM probit models. For instance, the proportion of irrigated land is found to be positive in Tobit models in contrast to the period two probit models. Likewise, distance from the market centre and distance to paved roads also contrast with the results of Tobit models.

3.7 Discussion of the results

The results from various models show both consistency and contradiction, particularly as far as the signs and level of significance of the estimated parameters are concerned, and surprising given the hypotheses of the models. As the study assumes the adoption of improved seeds and inorganic fertilizers as joint decisions, the structural probit GMM results weakly favours this assumption with the adoption of improved seeds being dependent on the decision of adopting inorganic fertilizers, but not other way round, while the reduced form LPM models are compatible with the hypothesis of joint decisions of adopting both technologies jointly. The coefficients in regards to factor markets such as labour and credit markets and obtaining agricultural extensions services give rise to the significant role in farm adoption decisions in the context of low-income countries. Despite many satisfactory results, few statistically insignificant coefficients combined with counter-intuitive signs have raised some issues related to the hypotheses that underlie the theoretical models and the consistency of the results.

Estimated parameters of variables such as the age and the education level of household heads, the irrigated land, the distance from the market centre and the distance to road networks differ in the level of significances and the signs among the different models (e.g., reduced form probit, structural GMM, and random effects Tobit models). In this case, some authors suggest that the results of the structural form may differ from the reduced form coefficients, because the coefficients of structural form provide estimates of the direct effects of exogenous variables and often ignore the indirect effects of the same exogenous variables on dependent variables (Weber and Dudney, 2003). Likewise, Ford and Jackson (1998) point out that in jointly dependent variables, when the relevant dependent variable changes in response to an initial change in an explanatory variable, the joint dependent variable will also respond to this change and this change gives rise to further changes in the relevant dependent variable and/or in dependent variables in other equations. This may be due to the assumption of considering all other variables in the structural coefficients as constant. A study carried out by Eppe and McCallum (2005) shows that among the 26 existing textbooks, no example with actual data in which all parameters estimates are of the proper sign and are statistically significant. The analytical basis for these results may not only depend on the few counter-intuitive results, especially in the case of estimating many simultaneous equations. It may rather be to consider these results as natural outcomes of the difference between the reduced form and the structural form models. Nevertheless, our results in this regard are in favour of the assumption of joint decisions of adopting improved seeds and inorganic fertilizers, particularly in this data set.

3.8 Conclusions

Increases in agricultural productivity through the adoption of new technologies such as improved seeds and inorganic fertilizers are considered as a primary means to reduce poverty and hunger and to shift from subsistence to commercial farming in Nepal. This objective has not been achieved in terms of increasing incomes through higher productivity in agriculture, even though high priority has been given to it by the government and a large amount of the budget in the national planning has been allocated to this sector. Since the performance of this sector has yet to improve in a substantive manner, many policy makers and agricultural economists have tried to understand the underlying mechanisms of new technology adoption in a broader perspective in order to improve policy formulation. This study has analysed agricultural technology adoption decisions in Nepal under the assumptions of missing or incomplete factor markets which are often pervasive in most low-income countries.

This study applies several econometric models to analyze the adoption of improved seeds and inorganic fertilizers using NLSS data, assuming that farmers often take adoption decisions about improved seeds and inorganic fertilizers jointly. The application of a single binary model, by ignoring simultaneity in decisions, may lead to bias, inconsistency, and inefficiency in the parameters estimated. This study thus applies the reduced form probit models for the period one (1996) in order to get instruments for LPM and GMM simultaneous probit models for the period two (2004), and then further applies Tobit models utilizing the proportion of land using both improved seeds and inorganic fertilizers by farm households as dependent variables.

The results of probit GMM structural models partially favour the assumption of joint decisions, implying that the probability of adopting improved seeds is likely to be influenced by the adoption of inorganic fertilizers, but not by improved seeds for fertilizer adoption. In the LPM, the results support the hypothesis of adopting improved seeds and inorganic fertilizers as joint decisions. However, there are some contradictions in estimated exogenous parameters, especially distance from the market centre and distance to paved roads for improved seeds (i.e. positive instead of negative signs) and household labour endowments for inorganic fertilizer adoption.

The results from the reduced form probit models for the period one (i.e. 1996) show that the adoption of improved seeds and inorganic fertilizers are significantly affected by local factor markets such as credit and labour, combined with household labour endowment. In addition, distance from the market seems to be an influential factor for improved seeds adoption. Information about new technology is vital: adoption decisions about new farm technology are observed to be higher in those households receiving extension services from the Agriculture Development Office. This finding clearly indicates that the government should increase extension services throughout the country. Adoption decisions are found to be high in larger farm size. Head's age has positive impact on adoption of new technologies but the head's education appears to affect adoption negatively.

The results from the reduced form probit models for the period 2 (i.e. 2004) are consistent with period 1, particularly on variables, such as labour, credit, the household labour endowment, extension services, distance from the market centre, distance to paved roads, and the age of household head. However, the results contrast with the period 1 coefficients as far as plot size and head's education are concerned.

The coefficients of Tobit models are also found to be consistent with the factor markets (credit and labour), level of infrastructures, and agricultural extension services. Moreover, human capital (i.e., educational level) can also affect decisions to invest in new technologies, improved seeds in particular.

To summarize, the evidence shows that the jointly adoption of improved seeds and inorganic fertilizers can not be ruled out and hence is in favour of the assumption of simultaneous decisions. Despite this, well-functioning of factor markets such as labour and credit, combined with agricultural extension services and infrastructural development are a prerequisite for agricultural-led growth in Nepal.

While this study focuses on adoption decisions about improved seeds and fertilizers, further research is needed to find out how the intensity of technology adoption over a period of time influences the behaviour of farmers making adoption decisions.

APPENDIX-3

Table 3.1: Descriptive statistics of farm technology adoption (both periods)

Variables	Description of variables	Type of Variables	Mean	Standard Deviation	Mean	Standard Deviation
			From Plot level data		From Farm level data	
Seed	Households adoption of improved seeds	Binary	0.43	0.46	0.34	0.47
fert	Households adoption of inorganic fertilizers	Binary	0.68	0.48	0.65	0.48
Sedfert	Whether household has used both improved seeds and inorganic fertilizers in the same plot	Binary	0.31	0.46	0.27	0.44
plotsize	Size of plot in hectares	Continuous	1.17	2.54	6.38[1]	11.65
soilquality	Soil quality of plot (1 best and 5 worst)	Continuous	2.73	1.01		
Irrigation	Irrigation facility in the plot	Binary	0.34	0.47	0.14	0.35
Shareland	Any sharecropping land	Binary	0.11	0.31	0.18	1.13
farmcredit	Receive any farm credit	Binary	0.13	0.34	0.13	0.34
Hirlab	Hired any farm labour	Binary	0.82	0.38	0.77	0.42
Dirtdroad	Distance of paved road from the households (in hours)	Continuous	12.25	10.86	10.83	9.68
locamarkt	Distance of local market centre (in hours)	Continuous	6.97	6.88	6.77	6.93
Agritech	Receive any advice from Agriculture Development Office about new farm technology	Binary	0.07	0.25	0.07	0.23
Sex	Sex of household head (1=male, 0 otherwise)	Binary	0.86	0.34	0.85	0.36
Age	Age of household head	Continuous	48.12	18.16	46.97	17.22
Edulevel	Education level of household head (in years)	Continuous	2.35	3.87	2.42	3.91
Adult	Number of adult family members in the household	Continuous	3.87	1.87	3.63	1.78

1 total farm size

Table 3.2: Results of GMM structural models and LPM for period 2 (2004)

Variables	Improved seeds		Inorganic fertilizers	
	Coefficients (GMM probit)	Coefficients (LPM)	Coefficients (GMM probit)	Coefficients (LPM)
Improved seeds			4.72	1.24*
			(1.18)	(7.25)
Inorganic fertilizers	0.73*	0.26*		
	(4.27)	(4.63)		
Plot size	-0.08	-0.03	-0.12	-0.005
	(1.25)	(1.28)	(0.74)	(0.15)
Irrigation land	-0.13*	-0.05	-0.50*	-0.007
	(4.04)	(4.01)	(2.39)	(0.36)
Soil quality	0.01	-0.005	0.20	0.05
	(0.17)	(0.16)	(0.93)	(1.23)
Sex of HH head	-0.001	0.00	0.02	0.001
	(0.002)	(0.003)	(1.18)	(1.02)
Age of HH head	0.05*	0.01*	-0.03	-0.01*
	(3.39)	(3.41)	(0.91)	(2.65)
Education level of HH head	-0.02	-0.007	-0.10	0.03
	(0.28)	(0.31)	(0.59)	(0.95)
Number of adult members	0.07*	0.03*	0.04	-0.02*
	(4.20)	(4.25)	(0.64)	(2.36)
Distance of road	0.006	0.001*	-0.09	-0.01*
	(1.88)	(1.98)	(1.82)	(8.09)
Distance of local markets	-0.01*	0.003*	-0.03*	-0.01*
	(2.82)	(2.27)	(2.53)	(2.79)
Hired labour	-0.01	-0.004	2.43*	0.17*
	(0.12)	(0.14)	(2.38)	(3.91)
Farm credit	0.01	0.01	0.38	0.05
	(0.18)	(0.23)	(1.61)	(1.64)
Information	0.33*	0.12*	0.96	-0.11
	(2.91)	(3.07)	(1.44)	(1.92)
Constant	-0.70	0.24*	-0.78	0.18
	(0.22)	(3.22)	(0.89)	(1.57)
Pseudo R^2	0.06	0.09	0.10	0.23
Number of observations	2176		2176	

* at least 5 percent level of significance

Table 3.3: Results of probit models on reduced form for period 1 (1996) & 2 (2004)

Variables	Improved seeds		Inorganic fertilizers	
	Coefficients (period 1)	Coefficients (period 2)	Coefficients (period 1)	Coefficients (period 2)
Plot size	0.03***	-0.12*	0.05*	-0.21*
	(3.49)	(17.36)	(5.6)	(42.83)
Irrigation land	-0.01	-0.20*	-0.03*	-0.39*
	(0.22)	(6.77)	(7.52)	(14.73)
Soil quality	-0.25*	0.08	-0.003	0.31
	(2.61)	(0.98)	(0.03)	(0.42)
Sex of HH head	-0.001	0.001	-0.001	0.004*
	(0.57)	(0.051)	(0.52)	(2.44)
Age of HH head	0.05*	0.03*	0.03*	0.006
	(6.38)	(3.56)	(2.91)	(0.84)
Education level of	-0.16*	0.003	-0.05*	0.12*
HH head	(2.13)	(0.04)	(2.01)	(2.02)
Number of adult	0.04*	0.07*	0.05*	0.06*
members	(2.54)	(4.71)	(2.68)	(4.19)
Distance of road	-0.01	-0.002	-0.003	-0.04*
	(1.90)	(0.77)	(0.97)	(19.69)
Distance of local	-0.01*	-0.008*	0.002	-0.012*
markets	(1.97)	(1.99)	(0.59)	(3.85)
Hired labour	0.31*	0.33*	0.77*	0.88*
	(4.12)	(0.062)	(10.82)	(17.39)
Farm credit	0.39*	0.07	1.43*	0.39*
	(2.52)	(0.55)	(6.09)	(2.35)
Information	0.63*	0.37*	0.30*	0.32*
	(5.02)	(3.35)	(2.01)	(2.84)
Constant	-0.80	-0.16	0.13	0.77*
	(4.55)	(0.98)	(1.42)	(5.58)
LR $\chi^2(12)$	180.29***	152.29***	376.00***	587.45***
Pseudo R^2	0.07	0.05	0.13	0.22
Number of observations	2176	2176	2176	2176

* at least 5 percent level of significance.

Table 3.4: Random Effects Tobit models

Variables	improved seeds	inorganic fertilizers
Farm size	-0.002	-0.003***
	(0.001)	(0.001)
Irrigation land	0.004	0.003*
	(0.003)	(0.002)
Sex of HH head	0.02	0.01
	(0.05)	(0.03)
Age of HH head	-0.001	-0.002**
	(0.002)	(0.001)
Education level of HH head	0.01*	-0.004
	(0.004)	(0.003)
Number of adult members	0.01	0.01
	(0.01)	(0.01)
Distance to road	-0.002	-0.003***
	(0.002)	(0.001)
Distance to local markets	-0.002	-0.004**
	(0.002)	(0.002)
Hired labour	0.13***	0.19***
	(0.04)	(0.03)
Farm credit	0.14***	0.10***
	(0.05)	(0.03)
Information	0.14**	0.06
	(0.06)	(0.05)
Constant	-0.24***	0.05
	(0.09)	(0.57)
Wald (χ^2_{15}) test	49.07***	101.55***
Number of observations	1585	1585

Standard errors are in parentheses.

Table 3.5: Tobit models for adoption of improved seeds

Variables	Adoption of improved seeds		
	Period 1(1996)	Period 2 (2004)	Both 1&2(1996&2004)
Farm size	-0.001	-0.02	-0.004***
	(0.002)	(0.02)	(0.001)
Irrigation land	0.006	-0.02	0.004
	(0.004)	(0.04)	(0.003)
Sex of HH head	0.07	-0.01	-0.024
	(0.10)	(0.81)	(0.05)
Age of HH head	-0.001	-0.002	-0.002
	(0.002)	(0.001)	(0.001)
Education level of HH head	0.004	0.01**	0.007*
	(0.009)	(0.005)	(0.004)
Number of adult members	-0.001	0.03***	0.02**
	(0.02)	(0.011)	(0.01)
Distance to road	-0.002	-0.005***	-0.002
	(0.002)	(0.002)	(0.001)
Distance to local markets	-0.001	0.004	-0.002
	(0.003)	(0.003)	(0.002)
Hired labour	0.16**	0.11**	0.15***
	(0.04)	(0.05)	(0.04)
Farm credit	0.53***	0.05	0.20***
	(0.15)	(0.04)	(0.04)
Information	0.28**	0.09	0.16**
	(0.14)	(0.07)	(0.07)
Constant	-0.73***	-0.12	-0.40***
	(0.17)	(0.09)	(0.08)
LR χ^2_{11}	32.84***	33.61***	80.34**
Pseudo R^2	0.04	0.03	0.04
Number of observations	797	788	1585

Table 3.6: Tobit models for adoption of inorganic fertilizers

Variables	Adoption of inorganic fertilizers		
	Period 1(1996)	Period 2 (2004)	Both 1&2(1996&2004)
Farm size	-0.003***	-0.04***	-0.003***
	(0.001)	(0.02)	(0.001)
Irrigation land	0.003	0.02	0.003*
	(0.002)	(0.03)	(0.002)
Sex of HH head	0.05	-0.01	0.02
	(0.06)	(0.04)	(0.03)
Age of HH head	-0.001	-0.002	-0.002**
	(0.001)	(0.001)	(0.003)
Education level of HH head	0.004	-0.001	-0.006*
	(0.005)	(0.003)	(0.003)
Number of adult members	0.01	0.02**	0.01
	(0.011)	(0.01)	(0.006)
Distance to road	0.002	-0.009***	-0.003***
	(0.001)	(0.001)	(0.001)
Distance to local markets	-0.005**	-0.003	-0.004**
	(0.003)	(0.002)	(0.001)
Hired labour	0.20***	0.15***	0.19***
	(0.04)	(0.04)	(0.03)
Farm credit	0.27***	0.06**	0.09***
	(0.09)	(0.03)	(0.03)
Information	0.10	0.05	0.07
	(0.08)	(0.05)	(0.05)
Constant	-0.01	0.21***	0.10**
	(0.08)	(0.07)	(0.05)
LR χ^2_{11}	57.13***	82.09***	102.6***
Pseduo R^2	0.05	0.09	0.05
Number of observations	797	788	1585

CHAPTER 4

PRICE VOLATILITY AND ITS IMPACT ON AGRICULTURAL INCOME INSTABILITY

4.1 Introduction

Agriculture is a risky business. Farmers encounter a number of risks and uncertainties, both market–related, such as fluctuations of input and output prices, as well as non-market–related, such as climatic shocks. This persistent risk is costly, particularly in less developed countries (LDCs), due to a poorly developed private sector, weak market infrastructure, and incomplete or poorly functioning financial and risk markets (Dorward et al., 2004). Market related risk is most acute in landlocked LDCs, such as Nepal, due to the wedge between export and import prices resulting from high transportation costs.

Recently, weather risks have also posed a major challenge in agriculture. Fluctuations of temperature and precipitation have increased over the last decade due to global climate changes that have most severely affected rain-fed agriculture, where most farmers are poor smallholders[22] (Sivakumar and Hansen, 2007). Variation of production due to climatic shocks may also lead to food prices being more unstable, leading to unstable agricultural income. Uncertainty in commodity prices has been a major problem to primary product exporting countries, both at the farm level and at the macro level. The issue of risk and uncertainty has, therefore, been a challenging task for policy makers and economists from a theoretical, as well as from an applied perspective.

Staple food crops, such as rice, wheat, maize and potatoes are the most widely consumed products, as well as source of income to the farmers living in low income countries. Instability in these prices is obviously a problem for agriculture dependent countries because of the high dependence on agricultural exporting commodities (Dana and Gilbert, 2008; Brown, Crawford and Gibson, 2008). Rural households participate in agricultural commodity markets in various ways, and the overwhelming evidence is that the majority of rural poor people, including smallholders are the net purchasers of food grain, both in LDCs in general (e.g., World Development Report, 2008 in '*Agriculture for Development*'), and in Nepal in particular[23]. Rises in food prices can have a severe impact on welfare, especially for food-deficit households in rural areas, because poor are the most

[22] In the Nepalese case, majority of farmers have less than 0.5 hectares of farmland, and fewer than 100,000 farmers have more than 3 hectares of cropland.

[23] In DFID's Nepal report, more than 60 percent of landholding households are shown as having a food deficit for some time during year. 78 percent of these deficits last for 4-6 months - http://www.dfid.gov.uk/countries/asia/Nepal-facts.asp .

vulnerable to instability in staple food prices (Brown, Crawford and Gibson, 2008). Several policy makers have insisted that food purchasing farm households should diversify into high-value crops, but such attempts depend on their confidence in being able to procure food at tolerable prices (World Bank, 2008). Price instability can act as a disincentive to diversify cropping patterns that raise farmers' incomes but also increase the risks inherent they face in food markets (Fafchamps, 1992).

Moreover, commodity price volatility notoriously creates instability and uncertainty for commodity-dependent developing countries. An estimated two billion people, nearly a third of the global population, depend on the production of primary commodities, such as rice, wheat, and cotton. In addition to this, a large portion of non-food expenses such as school fees, health care and clothing costs are also covered by the agricultural income. The data show that 95 of the 141 developing countries derive at least half of their foreign exchange earnings from commodity exports (Brown, Crawford and Gibson, 2008). Food price volatility can therefore pose acute economic, social and political consequences in agriculture-dependent countries. This can further lead to inefficient agricultural production decisions, particularly when credit and risk markets are poorly developed (Newbery and Stiglitz, 1981; Williams and Wright, 1991). An understanding of the sources of price volatility of food staples and its impact on rural household income is therefore of great importance for policy formulation in developing countries, such as Nepal.

Many developing countries started to reform their economic policies towards the liberalization of domestic markets[24], especially during 1980s and 1990s, mostly within the context of broader structural adjustment programmes of the World Bank[25] with the aim of restoring fiscal and current account balance, reducing or eliminating price distortions and facilitating efficient price transmission. This policy came into effect in the context of the then prevailing view that government interventions in the food sectors were too costly to continue due to rent-seeking behaviour, where politically powerful groups gain influence over the operations of parastatals to transfer income to themselves. This new policy was thus formulated with an aim to reduce rent-seeking behaviour and to transmit the benefit of higher export prices in domestic markets (World Bank, 2005). The impact of the liberalization is still a matter of debate among academics and policy makers. Producers in many low income countries faced increased price fluctuations arising from the world markets due to

[24] Before 1980s, many developing countries adopted semi-autarkic economic policies. During that period, the coping strategies for food price instability and risk took the form of direct intervention of the government in food markets in the form of public procurement of food, price controls, internal and external trade restrictions, and crop insurance.

[25] The World Bank's view on food marketing policy had three planks: (i) liberalize food markets and reduce direct government purchasing and selling; (ii) encourage the development of private-sector marketing services and innovation by investing in public goods, such as marketing infrastructure, marketing information, and grades and standards systems; and (iii) put greater reliance on international and regional trade, rather than government buffer stocks, to even out local imbalances in supply and demand (Meerman 1997).

slow progress in market reform programs, as well as weak technical skills for risk management. In many cases, reform programs have subsequently been partially reversed (ibid). It is also claimed that many developing countries only partially implemented food market reforms (Baffes and Gardner, 2003). Several reports carried out by the World Bank (e.g., WDR, 2008 in '*Agriculture for Development'*) recommended that these low income countries need to take into account the country-specific constraints such as the structure of local markets, public service deliveries, and functioning of financial institutions while implementing market reform policies to manage risk. Indeed, the absence of adequate insurance markets has provided a significant part of the rationale for government intervention, particularly for government price stabilization programmes (Newbery and Stiglitz, 1981). It is well known that risks and uncertainties can be more problematic to farmers when local prices do not move in line with prices on international markets, perhaps resulting from a number of factors, such as transportation costs, local policies, grade or quality differences, and local supply-demand characteristics (Larson, 1999). The evidence also shows that countries with excess food import bills are strongly affected by price rises despite a lower instability in world cereal markets (Sarris, 2000). An understanding of risk and its consequences to manage the inherent variability of agricultural income through price and yield volatility is therefore of great importance in low income countries.

Commodity price instability and its impact on the economy of low income countries are obviously a major concern for economists and policy makers. The impact of commodity price variability can have effects on economies in various ways and can distinguish between *ex ante* effects of volatility and *ex post* effects of extreme output (Dehn, Gilbert and Varangis, 2004). Many studies have shown that commodity price fluctuations in the context of economic globalization and increased liberalization of commodity markets have seriously affected the weaker economies of the developing world (Dehn, 2000; Byerlee, Jayne and Myers, 2006; Ivanic and Martin, 2008). However, fewer studies have focused on the impact of international and domestic market shocks on the income of farm producers. Most recently, Rapsomanikis and Sarris (2005) have analysed the impact of domestic and international price fluctuations on the agricultural income instability in developing countries using microeconomic approach for different income groups of households in Ghana, Vietnam and Peru. The authors estimated household's income variances and coefficients of variation which allowed them to compute the level of income variability under several scenarios. They found higher shocks from domestic prices and production variability as compared with international price shocks in the household income instability.[26] Similarly, Bourguignon, Lamvert and Suwa-Eisenmann

[26] The theoretical approach of this study was an extension of previous work by one of the authors (Sarris, 2002) who had developed this model and applied in Ghana for the commodity price insurance demand, using the Ghana Living Standards Survey data and monthly price data for both domestic and international prices.

(2004) applied a computable general equilibrium model to explore the impact of trade instability on domestic incomes. Their results show the effect of world agricultural trade instability on diverging domestic incomes for different groups of income earners.

The analysis of domestic market exposure to international markets could be relevant to examine the impact of domestic price volatility on various commodities. It is widely realized that domestic markets in many low income countries are incompletely integrated because of high transportation costs, poor infrastructure and communication services. In such case, international price changes will not be fully transmitted to domestic markets, indicating that price signals will not be transmitted in the same manner in all parts of the country. Studies such as those can capture several assumptions in order to understand the level of world price transmissions in domestic markets in different commodities.

The study of the issue of the impact of Nepal-India border price, as well as the world price fluctuations on agricultural household income instability can provide significant contribution in the literature due to a limited number of studies of Indian price transmission to the Nepalese markets and this study is one step towards this direction. This study attempts to fill the gap in this area by examining the impact of regional (i.e., India) and domestic price shocks on the agricultural household income instability in Nepal. The study with the regional markets is important in the Nepalese context, since India is the biggest trade partner of Nepal. Indian price shocks especially food staples may be more volatile for Nepal rather than the world commodity prices. The study thus aims to assess the impact of price volatility on agricultural income instability, applying data from both time series price data of both Nepal and India, and the Nepal Living Standard Survey 2003/04 under theoretical approach developed by Sarris (2002) and further extended by Rapsomanikis and Sarris (2005).

The paper is structured as follows. Section 4.2 reviews the literature on agricultural risk. Section 4.3 discusses trade policy regimes, particularly dealing with Nepalese agriculture. Section 4.4 explores various econometric models and procedures to calculate the coefficient of variation of agricultural household income. Data and descriptive statistics are given in section 4.5. Section 4.6 analyses the empirical results of the study and section 4.7 concludes.

4.2 Literature on agricultural risk

Agriculture is exposed to many risks and sources of uncertainty starting at the stage of planting to post-harvest and marketing because of various factors such as weather, yields, prices, government policies, global markets and other human related factors. An ever-changing landscape of possible price, yield, and other outcomes may affect farmers' financial returns and overall welfare. In particular, the variability of prices and yields is often considered as the major source of risk in agriculture (Patrick, 1998). However, in the economic literature, there are various forms of risk in agriculture. The major risks in agriculture are as follows (OECD, 2008):

- **Production risk** may occur from the uncertain natural growth processes of crops and livestock. For instance, weather, disease, pest, and other factors are major sources of production risk. The impact of these types of risk is in the quantity and quality of commodities produced.
- **Price or market risk** is the risk related to price fluctuation of both produced commodities and inputs used for production that may vary from country to country or commodity to commodity.
- **Financial risk** refers to the risk facing a farm business that borrows money and creates obligation to repay loan. Such risk may include rising interest rates, credit constraints, and other hidden costs for acquiring loans from lenders.
- **Institutional risk** arises from uncertainties of the government policies and actions. Some examples of government decisions are tax laws, regulations for inorganic fertilizer use, rules for animal waste disposal, and the level of price or income support payments. These decisions can have impact on the farm investment decisions.
- **Human or personal risk** is associated with the problems of human health or personal relationships which can affect the farm business. This risk includes accidents, illness, death, localized wildlife damage or pest infestation, and events such as fire or theft that can also affect the farm activities.

In the literature, risk is also divided in terms of its effects. If the impact of risk is felt by many households in the same locality, then the risk is called as covariate or collective risk, while if the effect of risk is concentrated only on a single household and is unrelated to that of neighbouring households, it is termed idiosyncratic. Human or personal risk falls under the category of idiosyncratic shocks, while all others are covariate shocks. In other words, idiosyncratic risks are due to characteristics of the individual household, while collective or covariate risks are external to the household and include macroeconomic shocks and natural hazards.

Newbery and Stiglitz (1981) distinguish between systematic and non-systematic risks. Systematic risks are related to events that repeat over time with a pattern of probabilities that can be analyzed in order to have a good estimate of the actuarial odds. On the contrary, non-systematic risks are characterized by very short or imperfect records of their occurrence and, therefore, difficulties in estimating an objective pattern of probabilities or distribution of outcomes. This distinction is similar to the distinction between risk and uncertainty and no clear cut line can be drawn between these two types of risk.

Risk can have an effect to both producers and consumers. For instance, price variability may create risks and uncertainties that can threaten agricultural performances, and negatively impact on the income and welfare of the producers and consumers (Quiroz and Valdès, 1995; Fafchamps, 2003; Brown, Crawford and Gibson, 2008). Moreover, these persistent shocks of prices and yields often create a big problem for commodity-dependent countries and developing countries in particular, probably due to a gap between world and domestic prices and cross-country variations in agricultural prices. The analysis of commodity price shocks is important in the sense that about 25 percent of world merchandise trade consists of primary commodities, and both long-term trends and short-term fluctuations in primary commodity prices are key determinants of development in the world economy (Cashin, Liang and McDermott, 2000). The study on agricultural commodity price volatility has been recognized as an important phenomenon for policy implications due to its broader impact on economic growth, income distribution, and the impact on the poor, especially in low-income countries. This section attempts to review the literature on commodity price volatility and its impact on the producers and consumers with special reference to low-income countries.

There are a substantial number of studies related to risk in agriculture in which price risk is analyzed in terms of international price transmission to domestic markets. These studies are typically quantitative. In commodity markets, price fluctuations are discussed under the rubric of volatility – how much prices are changing over a give period. There are various ways of measuring price volatility. Although, there is a long debate about the appropriate method of measurement, it is true that volatility arises from random price movements which occur naturally in every market. The rest of this section reviews the literature of international commodity price transmission to domestic markets with special attention to the agricultural products in the first part and the impact of commodity price volatility on household welfare in the second part, particularly in the context of developing countries. A literature review related to commodity price volatility and the research gaps in Nepal are presented in the final part.

4.2.1 Price transmission and spatial market integration: an overview

The study on the relationship between prices of two spatial markets helps to explain market performance and their degree of integration in which price transmission can be used to assess the direction of causal relationship between two spatial market prices. The analysis of market performance of two spatial markets is generally based on whether the difference of prices between two markets equals or is different than the transfer costs. Broadly speaking, the study on price transmission reflects the competitiveness of markets, effectiveness of arbitrage, efficiency of pricing, and the extent to which domestic markets remain insulated (Abdulai, 2006).

Price transmission is used to analyse the extent to what changes in the price of one market led to changes in prices in another market of the same commodity. If the change in price of one market has no effect to another then there is no market integration and hence no price transmission from one market to another. Price transmission is often measured by a coefficient from an application of quantitative analysis (e.g. correlation, regression), depending on the model applied to analyze price transmission.

It is often discussed in the literature that if the marketing system is well-integrated, then the price increases should be transmitted to the same extent as the price decreases, i.e. there is not rigidity of price adjustment in the marketing system (Goletti and Babu, 1994). On the other hand, any deviation from this norm indicates some sort of inefficiencies in two spatial markets perhaps due to nonexistence of perfectively competitive markets. A number of analytical approaches using quantitative techniques have been applied to address the issue of spatial market integration. This section thus aims to review the literature related to price transmission and market integration.

A large body of literature of empirical analysis on price transmission and spatial market integration has been undertaken by applying various quantitative techniques. A comprehensive review of literature on spatial price analysis can be found on Facker and Goodwin (2001), Balcombe and Morrison (2002), and Rapsomanikis, Hallam and Conforti (2004) in which the authors mention a number of theoretical and analytical aspects. In the literature, the initial approaches to deal with price transmission were simple bivariate correlation coefficients (Mohandru, 1937; Blyn, 1973), but this approach ignored the presence of other factors such as price inflation, seasonality, population growth, and procurement policy (Lele, 1971; Jones, 1972). This traditional approach treats all price movements as indicating price instability, which is usually measured as the variance or standard deviation of a price index. This approach tends to overstate variability in non-trending series (Swaray, 2006). It does not account for predictable components such as trends in the price evolution process and does not have constant range and the squaring tends to accentuate the effects of outliers (Offutt and Blandford, 1986). On the other hand, the confidence intervals of volatility forecasts can vary over time. In addition, there is also trend to measure price instability by ratio method, in which the variability of price level is calculated by measuring the standard deviation of log prices (P_t/P_{t-1}), where P_t is price of period t and P_{t-1} is price of period t-1. Another approach analysing volatility is one which distinguishes between predictable and unpredictable components of price series. But the weakness of this method is that it assumes price volatility as time invariant (Sekhar, 2003). It is true that many time series data are often confronted with the problems of nonstationarity and are time variant while simultaneous-equation models based on the assumption of stationarity are not valid, if the time series are indeed realizations of nonstationary processes. A nonstationary series that has time dependent statistical properties may contain stochastic or deterministic trends. Nonstationary series with stochastic trends contain unpredictable variation. On the other hand, a stationary series that has constant mean and finite covariance structure does not vary systematically with time and tends to revert to its mean value and to fluctuate around it within a more or less constant range.

The analytical approach of price transmission and spatial market integration has been changing rapidly due to availability of time series data of commodity prices. In these studies, price movements over time and the associated margins are seen as subject to various shocks. Many authors have studied price transmission within the context of the Law of One Price (e.g., Adreni, 1989; Baffes, 1991) or within the context of market integration (e.g. Ravallion, 1986; Palaskas and Harriss, 1993; Gardner and Brooks, 1995; Blauch, 1997). In addition, studies can also be found regarding the policy reform evaluation such as market integration of post structural adjustment programmes assessment implemented in the developing world (Goletti and Babu, 1994; Dercon, 1995). The research on vertical price transmission combined with the supply chain from the consumer to the producer level can also be found in the broader area of price analysis (e.g., Wohlgenant, 1985; Prakash, 1999; von Cramon-Taubadel, 1999). The remaining part of this section provides a summary and overall assessment of econometric approaches and empirical applications of price transmission and spatial market integration.

The Law of One Price (LOP) is often considered as the basic building block of the international trade literature, in which the LOP postulates that in the presence of a free market regime, and in the absence of transport costs and other barriers to trade, prices of identical products sold in different markets will be the same when expressed in terms of a common currency (Froot and Rogoff, 1995). The basic idea of the LOP is that market participants can exploit arbitrage opportunities by purchasing the commodity in the cheaper market and selling it where prices are higher. On the other hand, market integration analyses prices in widely spatial locations connected either by trade (Ravallion, 1986) or by locations that have one-for-one price changes (Goodwin and Schroeder, 1991). The spatial integration of markets depends on the difference between market prices. The general norm in the principles thought to underlie price differences are: (a) trade will only occur, when price differentials between two regions (or markets) at least equal or exceed transfer costs; and (b) trade will not occur when price differentials between two regions (or markets) do not exceed transfer costs (Faminow and Benson, 1990).

The LOP is the conventional tests for spatial market integration, as well as an important component for the study of international commodity markets. It postulates that after adjusting exchange rates and transportation costs, an equilibrium price among spatially separated markets exists (Enke, 1951; Samuelson, 1952; and Takayama and Judge, 1971). This model is often known as the Enke-Samuelson-Takayama-Judge model) and the conventional equations of spatial markets are:

(4.1) $$P_t^A = P_t^B + c$$

where P_t^i is the price level of a commodity at the location *i* in the time *t* and *c* is a constant that is often assumed to be transfer costs. Indeed, spatial arbitrage is expected to trigger trade between two markets until price differences are at least reduced to the level of transfer costs and the trade between two markets can only exist, if the following inequality holds:

(4.2) $$P_t^A - P_t^B \leq c,$$

Fackler and Goodwin (2001) refer this equation as the spatial arbitrage condition and explain that it identifies a weak form of the LOP, while equation (4.1) is mentioned as the strong form. In equation (4.1), if the condition holds, the two markets are said to be perfectly integrated. But in general, the condition of perfect market integration is unlikely, particularly in the short-run. In the short-run, the prices may drift apart, as shocks in one market may not be instantaneously transmitted to other markets due to delays in transport (Rapsomanikis, Hallam and Conforti, 2004). Empirical evidence from recent studies on international trade of agricultural commodities also shows mixed results and strongly reject the LOP hypothesis (Miljkovic, 1999). In addition, the LOP ignores the time series properties of individual price data series that may lead to the problem of serial correlation in the empirical test. Under the presence of serial correlation , test result of the LOP may give inferential biases and inconsistencies (Adreni, 1989; Goodwin, 1992). Therefore, there was a conventional wisdom on how to incorporate and address the time-series price data to model spatial price analysis. It is a fact that traded commodities are often bulky and costly to transport and involve delivery lags and other impediments to adjustment and this adjustment of shocks may take several periods to be complete (Fackler and Goodwin, 2001). The analysis of such shocks may require dynamic time series price data in which precise measurement of different degrees of integration can be achieved by measuring the magnitude of price transmission with the help of dynamic multipliers. Moreover, the analysis of dynamic adjustments also allows to compute the speed of price transmission.

The concept of price transmission is widely analysed under the three notions, or components (Prakash, 1999; Balcombe and Morisson, 2002; Rapsomanikis, Hallam and Conforti, 2004) which are as follows:

(i) co-movement and completeness of adjustment price changes in one market are fully transmitted to other at all points of time;

(ii) the dynamics and speed of adjustment which refers as the process by, and rate at which, changes in prices in one market are filtered to the other markets or levels; and,

(iii) asymmetry of response, implying upward and downward movements in the price in one market is symmetrically or asymmetrically transmitted to the other, in which the extent of completeness and the speed of the adjustment can be asymmetric.

The recent literature on international price transmission is mostly carried out using dynamic time series analysis techniques because of widely available of time series price data of commodities. The application of these techniques is obviously in light of the dynamic nature of interregional commodity trade and arbitrage activities (Fackler and Goodwin, 2001). The major techniques to analyse price transmission are co-integration, causality, error correction and symmetry (Rapsomanikis, Hallam and Conforti, 2004). These methods focus on the distinct aspects of the spatial price linkages and shed light on dynamic nature of the time series. A brief review of these methods follows.

Cointegration is a concept for modelling equilibrium or long-run relations of economic variables and one way to formalize the idea of comovements among the prices of a same commodity in different countries. Granger (1981) developed the concept of cointegration and its applications. However, comprehensive framework for estimating and testing the long-run equilibrium relationships between non stationary integrated variables was provided by Engle and Granger (1987) and Johansen (1988, 1991, and 1995). This testing framework can be described with the simple case of two time series P_t^A and P_t^B (prices of two spatially separated markets) which are assumed to be integrated of order one [e.g. I(1), implying that the process contains a unit root] in which P_t^A and P_t^B are said to be cointegrated if:

(4.3) $$\mu = P_t^A - \beta P_t^B$$

is a stationary process.

The cointegrating vector [1, $-\beta$] that measures the long-run equilibrium relationship between two variables, is often interpreted as the "elasticity of price transmission" when prices are converted into logarithms, only if the price of one market (e.g., world market) is considered as exogenous and assuming that the price of the local market does not affect to the price of world market. This model can also be estimated and cointegration can be tested utilizing either Ordinary Least Squares (Engle and Granger, 1987) or a Full Information Maximum Likelihood method (e.g., Johansen, 1988, 1991). In a cointegrated system, the residuals are necessarily stationary which is tested either by unit root test of $\hat{\mu}$ (Engle and Granger) or by the distribution of two test statistics (Johansen).

Despite the prevalent tool for analysing time series econometrics, cointegration is not beyond criticism. For instance, Rapsomanikis, Hallam and Conforti (2004) mention that cointegration is a statistical concept and thus "atheoretical" in which the parameters estimated in cointegration may not have economic interpretation as in case of structural models. Some authors show their doubt considering the estimated parameters as the completeness of transmission (Balcombe and Morrison, 2002; Barret and Li, 2002). Mastroyiannis and Pippenger (1993) mention that cointegration is a necessary but not a sufficient condition for the analysis of the LOP. The existence of cointegration between price variables does not imply that the LOP holds by taking into account the transaction costs. For this, the cointegrating vector needs to be shown to be equal to [1,-1] between world and domestic prices. In the presence of unit roots and cointegration of two series, OLS regression will be consistent. Barret (1996) argues that cointegration is neither necessary nor sufficient condition for market integration. Cointegration between two price series may not be consistent if the transaction costs are nonstationary. In addition, market integration often suggests positive correlation, but cointegration can be consistent in negative correlation between two market prices. The author further mentioned that the magnitude of the cointegration coefficient is informative about the relative rates of change, and many reported coefficients have magnitudes implausibly far from unity. A potential shortcoming in testing for market integration is the implicit assumption that transfer costs are stationary (Fackler and Goodwin, 2001; Barret and Li, 2002).

Nevertheless, cointegration is an appropriate statistical technique that has an important implication, postulated by the Granger Representation Theorem (Engle and Granger, 1987). This theorem forms the basis of many empirical applications on time series in the presence of unit root nonstationary process (Ogaki, 1998).The theorem shows that in a multivariate time series, if both variables are unit root [I(1)] then both variables are cointegrated if and only if there exist the error correction model (ECM). ECM enables us to combine the long-run cointegrating relationship between the levels variables and the short-run relationship between the first differences of the variables. In other words, this model allows direct estimation of the long-run, steady-state equilibrium condition implied by theory along with the short-run dynamic adjustments based on nonstationary properties of data (Kesavan et al., 1992). A vector error correction model (VECM) for two spatially separated markets when both prices are I(1) and cointegated (Engle and Granger, 1987; Rapsomanikis, Hallam and Conforti, 2004) is as follow:

$$\begin{pmatrix} \Delta P_t^A \\ \Delta P_t^B \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} \left(P_{t-1}^A - \beta P_{t-1}^B \right) + A_2 \begin{pmatrix} \Delta P_{t-1}^A \\ \Delta P_{t-1}^B \end{pmatrix} + \ldots.. + A_k \begin{pmatrix} \Delta P_{t-k}^A \\ \Delta P_{t-k}^B \end{pmatrix} + \begin{pmatrix} \nu_1^A \\ \nu_1^B \end{pmatrix}, \tag{4.4}$$

where the terms ν_1^A and ν_1^B are independently and identically distributed (i.i.d) disturbances with zero mean and constant variance and Δ is the first difference, showing that the data are stationary in first difference.

The parameters $\begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix}$ are often called as error correction coefficients that are usually between zero and one[27] ($0 < |\alpha_i| < 1, i = 1,2$). These coefficients assess how much of the difference between the two spatial market prices [P_t^A (i.e. local) and P_t^B (i.e. world)] in the previous period would affect price changes to current period. The term β is the cointegrating parameter that shows the long-run equilibrium relationship between two prices, while the parameters contained in matrices $A_2, \ldots\ldots, A_k$, show short-term adjustment, that is how much of the price change in 'B'(world) market price series (ΔP_t^B) is transmitted to the price change in 'A'(local) market price series (ΔP_t^A). The short term adjustment parameters can be interpreted as a measure of the speed of price transmission, while the long-run multiplier can be interpreted as a measure of the degree of price transmission of one price to other (Prakash, 1999).

In the price transmission and the market integration literature, ECM often consider as the most useful tool as it provides a stylized picture of the relationship between two prices (ibid). ECM allows us to estimate additional confirmation of the presence or absence of cointegration. If the variables are not cointegrated, a valid ECM will not exist between the variables. ECM estimates between the variables are only possible if both variables are I (1) and cointegrated.

Despite a number of *caveats* relating to cointegration analysis, the model is also applicable for the causality effects between the two prices (e.g., Granger causality), in which there will be at least one direction between two markets (Granger, 1988). The analysis of causality effect seems to be necessary because cointegration on itself cannot be applied to make inferences about the direction of causation between two variables (Rapsomanikis, Hallam and Conforti, 2004).

Granger (1969) proposed a technique for determining whether one time series is useful in forecasting another, widely known as Granger causality test. The simple interpretation of the test for the causality between two time series P_t^A and P_t^B is as follows:

(i) Granger Causality: P_t^B is Granger causal to P_t^A if and only if the application of an optimal linear prediction function leads to $\sigma^2(P_{t+1}^B \mid I_t) < \sigma^2(P_{t+1}^B \mid I_t - \overline{P}_t^A)$, where $\sigma^2(.)$ is the variance of the corresponding forecast error and $\overline{P}_t^A$ be the set of all current and past values of P_t^A i.e. $\overline{P}_t^A = \{P_t^A, P_{t-1}^A, \ldots, P_{t-k}^A, \ldots\}$ and analogously to P_t^B, while I_t refers as all

[27] The value of α close to one shows the speed with which market returns to its equilibrium, in which short-run adjustments are directed by, and consistent with, the long run equilibrium relationship, allowing the relationship between the two prices to be consistent with the speed of adjustment. On other hand, if the value of α is close to zero, then we can assess the extent to which policies, transaction costs and other distortions delay full adjustment to the long run equilibrium (see, Rapsomanikis, Hallam and Conforti, 2004).

information available at time t which is normally considered only the current and lagged values of the two time series P_t^A and P_t^B (i.e. $I_t = (P_t^A, P_{t-1}^A, ..., P_{t-k}^A, ..., P_t^B, P_{t-1}^B, ..., P_{t-k}^B, ...)$ The interpretation is that future values of P_t^B can be predicted better with a smaller forecast error variance, if current and past values of P_t^A are used.

(ii) Instantaneous Granger Causality: P_t^B is instantaneously Granger causal to P_t^A iff the application of an optimal linear prediction function leads to $\sigma^2(P_{t+1}^B \mid I_t, P_{t+1}^A) < \sigma^2(P_{t+1}^B \mid I_t)$, implying that the future value of P_t^B, P_{t+1}^B can be interpreted better with a smaller forecast variance, if the future value of P_t^A, P_{t+1}^A is used in addition to the current and past values of P_t^A.

(iii) Feedback: there exists feedback between P_t^B and P_t^A, if P_t^B is causal to P_t^A and P_t^A is causal to P_t^A. For this, there needs to have some additional information and assumptions. For instance, P_t^A and P_t^B are independent, with or without instantaneous causality (both), feedback with or without instantaneous causality.

Granger causality is normally tested in the context of Vector Autoregression (VAR) framework (details about VAR with Granger causality are given in the next section). In other words, VAR models provide a natural framework to test the Granger causality. A variable P_t^B Granger-causes P_t^A, if P_t^B can be better predicted using the histories of both P_t^A and P_t^B than it can using the history of P_t^A. The idea of Granger causality has several components which are as follows:

- temporality: it deals with only past values of P_t^B can "cause" P_t^A;
- strong exogeneity: a necessary condition for P_t^B to be exogenous of P_t^A is that P_t^B fails to Granger-cause P_t^A (see, Handry and Richard, 1983); and
- independence: variables P_t^B and P_t^A are only independent if both fail to Granger-cause the other.

VAR models are generally estimated after conducting various tests on statistical properties of time series data. The procedures to determine the order to integration are augmented Dickey-Fuller (ADF) and Philips-Perron (PP). The augmented Dickey-Fuller (ADF) is based on the following regression: ($P_t^B - P_{t-1}^B = \lambda + \delta P_{t-1}^B + lags(P_t^B - P_{t-1}^B) + \omega_t$, where P_t^B is the series under consideration. According to this procedure, a negative and significant value of δ indicates that P_t^B is I (0). Likewise, PP test is also similar to ADF, but their difference lies on the treatment of any nuisance serial correlation aside from that generated by the hypothesized unit root. Both ADF and PP the null H_0: P_t^B is not I (0) against H_1: P_t^B is I (0) to identify the presence of one unit root. Finally, the test of trend stationary is often done by including time as an explanatory variable in the model (see, Baffes and Gardner, 2003; Stock and Watson, 2007).

Though there are some controversies about Granger-causality because of its focus on the causation over time rather than instantaneous causality (Pagan, 1989), Granger causality provides some indications as to whether, and in which direction, price transmission is taking place between two price series.

Granger (1988) further developed a test for long run Granger causality within the framework of the error correction representation of a cointegrated system of variables. The presence and direction of Granger causality in the long-run can be assessed by testing the null hypothesis that the error correction coefficients in the VECM (4.4) are equal to zero and this test can also show the weak exogeneity in the econometric sense. For examples, if $\alpha_1 = 1, \alpha_2 \neq 0$, then P_t^B Granger-causes P_t^A in the long-run, if $\alpha_2 = 0, \alpha_1 \neq 0$, then P_t^A Granger-causes P_t^B in the long-run, and if $\alpha_1 \neq 0, \alpha_2 \neq 0$, both series Granger-cause each other in the long run, which is often called as bidirectional causality. Some noted studies on Granger causality tests are Uri et al. (1993), Alexander and Wyeth (1994), and Mendoza and Rosegrant (1995).

Traditionally, Granger causality tests within an error correction representation is based on linear regression modelling of stochastic process that allows reciprocal relationship between rises and falls of prices. However, recent literature examining whether prices rise faster than prices fall has distinguished the price dynamics into symmetric and asymmetric processes, revealing that the price transmission may differ in the case of increasing or decreasing prices (i.e asymmetric price transmission). In the economic literature, such asymmetric price transmission may occur due to presence of imperfect competition and monopoly markets which often assume that price should respond symmetrically to increase and decrease of costs. There is also a convention that asymmetric price transmission points out the gaps in the economic theory and is also important for welfare and thereby policy implications (von Cramon-Taubadel and Meyer, 2004). It is more simple to measure the economic welfare under symmetry, because asymmetric price transmission alters the timing and/or the size of the welfare changes associated with price changes. It is therefore a suspicion that linear (or symmetric) form of cointegration and Granger causality tests might overlook a significant non-linear relationship between two market prices. Nonlinear dynamics may be more relevant in the case of relaxing the components (e.g., exogeneity or independence). To address this issue, Granger and Lee (1989) proposed an asymmetric ECM (AECM). This method assumes that the speed of adjustment of the endogenous variable depends on whether the deviation from the long run equilibrium is positive or negative. The single asymmetric ECM is presented as follows:

$$\Delta P_t^A = \mu_1 + \alpha_1^+\left(P_{t-1}^A - \beta P_{t-1}^B\right)^+ + \alpha_1^-\left(P_{t-1}^A - \beta P_{t-1}^B\right)^- + \sum_{i=0}^{k}\delta_i \Delta P_{t-i}^B + \sum_{i=0}^{n}\gamma_i \Delta P_{t-i}^A + \nu_t^A, \quad (4.5)$$

where $\left(P_{t-1}^A - \beta P_{t-1}^B\right)^+$ and $\left(P_{t-1}^A - \beta P_{t-1}^B\right)^-$ are the positive and negative changes disequilibria respectively, μ_1, α_1^+, and α_1^- are the parameters and *t* is the current period. Long run asymmetry is tested by determining whether $\alpha_1^+ = \alpha_1^-$, assuming that asymmetric transmission occurs, if $\alpha_1^+ \neq \alpha_1^-$. On the other hand, the short run asymmetry can be captured by decomposing the first differences into price rises and price falls, and testing for equality of the corresponding short run coefficients. In addition to AECM, there are also other models based on cointegration such as the threshold ECM[28].

A large body of literature can be found on spatial market integration and price transmission in the developing world. Some examples are Sharma (2002), Baffes and Gardner (2003), Conforti (2004), Rapsomanikis, Hallam and Conforti (2004), and Imai, Gaiha and Thapa (2008). Likewise, studies on commodity price transmission applying econometric applications to test the LOP are Ravallion (1986), Baffes (1991), Mundlak and Larson (1991), Gardner and Brooks (1994), Goletti and Babu (1994), Mohanty et al. (1998b), Yang et al.(2000) and Barrett (2001). Moreover, a significant number of studies have also analysed the various kinds of risks farmers face and their copping strategies (Newbery and Stiglitz, 1981; Fafchamps, 2003; Dehn, Gilbert and Varangis, 2004; Gilbert, 2006; Dana and Gilbert, 2008). Finally, the literature shows that the analysis of price transmission has gradual shifted from the estimation of bivariate correlation coefficients and regression between prices to more recent techniques such as cointegration, error correction models by exploring the dynamic relationships between non-stationary time series data of commodity prices (Hallam and Sarris, 2006).

4.2.2 Commodity price fluctuations and household welfare

The impact of the world commodity price fluctuations on household welfare has been a topic of some interest and also a debate for many years, particularly after the implementation of market liberalization economic policies by many developing countries. The research on the commodity price volatility, trade liberalization and welfare both at the theoretical and at the analytical levels has been increased tremendously during the last couple of decades, where most of the studies were initiated after the shift by many developing countries towards market economy during 1990s.

[28] Threshold autoregressions were initially introduced by Tong (1983). In this method, it is possible to consider an intuitively appealing type of ECM in which deviation from the long run equilibrium between two spatial markets will lead to a price response in these markets exceed a specific threshold level.

In the part, few studies were initiated to analyze the effects of price instability on welfare in a closed economy (e.g., Waugh, 1944). Waugh's seminal paper entitled "Does the consumer benefit from price instability?" is often considered as milestone in the literature that laid the groundwork for the early theoretical work on price instability. In this paper, Waugh (1944) examined the effect of price instability on consumers and concluded that consumers preferred instability to stability in the prices. The author assumes that consumers as price takers and under the given price, may prefer instability if they can take advantages from instability by gaining more from a price decline than loosing from an equal price rise. This theoretical approach is based on the concept of consumers' surplus. Following Waugh's approach, Oi (1961) analyzed the effects of price instability on producers, where the results were in line with Waugh (1944), revealing that producers preferred instability to stability. The basic idea of this analysis is that producers can adjust instantaneously to price changes. Both Waugh (1944) and Oi (1961) assume that price variations may be caused by random variation in demand and supply respectively.

Although these studies provide some idea about the analysis of price stabilization, the question is that if these results are correct, then why do policy makers need to introduce price stabilization policies? Massel (1969) who disagreed with the way of analyzing the effect of instability on consumers and on producers separately, felt the need to integrate both consumers and producers to analyze the gains from price instability through economic surplus. This approach is now widely known as the Waugh-Oi-Massel approach that assumes linear demand and supply schedules, instantaneous reaction of supply and demand to changes in the market prices, additive stochastic disturbances and price stabilization at the mean of the prices which would have prevailed in an unstabilized market (World Bank, 1977; Newbery and Stiglitz, 1981). The general idea of Waugh-Oi-Massel is that society benefits by stabilizing prices of storable commodities through a reserve policy.

The Waugh-Oi-Massel model, despite simple to understand, is mostly unsatisfactory within the context of stabilizing prices, particularly in agricultural commodities. For instance, additive disturbances imply that bad weather has the same absolute impact on supply regardless of the acreage of the crop planted, while a more natural specification would make disturbances proportional to potential yields (Hazell and Scandizzo, 1975). Likewise, the linearity assumption which implies that price stabilization is possible at mean that indicates no change in average supply seems to be unsatisfactory. Demand and supply schedules are more likely to be non-linear, making price stabilization infeasible (Newbery and Stiglitz, 1979). The model may no longer be optimal to pursue complete price stabilization, if there are positive storage costs. In addition, this analysis is based on the assumption of perfectly competitive markets, but many studies show the results in a closed economy model where imperfectly competitive markets are pervasive. The model also does not incorporate farmers' attitude towards risk. Price stabilization may affect differently farmers depending on their attitudes towards risk. It may affect both average incomes and their riskiness, possibly in different directions.

More recent studies on the effects of commodity price instability in developing countries are mostly classified into two major groups. The first type of study concentrates on the behaviour of producers confronted by risk at the micro level (e.g., Newbery and Stiglitz, 1981; Deaton, 1989; Rosenzweig and Binswanger, 1993; Sadoulet and de Janvry, 1995; Sarris, 2002; Nicita, 2004; Rapsomanikis and Sarris, 2005, 2008), while the second type of research focuses on macroeconomic perspective, mostly applying Computable General Equilibrium (CGE) models[29] (e.g., Ravallion and Lokshin, 2004; Bourguignon, Lambert and Suwa-Eisenmann, 2004; Taylor et al., 2009).

The theoretical approach for the analysis of commodity price stabilization is explained in the widely cited book entitled "The Theory of Commodity Price Stabilization" of Newbery and Stiglitz (1981), in which the authors incorporated a number of issues such as risk and uncertainty, market imperfections, nonlinearity and multiplicative disturbances. This approach is further extended by Sarris (2002) and Raspomanikis and Sarris (2005 and 2008) giving more focus on the context of developing countries, where the theoretical framework is mostly based on the concept of farm household model developed by Singh, Squire and Strauss (1986). Because, in the economic literature, the farm household model is considered as the building block of analysis to capture the effect of any policy on household's welfare, particularly in the context of farm household's dual role as consumers and as producers of goods. The problem of the household income cycle in the presence of risk in mathematical framework is routinely captured in the standard intertemporal stochastic models. However, the purpose of this section is to show how domestic and world price shocks affect household income variance, where household welfare is captured by expected indirect utility. This specification is made under the assumptions of steady state condition, in which the household's portfolio activities and other risk copping strategies are considered stable.

Let V be the value of expected indirect utility at time $t+1$, given the information and including time t Ω_t, $E\{V(P_{t+1}, I_{t+1})/\Omega_t\}$, where P is a price vector and I is the expenditure of household[30]. The conditioning notation and time subscripts will be omitted in what follows. Because price variability is considered as conditional and the farmer's decisions are based on conditional expectations

[29] CGE models that allow simulation and calibration to capture economy-wide impacts on markets, are widely applied techniques both at macro and micro (e.g., village economy CGE) levels. CGE models can be static and dynamic equilibrium. However, this study does not cover about CGE model which is beyond the analytical framework of this study. This part concentrates more on micro impact of world price fluctuations.

[30] The use of expected indirect utility is more convenient in the context of attitude towards income variability at fixed prices and attitude towards price variability at fixed incomes (for details see Newbery and Stiglitz, 1981, pages 116 and 129-130).

of prices and production in the period ahead, this allows to utilize conditional distributions to measuring welfare.

Using the procedure developed by Newbery and Stiglitz (1981) and further elaborated by Rapsomanikis and Sarris (2005 and 2008), the expected values of random variables, P and I under the second order approximation of *V* can be written as follows.

(4.6)
$$V(P,I)=V(\overline{P},\bar{I})+\sum_i \frac{\partial V}{\partial P_i}(P_i-\overline{P}_i)+\frac{\partial V}{\partial I}(I-\bar{I})$$
$$+\frac{1}{2}\left\{\sum_i\sum_j \frac{\partial^2 V}{\partial P_i \partial P_j}(\overline{P}-\overline{P}_i)(P_j-\overline{P}_j)+2\sum_i \frac{\partial^2 V}{\partial I \partial P_i}(P_i-\overline{P}_i)(I-\bar{I})+\frac{\partial^2 V}{\partial^2 I}(I-\bar{I})^2\right\},$$

where a bar above a random variable denotes the conditional mean or expected value. The two first order terms after the constant on the right hand side of equation (4.6) disappear after taking expected values, while the term in the bracket containing the variances of prices and income, as well as the covariance between prices and expenditure, remains.

Let $V_{P_i}, V_I, V_{P_iP_j}, V_{IP_i}, V_{II}$ be the first and second order derivatives of indirect utility with respect to prices and expenditure which can be expressed as follows:

(4.7)
$$V_{P_iP_j}=-\frac{1}{\overline{P}_i\overline{P}_j}\beta_i\bar{I}V_I\left[\varepsilon_{ij}+\beta_j(\rho-\eta_j)\right]$$

(4.8)
$$V_{IP_i}=\frac{V_I}{\overline{P}_i}\beta_i(\rho-\eta_j),$$

(4.9)
$$V_{II}=-\frac{V_I}{\bar{I}}\rho,$$

where β_i is the household's budget share for good *i* and ε_{ij} are the cross-price elasticities of demand for product *i* with respect to the price of product *j*. The elasticity of demand becomes own price elasticity in case when *i* = *j* ($\varepsilon_{ij}=\frac{\overline{P}_j \partial q_i}{\overline{q}_i \partial P_j}$), and η_i denotes as the expenditure elasticity of demand for product *i*. ρ is the coefficient of relative risk aversion and a positive scalar in (4.9). If the household is assumed to be risk averse, then V_{II} will be negative.

If the formulas displayed in (4.7) to (4.9) apply in (4.6) by normalizing the welfare, and dividing both by mean expenditure and by the marginal utility of expenditure, the equation for the welfare of the household from its exposure to risk which is considered as a share of average expenditure can be presented as follows:

(4.10) $$W^n = \frac{E(V)}{\bar{I}V_I} = \frac{V(\bar{P},\bar{I})}{\bar{I}V_I} - \frac{1}{2}\sum_i \sum_j \left[\beta_i \varepsilon_{ij} + \beta_j(\rho - \eta_j)\right]\left[\frac{Cov(P_i,P_j)}{\bar{P}_i\bar{P}_j}\right]$$

$$+\sum_i \beta_i(\rho - \eta_i)\left[\frac{Cov(P_i,I)}{\bar{P}_i\bar{I}}\right] + \frac{1}{2}(\ -\rho)\left[CV^2(I)\right],$$

in this expression, the terms *Cov* and CV denote the covariance and the coefficient of variation respectively. All terms in the above expression are unit-free, and all variances and covariances are conditional on information as of time t. It is not possible to infer the direction of a mean preserving change in the distribution of the random variables facing households a priori from equation (4.10). This impact will depend on household demand and risk parameters, as well as the variance and covariance of prices and income.

Equation (4.10) reveals that the household welfare depends on both demand and risk characteristics. As the main purpose of the study is to calculate the coefficients of variation of expenditure, equation (4.10) assumes that an increase in the CV of expenditure will reduce the household welfare, and also reduce the proportional to the coefficient of relative risk aversion, if prices of the different expenditure categories are not strongly correlated with each other. According to Newbery and Stiglitz (1981), this approximation also holds under a number of restrictive conditions.

The welfare measures in the presence of risk depend on the signs of square brackets in equation (4.10). The first square bracketed term reflects the direct effect of price variability on expected utility, in which the welfare effect is determined by the extent of curvature of indirect utility function that further depends on the sign of expression $\beta_i \varepsilon_{ij} + \beta_j(\rho - \eta_j)$. The second square bracket reflects the covariance between two commodity prices *i* and *j* by the product of their expected values. Likewise, the third square bracket reflects the covariation between prices and expenditure, weighted by the extent to which price variations influence the marginal utility of income [i.e. from this expression $\beta_i(\rho - \eta_i)$]. The last square bracket reflects income variability weighted by the extent to which households are risk averse. This framework (4.10) is widely considered as pragmatic approach in order to capture various theoretical and mathematical issues.

Existing studies on commodity price fluctuations show that the impact of rises in food prices on poverty are likely to be diverse, depending upon the reasons for the price change and on the structure of the economy (Ravallion and Lokhsin, 2004; Hertel and Winters, 2006). The differences among countries or regions in the world price transmission to domestic markets may be due to a number of factors: differences in food commodities that comprise the food price index; tradability of a country's main staple; whether a country is a net importer or net exporter of food; and whether a country is landlocked or not (World Bank, 2008a). Moreover, the effects of world price fluctuations are not clear cut, because a rise in the world price may have opposite effects for producers and for consumers. For example, producers may gain from increased world prices, if they are net sellers, while lose as consumers when prices fall. However, the impact of price rises may vary depending on: (i) the evolution of the costs of production; (ii) cash available to buy the inputs and tools for additional cropping; and (iii) the organization of cooperative efforts to store and market products until selling is opportune (IFAD, 2009).

The number of studies on the impact of world price instability on household welfare in the developing world has increased, particularly after the implementation of liberalized market economy and their main focus is on the issue of the impact of world price fluctuations on household welfare and poverty reduction. For instance, Leyaro (2009) explores that an increase in commodity prices worsens the welfare of most consumers in Tanzania during the 1990s to 2000s. Cudjoe et al. (2008) also show similar results, where the world prices pass through Ghanaian commodity prices at different levels in different regions. They show that an increase in food prices has a negative effect on urban poor and north of Ghana. Likewise, Barret and Dorosh (1996) observe negative effects on welfare from an increase in the mean and variance of rice prices of poor farmers in Madagascar. Fafchamps et al. (2003) reveal that world coffee prices are reflected in domestic prices paid by exporters and larger traders in Uganda and Bussolo et al. (2006) also explore the effect of world price fluctuations in domestic coffee markets in Uganda. The world coffee prices pass through the farm-gate level partially, but their results do not show any substantial change of the rise in world coffee prices to the coffee farmers' income. However, Ravallion and Lokshin (2004) show small impacts on mean consumption and inequality in the aggregate with the rural poor are worse off on average after trade reform scenarios called de-protecting in Morocco. Chen and Ravallion (2004) examine welfare impacts of changes in goods and factor prices after China's access to the World Trade Organization and show negligible impacts on inequality and poverty in the aggregate but their results show diverse impact across household types and regions. Minot and Golleti (2002) conducted a study in Vietnam and they found slightly a positive effect on rural income with an increase in rice prices. Another study carried out by Nicita (2004) examined the impact of trade liberalization on household welfare in Mexico. The author shows different levels of impact of trade liberalization on domestic prices and labour income across income groups and geographical regions.

4.2.3 Commodity price volatility in Nepal: present studies and research gaps

Nepal initiated a number of economic liberalization programmes during mid-1980s after a long period of adopting protectionist economic policies. The country also became a member of the World Trade Organization (WTO) in 2004. Nepal is one of the South Asian countries which has most extensively liberalized trade on both domestic and external fronts with very low tariffs (Pyakuryal, Thapa and Roy, 2005) with trade reforms taking place rapidly, targeting the phasing out of all duties and charges other than custom duties by 2010 (Sanogo, 2008). There is therefore a growing interest among economists and policy makers regarding the impact of economic liberalization on agriculture and household welfare in Nepal. There is a major concern at policy level whether agricultural trade liberalization helps to reduce poverty level in low income countries. In the Nepalese context, as the country is land-locked and surrounded by India in the east, west, and south and it is likely that the market access to the world is limited, particularly in agricultural commodities.

There are a number of studies on the impact of market liberalization in Nepal, most of which were carried out during the last decade. These studies are mostly focused on the macroeconomic impact of trade liberalization in Nepal (Sharma, 1994; Upadhaya, 2000; Sapkota, 2000; Cockburn, 2000; Sharma, Jayasuriya and Oczkowski, 2000; Chapagain, 2002; ANZDEC, 2002; Pyukuryal, Thapa and Roy, 2005; Sharma, 2005; Acharya and Cohen, 2008; and Sapkota and Cockburn, 2008). However, there are limited studies conducted to analyse the impact of agricultural commodity price fluctuations on household welfare at micro level, applying price transmission coefficients in Nepal. Pan, Fang and Rejesus (2009) examine the grain output uncertainties on farm income and on calorie intake in rural Nepal, using both time series output price data from various districts of Nepal and Delhi, India, along with the cross-section data of the Nepal Living Standard Survey. Their results show a reduction in crop production income with an increase in output price uncertainty (especially rice and wheat) that further decreases the calorie intake of rural households. Karmacharya (2006) examines the impact of OECD countries' agricultural liberalization on household welfare in Nepal, applying world price transmission coefficients and shows declining trend in household welfare both in the short-run and in the long run. He concludes that declining trend in household welfare is primarily due to Nepal being a food deficit country.

Karmacharya (2008) further analyses the impact of multilateral trade liberalization on household welfare in Nepal. This study first estimated the extent of price transmission from Indian prices to markets of agro-ecological regions (e.g., mountain, hills and *Terai*, the southern plain) of Nepal for selected agricultural commodities (e.g., paddy rice/milled rice, maize, wheat) using error correction method. In the second step, the author examined the impact of local commodity prices on wages in agro-ecological regions applying earning equations and simulated the impact of changes in border (i.e. Indian) prices on household welfare by applying indirect utility function taking into account the second-order effects for consumption (both for the adjustment in the expenditure basket, as well as the changes in income of the households) and for production (substitution effects) in the third step.

This study shows that Indian prices are transmitted differently to agro-ecological regions where transmission coefficients are high in the southern region adjacent to Indian border and low in mountains. Household welfare for rice seems to decline both in short and long run due to rise in Indian rice prices. But for wheat and maize, the author shows improvement in household welfare in the long run because of the domination of positive supply side effects over negative demand side effects. Poor households were relatively less favourable of welfare change as a result of change in world prices of rice and maize but not of wheat. Finally the author obtains a mixed result of the impact of agricultural liberalization, with household welfare largely depending on domestic price transmission and the extent of the commodity deficit.

Despite a comprehensive analysis for the impact of agricultural trade liberalization on household welfare, the study does not pay much attention to the impact of Indian border prices in adjacent cities of Nepal. The transmission of border prices may vary among Indian and Nepalese adjacent cities and the effect of price change on household welfare may be different among the regions of adjacent cities. The study therefore ignores intra-market characteristics of Nepal, because in some regions, Nepalese people often cross Indian border in order to travel from one place to another place in Nepal.

Recently, Sanogo (2009) has analyzed the spatial integration of rice market in the Far and the Mid-Western regions with regional market (i.e. Nepaljung) of Nepal, as well as with Indian border markets. The author assessed price transmission across different locations within region and the role of Indian border cities adjacent to Nepal in the rice supply. A number of quantitative techniques (e.g, correlation, error correction model, regression) were applied to explore the spatial market efficiency of rice in Nepal.

The results reveal a poorly integrated regional rice market, particularly with the main regional market (i.e. Nepalgunj) in the Far-Western and the Mid-Western regions of Nepal, in which large price differentials are primarily due to poor road infrastructure within the regions, but where Nepalese-Indian border price fluctuations are transmitted both in the short and medium run. The results from the impact of isolation (through road distance and availability) both on price correlation and the price convergence show that high transaction costs can make arbitrage unprofitable for traders and that markets are isolated primarily due to poor road network and infrastructure. These results are also supported by the positive relationship between price differentials, road distance and transport costs.

The study on spatial market integration in one of the remote areas of Nepal is an important contribution in the literature to assess the food markets in the region, particularly in food deficit region of Nepal. However, this study would be better to analyse the market integration of these hilly districts with the region specific market centre. For instance, the main market centre for hilly districts located in Far-Western region is Dhangadi, Kailali and these districts have limited trade with regional centre of the Mid-Western region (i.e. Nepaljung) and thereby may provide misleading results for price transmission. Likewise, Jogbani city of India lies in the eastern region of Nepal and the trade relation of Jogbani city with the mid-western region of Nepal may be nil. It is worthless to include Jogbani in the analysis of spatial market integration. Moreover, the study may give better insights, if other food crops such as wheat and maize (staple food of the study areas) include in the analysis.

There are still only limited studies on the analysis of spatial market integration within the country and with the world and neighbouring countries, India in particular. In Nepal, price volatility of agricultural commodities has become an important issue in the context of agricultural trade liberalization. One of major concerns for this is to understand how the international prices transmit to the domestic markets. For this, there needs to be a detailed empirical analysis of agricultural price volatility in international and domestic markets.

4.3 Trade policy regimes and Nepalese agriculture

Nepal is one of the poorest countries in the world. Approximately 31 percent of people are still below poverty line, with the majority of these from rural areas. The agricultural sector accounts more than 70 percent of employment and contributes 39.5 percent of total Gross Domestic Product (World Bank, 2007). More than 75 percent of farm households have less than one hectare of farmland, and the average farm size is 0.8 hectares (CBS, 2002). The overall Human Development Index (0.49) ranks Nepal at 138th among 177 countries in the world. The country is heavily dependent on aid, tends to have a persistent trade deficit and is dominated by subsistence smallholder agriculture. The major staple food crops are rice, maize, and wheat and the agricultural sector accounts the major share of foreign trade. However, the trade deficit of Nepal has increased consistently during the last decade partly due to the low productivity in the agricultural sector. This is mainly the result of more than a decade of internal political conflict between the government and rebel groups which has severely affected the growth rate of both the agricultural and non-agricultural sectors and hence the trade balance. As a result, Nepal has been acutely facing problems of both exchange rate fluctuations and international price volatility.

The issue of both domestic and international market integration and trade policies can also play a crucial role in reducing price volatility and thereby income instability. It is due to the fact that most primary commodity prices are extremely volatile over short term and these prices rise at a slower rate than manufactured goods and services (Brown and Gibson, 2006). Because the fluctuations of primary commodity prices in response to changes in demand and supply are larger than those in other prices, they increase the cost to producers of holding stocks or working capital (Page and Hewitt, 2001). A standard argument is that by pooling shocks, trade may reduce volatility. However, this depends on the volatility between world or regional and local prices and the level of infrastructure. For instance, if world price or regional prices are more variable than local prices, trade may increase volatility (Gilbert, 2009). Keeping the view of the importance of regional market (i.e. India) and the level of infrastructure, this study intends to shed light on how Nepalese markets in different regions are exposed to Indian markets of adjacent regions. The analysis of the impact of Indian price transmission adjacent to Nepalese markets may give better insights on domestic price volatility in the respective region as compared with the single market.

As in many low income countries, Nepal initiated economic stabilization and structural reforms during mid-1980s, giving a greater emphasis on use of the price mechanism and reducing the government intervention. Major reforms included an economic stabilization plan for the period 1985/86-1986/87, Structural Adjustment Programmes during 1987/88-1989/90, and Enhanced Structural Adjustment Programmes (ESAPs) during 1992/93-1994/95. The economic reforms came into full operation after the implementation of a liberalized trade policy in 1992 giving greater emphasis to the private sector.

Table 4.1: Trade status of major crops in Nepal (in 1000US$)

Year	1969-70	1979-80	1989-90	1999-2000	2001	2002	2003	2004	2005
Rice									
Import	na	na	998	844	2145.92	4421.76	8854.31	5321.39	32220.16
Export	40300	24957	na	6874	na[a]	145.54	675	na	669
Maize									
Import	na	na	74	2000	13	223	2685	1294	2323
Export	na	633	89	21	23	na	na	3	3
Wheat									
Import	259	633	89	21	600	1700	2497	3676	535
Export	9	11400	2065	5277	219	na	38	22	na
Potatoes									
Import	161	na	2550	3584	700	1354	5215	4262	3967
Export	101	90	34	654	Na[b]	na	131	na	na
Mustard oil									
Import	na	na	460	126	2135	6736	3950	14010	6900
Export	na	3600	1566	2	85	520	na	na	na
Chicken meat									
Import	na	na	na	5	na	34	34	49	49
Export	na	na	na	206	na	na	na	na	na

Source: FAOSTAT. *a* data of rice products since 2001 are taken as aggregate of milled rice, husk rice and paddy rice. *b* data of mustard oil from 2001 are taken as aggregate of both mustard oil and mustard seeds.

Agricultural products constitute the major part of foreign trade. In Nepal, trade on agricultural commodities remains sparse in particular because it is difficult to collect accurate data on trade with India due to open border. Table 4.1 shows the status of trade in major staple foods such as rice, wheat, maize, mustard oil/seed, potatoes and chicken meat. The data show that Nepal was a net exporter of rice before 1980s, but that exports fell slightly from 1968 and that from 1980, the country has been a rice net importer. Table 4.1 also shows fluctuations in wheat imports and exports. Likewise, maize was largely imported after 1998, with lower levels of exports. Exports of mustard oil and seeds have decreased and the imports of chicken and mustard oil have increased during the last decade. Finally net imports potatoes have also increased since 1999.

There have been several policy attempts to meet the food demand of the increasing population in Nepal. Liberalization of domestic markets with world markets and implementation of long term agricultural plan such as Agriculture Perspective Plan[31] are the most recent programmes undertaken by the government. However, Nepal's trade has faced many constraints such as transit difficulties due to being a land-locked country and these have particularly affected in food markets. Agricultural transformation from a traditional technology to modern and market-oriented technologies remains a top priority of the government because of the low growth rate and low productivity. Despite these efforts, the Gross Domestic Product (GDP) growth rate of the agricultural sector has not exceeded 2.3 percent on average during last decade. Due to higher population growth and low productivity in agriculture, Nepal has shifted from a food surplus to food deficit country since 1980s. Since that time, exports of food grains have declined and on the contrary, imports of food grains have increased.

Out of the total trade volume, India is the largest trade partner of Nepal and also the major transit providing country for Nepal. India's share accounts about 70 percent of the total export and about 64 percent of the total import. Agricultural and semi-processed goods are the major items to trade with India (TPCN 2008). Nepal also depends heavily upon India for most of its essential foodgrain supplies such as rice, wheat, oilseeds, and other products like petroleum products, infrastructure items and agricultural equipment. The country receives foodgrains from countries other than India mostly as a grant, most of which are under the food for work program provided by donor countries and agencies (MOCS, 2007). Given the extent of trade with India, Nepal is indirectly influenced and protected by Indian trade policies (Samartunga, Karunagoda and Thibootuwawa, 2006). It is therefore plausible to analyze the impact of Indian commodity price fluctuations on

[31] The Agriculture Perspective Plan is a 20 year plan implemented in the fiscal year of 1995/96 with an aim of increasing per capita agricultural growth through technological innovation (APROSC and JMA. 1995). Its strategy was to accelerate the agricultural growth rate sufficiently to obtain strong multiplier effects on growth and employment, in both the agricultural and non-agricultural sectors.

Nepalese markets rather than that of the world markets, as India is a dominant neighbouring country. The unique feature of this study is that it also explores the price transmission from different market centres adjacent to both countries. It is because, the volume of trade and the level of commodity prices in adjacent cities of different regions between India and Nepal may be different, thus influencing the Nepali markets in different ways.

Non-marketed risks that include production risks arising from the unpredictable nature of the weather, other natural disasters, and plant diseases across regions can also lead to the uncertain performance of crops. Variability in agricultural production systems is one way to measure non-marketed risk. The variability of yield of major crops in Nepal over the last couples of decades is shown graphically - see Appendix Figure 4.1. An increasing trend is evident with some fluctuations in paddy rice. Other crops such as maize and wheat have also shown fluctuations in yield. Wheat yield is increasing over time, while that of maize has not exceeded more than 2000 kilograms per hectare. On the other hand, cash crops such as potatoes show an increasing trend in yield per hectare with some fluctuations. However, the production of mustard seeds and chicken meat seems more stable in terms of yield. Mustard seeds have more fluctuations in yield, while chicken meat has constant yield (in carcass weight) with little fluctuations.

4.4 Analytical framework

This study investigates the impact of commodity price and production variability on agricultural income instability based on the theoretical idea discussed in the previous section. As price volatility is a multi-dimensional phenomenon, particularly to the farm households involving in various income-earning activities in agriculture sector, farmers often face both *ex ante* and *ex post* risks and such risks can also influence income level of farm households. There are various ways to formalize these risks into a mathematical framework, depending on the data availability and the purpose of the study.

As the main purpose of this study is to explore the instability in agricultural income denoted by Y_a, consider δ as the share of agricultural income in total income and s_i is the average share of each agricultural product *i* in income and q_i denotes the quantity of product *i*, which is normalized by dividing the amount Q produced in any period by the average value of production, and the normalized price of product *i* by p_i (this is the price P of the product in a period divided by its sample average). $\overline{P_i}$ and $\overline{Q_i}$ are mean values of the normalized price and quantity produced respectively. This calculation is made on the assumption that the quantities produced by the household in period *t* are independent of the prices faced by the household in the same period, and the normalized deviation of total income from its mean is expressed as:

(4. 11)
$$\hat{Y} \equiv \frac{Y - E(Y)}{E(Y)} = \delta \frac{Y_a - E(Y_a)}{E(Y_a)} = \delta \frac{\sum_i P_i Q_i - E\left(\sum_i P_i Q_i\right)}{E\left(\sum_i P_i Q_i\right)} = \delta \frac{\sum_i P_i Q_i - \sum_i \overline{P_i}\overline{Q_i}}{\sum_i \overline{P_i}\overline{Q_i}},$$
$$= \delta\left[\sum_i s_i \left(\Delta p_i \Delta q_i + \Delta p_i + \Delta q_i\right)\right]$$

where Δ is a difference operator indentifying the difference between the realization of the variable and its expected value normalized by the expected value, for instance, $\Delta P_i = \left[P_{i,t+1} - E\left(P_{i,t+1}\right)/E\left(P_{i,t+1}\right)\right]$ for price and $\Delta q_i = \left[q_{i,t+1} - E\left(q_{i,t+1}\right)/E\left(q_{i,t+1}\right)\right]$ for quantity output.

Given the above equation (4.11), the coefficient of variation in square form can be written as:

(4.12)
$$CV^2(Y) = \delta^2 \sum_i \sum_j s_i s_j E\left[(\Delta p_i \Delta q_i + \Delta p_i + \Delta q_i)(\Delta p_j \Delta q_j + \Delta p_j + \Delta q_j)\right],$$

where δ is the share of agriculture in the total household income, s_i represents the average share of each agricultural product i in the agricultural income, and q_i is the quantity of product i produced by the agricultural household.

(4.13)
$$CV^2(Y) = \delta^2 \sum_i \sum_j s_i s_j E\left[\Delta p_i \Delta p_j \Delta q_i \Delta q_j + \Delta p_i \Delta p_j + \Delta p_i \Delta q_j + \Delta p_j \Delta q_i + \Delta q_i \Delta q_j\right]$$

the coefficient of variation (CV) of income is simply the square root of (4.13), where the calculation of different components can be made as follows.

Consider now there exists a trade relationship between Nepal and India of various commodities. Let P_{it}^d and P_{it}^I be the prices of domestic and Indian commodities respectively. According to the Law of One Price (LOP), the model assumes that at all point of time with allowing transfer costs *c*, the relationship between the prices presents as follows;

(4.14)
$$P_{it}^d = c + P_{it}^I,$$

if the relationship between two prices in (4.14) held, then the markets are supposed to be fully integrated. However, such model represents only a simple radial configuration of markets linking one market directly with another market (Ravallion, 1986) and this market situation occurs very rarely in the short run, particularly in developing countries such as Nepal because of high transaction costs, which often drive a wedge between the prices of one market to the prices of another market, at least in the short run. On the other hand, if the probability distribution of two prices found to be independent, then one would assume at the conclusion that there is no market integration and no price transmission.

Empirically, the impact of international price changes to domestic price is expressed in the following functional form:

(4.15) $P_{it}^{d} = \alpha_i + \beta P_{it}^{I} + \mu_{it}$,

where P_{it}^{d} is the monthly/yearly domestic food prices (e.g., rice, maize, wheat, potato, mustard oil and chicken) of selected cities of southern part of Nepal and P_{it}^{I} is the monthly/yearly prices of the same commodities in selected Indian cities adjoining to southern part of Nepal, and μ_{it} is an error term. Equation (4.15) implies that domestic food prices are determined by Indian market prices at least in the long run.

The functional form in logarithms can be written as:

(4.16) $\log P_t^{d} = \alpha_i^{'} + \beta^{'} \log P_t^{I} + \mu_{it}$,

here, prices are converted in logarithms, then $\beta^{'}$ is interpreted as the elasticity of transmission of Indian prices to domestic prices, that is percentage change in domestic prices in response to one unit change in Indian prices. However, the interpretation of the parameter ($\beta^{'}$), and the extent of the relationship between domestic and Indian prices depend on the application of statistical method for estimation rather than the underlying theoretical concept itself (Rapsomanikis, Hallam and Conforti, 2004). In addition, it is also standard to include trend and seasonal dummy variables.

Let σ_i be the coefficient of variation of production of the i^{th} crop produced by the household, and the correlation coefficient between the production of the i^{th} crop and j^{th} crop produced by the household is denoted by κ_{ij}. v_i^{I} is the coefficient of variation of Indian price of the product *i*, and ρ_{ij} refers to the correlation of coefficients of Indian prices of the i^{th} and j^{th} products (only in the case of both tradable). The coefficient of variation of the random component u_{it} of the domestic prices is denoted by υ_i for product i, and γ_{ij} is the correlation coefficient between the random components u_{it} of domestic prices of the i^{th} and j^{th} products.

Under these notations, terms in equation (4.13) can be calculated as:

(4.17) $E(\Delta p_i \Delta p_j \Delta q_i \Delta q_j) = (\beta_i \beta_j \rho_{ij} v_i^{I} v_j^{I} + \gamma_{ij} \upsilon_i \upsilon_j) \kappa_{ij} \sigma_i \sigma_j$

(4.18) $E(\Delta p_i \Delta p_j) = \beta_i \beta_j \rho_{ij} v_i^{I} v_j^{I} + \gamma_{ij} \upsilon_i \upsilon_j$

(4.19) $E(\Delta p_i \Delta q_j) = 0$

(4.20) $E(\Delta q_i \Delta q_j) = \kappa_{ij} \sigma_i \sigma_j$.

The equation (4.19) assumes that the quantity produced by the household in period *t* are independent of the prices faced by the household in the same period, allowing the expected value equals to zero. The CV can be calculated or analyzed under different scenarios with transmission coefficients. For instance, putting the transmission coefficient (β) equal to zero allows to interpret the factor influencing the agricultural income instability only due to domestic shocks such as production, but not due to Indian price shocks. On the other hand, setting β equal to 1 and at the same time, setting the variance of domestic error term equal to zero will simulate the situation when the domestic prices are equal to Indian prices. The result from this calculation then correspond to the case in which the agricultural household is faced only with Indian price variability, which is the case of perfect market integration between Nepalese and Indian prices.

The functional forms (4.15) or (4.16) can be extended to a multivariate case or to a Vector Autoregressive (VAR) model, revealing that both domestic and international prices are stochastic in nature. VAR models developed by Sims (1980) have been much used in empirical studies of macroeconomic issues. This may be seen as natural extension of the univariate autoregressive model to dynamic multivariate time series and is a *n*-equation, *n*-variable linear model in which each variable is in turn explained by its own lagged values, plus current and past values of the remaining *n*-1 variables. The model is considered as a coherent and credible approach to data description, forecasting, structural, and policy analysis. VAR models can be estimated by Ordinary Least Squares without loss of efficiency.

A *reduced* (or standard) *form* VAR expresses each variable as a linear function of its own past values and the past values of all other variables being considered and a serially uncorrelated error term. VAR models are good at capturing co-movements of multiple time series. In theory, the VAR uses all available or relevant past values. The VAR (*p*) model of order *p* can be written as follows[32]:

(4.21) $$y_t = v + A_1 y_{t-1} + ... + A_p y_{t-p} + u_t,$$

where $y_t = (y_{1t},...y_{kt})'$ is a $(k \times 1)$ random vector, $v_t = (v_1,...,v_k)'$ is a fixed $(k \times 1)$ vector of intercept terms allowing for the possibility of non-zero mean $E(y_t)$, and the A_i are fixed $(k \times k)$ coefficient matrices. Finally, $u_t = (u_1,...,u_k)'$ refers to *K*-dimensional white noise or innovation process, satisfying $E(u_t)$=0, $E(u_t u_t')=\Omega$, and $E(u_t u_s')= 0$ for $s \neq t$. The covariance matrix Ω is assumed to be non-singular, if not otherwise stated (Lütkepohl, 1993). The Akaike (AIC) or Bayes (BIC) information criteria are used to test for the lag length *p*.

For empirical estimation, this paper applies bivariate reduced VARs of the form

(4.22) $$P_{it}^I = a_1 + \sum_{j=1}^{k} b_{11,j} P_{it-j}^I + \sum_{j=1}^{k} b_{12,j} P_{it-j}^d + \mu_{it}^I, \text{ and}$$

(4.23) $$P_{it}^d = a_2 + \sum_{j=1}^{k} b_{21,j} P_{it-j}^d + \sum_{j=1}^{k} b_{22,j} P_{it-j}^I + \mu_{it}^d,$$

where, $b's$ are parameters and $\mu's$ are contemporaneously correlated error terms.

[32] For more details, see Lütkepohl (1993).

Equations (4.22)-(4.23) are the basis for estimating, forecasting, and computing mean and variances of the prices, conditional on the VAR relationships. The parameters b_{ij} provide a basis for the estimation of h-step ahead forecast means and variances of the prices, under the assumption that economic agents behave according to the VAR relationships. In addition, these equations (4.22) and (4.23) provide the information of relative importance of shocks to the domestic and Indian prices and can also be analysed their overall impact on domestic prices.

VARs can also be considered as means of conducting causality, more specifically Granger causality tests, meaning to what extent and direction causality between Indian and domestic prices. In causality test, the innovation of the first price, say P_{it}^{I}, is assumed to be independent and the part of domestic shock in P_{it}^{d} is due to the volatility of P_{it}^{I}, but not necessarily *vice versa*. The relationship between innovations can be written in the following way:

(4.24) $$u_{it}^{d} = \beta u_{it}^{I} + \vartheta_{it},$$

where ϑ_{it} refers to shocks or innovations in the domestic price, but not due to the innovations in Indian prices – see Rapsomanikis and Sarris (2005)[33]. The parameter β is the elasticity of the domestic price in the short run with respect to Indian price as in the equations (4.15 or 4.16). This framework is also useful to decompose variation in the system into component that are due to variation in the innovations.

For the estimation of the coefficient of variation for yield, the paper assumes that yields follow a linear deterministic trend processes, which are given as follows:

(4.25) $$Q_{it} = \phi_i + \xi_i T + \varsigma_{it}, \text{ where } \quad \varsigma_{it} \sim \text{iid}(0, \sigma_{i\varsigma}),$$

where Q_{it} is yield per hectare of crop *i* at time *t* and *T* is time trend. The simple autoregressive models will apply after unit root tests and then calculated the coefficient of variations and correlation coefficients for yields from the k-step ahead conditional expectation and the corresponding forecast error variances.

Based on the conceptual framework mentioned above, the model is implemented in different stages, depending on the statistical properties and their process to apply for the particular statistical property in the model. At the first stage, the model first proceeds by various tests on statistical properties of time series data[34]. If both price series are stationary with internationally traded, the

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[33] The authors mention that shocks μ_{it}^{d} and μ_{it}^{w} are likely to have correlation. So the variation in the system is not only determined by the variance of each of the innovations, but also by the covariance.

[34] Two standard procedures to determine the order to integration are augmented Dickey-Fuller (ADF) and Philips-Perron (PP). The augmented Dickey-Fuller (ADF) is based on the following regression: ($x_t - x_{t-1} = \lambda + \delta x_{t-1} + lags(x_t - x_{t-1}) + \omega_t$, where x_t is the series under consideration. According to the authors, a

model applies VAR and then tests Granger causality. The model further orders the system and estimates conditional variance and covariances through variance decomposition by doing 12-month ahead forecast . If time series data are not stationary, then the model applies AR, depending on whether price series data are I (0) or I (1). The model estimates conditional variance and covariances by 12-month ahead forecast.

After the calculation of conditional variances and covariances of commodity prices and yields, as well as transmission coefficients, these estimates use for calculation of CV of income of the agricultural households under the assumptions discussed above. This study also estimates the impact of price volatility on agricultural income instability under different scenarios as made by Rapsomanikis and Sarris (2005):

- the estimation of household income variances assuming that households are exposed to both domestic and Indian market prices, taking into account the estimated transmission coefficients of agricultural commodity prices;
- estimation of household income variances assuming that households are exposed to domestic price volatility only, and
- estimation of household income variances is also made under the scenario of complete exposure to Indian markets as an assumption of perfect market integration, implying that the prices to which farmers are exposed to Indian markets, are measured in foreign currency and converted into domestic currency by a fixed exchange rate, thus excluding the variability of exchange rate variations.

4.5 Data and descriptive statistics

The data for the analysis of this study comprise monthly prices of Nepalese and adjacent Indian markets of various food crops such as rice, wheat, maize, potato, mustard oil and chicken meat. Analysis of world price transmission without considering Indian price transmission would be inadequate due to Nepal's de facto economic integration with India. Nepal is a landlocked country with poor transport links to the sea, combined with a long open border and preferential trade agreement with India. Moreover, there is also heterogeneity in access to Indian markets from different regions and belts of Nepal, in which people often use Indian territory to travel from one place to another place in Nepal. Indian commodity prices of different cities adjacent to Nepalese borders are therefore more relevant than world prices in order to analyze price volatility due to a stronger de-

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negative and significant value of δ indicates that x_t is I (0). Likewise, PP test is also similar to ADF, but their difference lies on the treatment of any nuisance serial correlation aside from that generated by the hypothesized unit root. Detailed information has been given in Chapter 2 (See Baffes and Gardner 2003; Stock and Watson 2007).

gree of integration with Indian prices in different administrative regions and ecological belts of Nepal. Prices of these commodities collected from four Indian cities: Bahraich, Gorakhpur, Muzaffarpur, and Purnia and four Nepalese cities: Nepalgunj, Bhairahawa, Birgunj, and Biratnagar respectively. The data extend from the August 2003 to November 2007 providing a total of 58 observations for each crop[35]. The analysis of the price data uses both average monthly prices of four cities and prices of single city having close links in terms of distance and traditional trade relations between Nepal and India. Price transmission coefficients are also estimated for the closest cities of two countries, specifically the pairs Bahraich-Nepalgunj, Gorakhpur-Bhairahawa, Muzaffarpur-Birgunj and Purnia-Biratnagar. The selection criteria for these city pairs were based on geographical location as well as traditional trade relation between these cities.

Information on the share of agricultural income in the total household income and the share of major crops in agricultural income in the household was obtained from the Nepal Living Standard Survey (NLSS 2003/04). NLSS is the national survey of Nepal conducted by the Central Bureau of Statistics with technical and financial cooperation from the World Bank. The survey is the second nationally random cross-section sample of 4,008 households from six explicit strata of the population. The sample covers most of the regions including mountain regions (408 households); hilly regions (1,968 households); and *Terai*, the southern plain area (1,632 households).

Table 4.2: Average share of income by major crops in different ecological belt (percent)

Ecological belt	Mountain		Hill		*Terai* (southern plain)	
	Poor	Non-poor	Poor	Non-poor	Poor	Non-poor
Rice	17.90	15.60	13.10	11.30	18.20	17.30
Maize	12.80	10.10	15.00	5.20	1.80	1.30
Wheat	4.90	4.30	3.70	2.00	4.40	3.60
Potato	3.40	3.50	2.11	0.98	0.89	0.69
Mustard Oil	1.52	1.74	2.07	1.90	2.83	2.15
Chicken	1.52	1.11	1.96	3.14	2.18	2.49

Source: NLSS 2004 (calculated by author)

The NLSS sample households are divided into poor and non-poor on the basis of the poverty index[36]. The share of various crops such as rice, maize, wheat, potatoes, mustard oil and chicken meat in agricultural income are calculated based on the information provided in the sample. Table 4.2 shows the share of each commodity in the total agricultural income, where rice covers the high-

[35] The data sources for Indian prices adjoining to southern border of Nepal were obtained from Nepal Rastra Bank (National/Central Bank of Nepal), while price data for domestic markets were obtained from the Agricultural Marketing and Information Bulletin, Ministry of Agriculture and Cooperatives, Government of Nepal. These price data have been deflated utilizing the IMF consumer price index of Nepal, which is equal to the values of year 2000.

[36] Headcount ratio is broadly applied to find the poverty index. Headcount ratio is the proportion of the national population whose incomes are below the official threshold set by the national government. Generally, national poverty lines are set for households of various compositions to allow for different family size. If the household is below the official poverty lines, then the household is defined poor, if above poverty line, then the household is non-poor. This method is commonly applied by the World Bank.

est share in the agricultural income, followed by wheat and maize. In cash crops, potatoes constitute a higher share in agriculture in mountain regions, but not in hills and *Terai*. The share of mustard oil and chicken meat in the total agricultural income is higher in southern region of Nepal in compared to mountain region.

Nepal is divided into five development administrative regions: Eastern, Central, Western, Mid-western and Far-western. Table 4.3 gives the share of various crops in the agricultural income by administrative region. Rice occupies the highest share in agriculture income, followed by maize and wheat. Potatoes cover higher share in cash crop in total agricultural income, followed by mustard oil.

Table 4.3: Average share of income by major crops in different administrative regions (percent)

Administrative region	Eastern	Central	Western	Mid-far western
Rice	17.90	14.60	12.30	13.20
Maize	5.90	5.50	4.60	4.30
Wheat	2.40	2.40	2.00	6.80
Potato	3.24	2.10	2.83	3.03
Mustard Oil	1.52	1.40	2.94	3.39
Chicken	1.16	0.89	1.11	1.20

Source: NLSS 2004 (calculated by author)

The data for the calculation of the conditional measures on yield variability (given in Table 4.4) of these commodities were obtained from FAOSTAT. The data for yield and trade cover from the year of 1961 to 2007. The yield data are measured in kilogram per hectare for cereal crops and carcass weight for chicken, while the amount for trade is measured in US dollar.

The CVs of crop yield are give in Table 4.4 (see Appendix 4.1), estimating from 12-step ahead forecasts[37]. The CV of yield is found to be higher for rice and maize (0.22) followed by wheat (0.21) and potatoes (0.19), while mustard oil appears lowest CV of yield (0.06).

4.6 Empirical analysis

Estimation of agricultural income CV follows a number of steps.

a) I establish whether or not the time series are stationary by calculating Augmented Dickey-Fuller tests. A summary of unit root tests are given in Table 4.4 to 4.8 and also in Appendix 4.2. The results (i.e. national average price data) show that most of price series are I (1) except those for Nepalese maize, potatoes and chicken prices which are I (0). However, few city wise price series data are both I(0) in different cities of different commodity prices, such as potatoes for Biratnagar, Nepal- Purnia, India (see, Table 4.5), maize and potatoes for

[37] This paper first carried out the stationary tests and applied simple autoregressive models, and calculated conditional means and variances form 12-month ahead forecasts.

Birgunj, Nepal-Muzaffarpur, India (see, Table 4.6), and chicken for Bhairahawa, Nepal – Gorakhpur, India (see Table 4.7) and for Nepalgunj, Nepal- Bahraich, India (see Table 4.8).

b) I estimate a VAR for stationary price series of both countries and cities and test Granger causality. If Granger causality exists, then I estimate conditional expectation and the corresponding error variances and use the residuals for both Nepalese and Indian border prices to run a regression from domestic price to Indian prices to obtain transmission coefficients.

c) If both price series are not stationary, then I apply AR model, depending on whether price series data are I (0) or I (1).

d) Finally, I conduct 12-step ahead forecasts to obtain variances and covariances to calculate the CVs of each commodity depending on their statistical properties.

The results of VAR or AR estimation and the CVs of agricultural income are discussed in detail.

The results of time series analysis for market integration and commodity price and production variability are given in Table 4.4-4.8, in which most price series both at national and adjacent city levels are I (1). The price CVs calculated from 12-step ahead forecasts are found to be high in potatoes ranged from 0.38 to 0.71 in domestic prices and from 0.24 to 0.65 in Indian prices, indicating that the variation of potatoes prices seem to be high in domestic markets than in Indian markets. The CVs of mustard oil appear to be low ranged from 0.05 to 0.23 in domestic and from 0.06 to 0.23 in Indian markets. The CVs of main staple food (i.e. rice) prices are ranged from 0.08 to 0.25 in domestic and from 0.12 to 0.24 in Indian markets, while maize CVs are mainly between 0.15 to 0.30 in both markets and wheat ranged from 0.10 to 0.20 in both markets. However, the CVs of chicken prices are ranged from 0.13 to 0.25 in domestic markets and from 0.16 to 0.40 in Indian markets. Finally, the CVs of commodity prices imply that the price variability of both markets shows similar characteristics with few exceptions.

As discussed above, few price series data are I (0), allowing us to apply VAR and then test Granger causality[38]. The Granger causality tests (see Table 4.5-4.8) show that chicken price of Gorakhpur market of India Granger causes to Bhairahawa market of Nepal, and potatoes price of Purnia market of India also Granger causes to Biratnager market of Nepal. The study also intends to test Granger causality between Nepalese commodity prices with the world prices[39] with an aim to whether Nepalese commodity prices are integrated with the world prices. But none of the price series of both domestic and world markets are I (0).

[38] In this analysis, Granger causality tests are done only after the estimation of VAR with those price series data which have similar statistical properties (i.e. I (0)) but not by using cointegating vector.

[39] The selected markets for world prices are: rice from Bangkok, Thailand, wheat from United States Gulf, and maize from United States of America (source: IMF statistics) and yearly price of Nepalese rice, wheat and maize are collected from Ministry of Agriculture and Cooperatives, Nepal. This study could not test causality with other crops such as mustard oil, potato, and chicken meat due to data unavailability.

Table 4.9 shows the CV of agricultural income which is the main interest of this study. This CV of agricultural income is calculated after the computation of all components (4.17-4.20), such as price CVs and correlation coefficients of prices for both Nepalese and Indian markets, CVs and correlation coefficients of yield variability, and transmission coefficients of prices[40]. The CVs of agricultural income presented in Table 4.9 are the conditional CVs. These calculations were undertaken under three scenarios:

(i) actual exposure to Indian markets includes all components from equations (4.17) to (4.20) in the analytical framework;

(ii) no market integration with India (isolation): CVs from domestic price and production shocks (i.e., $\beta = 0$, no exposure to Indian markets) account yield variability and domestic price shocks (i.e., CVs and correlation coefficients of prices) by putting the variability of international prices zero; and

(iii) full market integration with India: simulated and production shocks (e.g., $\beta = 1$, full exposure to Indian markets) measured in foreign currency and converted into domestic exchange rate by a fixed exchange rate.

Since the CVs of agricultural income are estimated on the basis of partial agricultural income that covers about 50 percent share of the total household agricultural income in Nepal [41], the conditional CVs of agricultural income may therefore underestimate the actual variability of income in this study. However, these CVs will give some indication on how domestic and Indian price volatility affects the agricultural income instability because these commodities (rice, wheat, maize, potatoes, mustard oil and chicken meat) are the major crops produced by the agricultural households for their livelihoods.

Table 4.9: CVs of agricultural income by ecological belt (poor and nonpoor)

Ecological belt	Mountain		Hill		*Terai* (southern plain)	
	Poor	Non-poor	Poor	Non-poor	Poor	Non-poor
Actual CV's	6.50	5.92	5.16	3.74	4.23	3.64
CV's in isolation (no market with India)	6.71	6.11	5.32	3.87	4.37	3.73
CVs with full market integration	6.61	6.03	6.25	4.81	4.31	3.71

The estimates of agricultural income variability show that the uncertainty the households face varies with the variation of production and the level of market integration. The agricultural in-

[40] Only significant transmission coefficients and correlation coefficients are included for CV calculation as carried out by Sarris (2002).

[41] NLSS data show more than 100 commodities produced by the agricultural households. So it is difficult to include all commodities in this analysis because of insignificant share (<1 percent) in agricultural income and no specific information about prices both in domestic and international markets.

come CV ranged from 3.64 to 6.71 percent which is relatively small. However, these estimated CVs of Nepal are more closer with those CVs estimated in Ghana and Peru by Rapsomanikis and Sarris (2005) in terms of the effects by simulation of full exposure to International markets. The lower CVs of agricultural income in this study may be due to more integration of Nepalese markets with Indian markets. It may also be the fact that the exchange rate[42] between Nepalese and Indian rupees is relatively low and stable than the exchange rates of Nepalese currency with US dollars, in which a small change in US dollars may give higher shocks in domestic markets than with Indian rupees. It may also be the fact that Nepalese markets are more integrated with Indian markets adjacent to Nepalese border than the world markets, because the CVs are found to be lower in *Terai* (the southern belt adjacent to Indian borders) than in the mountain belts.

The results further allow us to examine the view that the uncertainty of the agricultural household income slightly increases by the production variability (i.e. domestic shocks), followed by full market integration with India. However, differences in agricultural income CVs are smaller among different scenarios (e.g., actual, no market integration, and full market integration). But there is variation in the agricultural household income CVs among different ecological belts. For instance, agricultural income CV is higher in the upper ecological belt of Nepal. It may be due to the geophysical structure of Nepal. For example, the southern part of Nepal is relatively developed in terms of infrastructure, agricultural innovation and commercialization than the northern part which may lead to the agricultural income being CV less volatile in the southern part. Moreover, Nepal is a landlocked country surrounded by Indian in the east, the south and the west and its international trade goes mostly through the India port, so domestic markets are obviously more sensitive with Indian markets than any other country in the world.

The results also show that the agricultural household faces slightly higher income variability by domestic shocks than the full market integration and actual shocks, perhaps due to high dependency on rainfed agriculture in Nepal. It may be due to the fact that some of the domestic price CVs such as maize and potatoes are higher than the CVs of respective Indian commodity prices. CVs appear to be relatively higher in poor than nonpoor households. The relatively higher variation of agricultural income in poor households seems to be reasonable because they are mostly small farm holders and price fluctuations of staple crops such as rice, wheat, maize, mustard oil, and chicken meats can have higher impact on their income. A small variation of staple crops seems more acute for poor farmers than rich farmers, so that their agricultural income will be more varied by the variation of staple crops for subsistence farmers.

[42] The exchange rate between Nepal and India is about 1 Nepalese Rupees= 1.60 Indian Rupees and this exchange rate is somehow more stable since a long time, but there is often fluctuation in buying and selling exchange rates.

The result of CVs under the scenario of actual markets shows that the present fact is less volatile than the isolation and full market integration with India. However, there is less variation between actual and full market integration. These results are from the average price of four adjacent cities bordering to Nepal and India. These results vary in different ecological belts, showing higher CVs in mountain belts, followed by hills and *Terai*. This is perhaps due to the share of these commodities in the total income and the geographical heterogeneity in which the transportation costs may influence market transaction. In Nepal, some of mountain districts do not link with road networks.

Table 4.10: CVs of agricultural income by administrative region (poor and nonpoor)

Administrative region*	Eastern	Central	Western	Mid-far western
Actual CV's	2.39	2.52	2.91	3.22
CV's in isolation (no market with India)	3.01	2.43	3.09	4.07
CVs with full market integration	3.35	3.20	1.74	3.03

Note: CVs are in percentages. * These CVs are calculated by four adjacent border markets of both countries separately.

The CVs of agricultural income are also estimated on the basis of administrative regions with separate prices of adjacent markets of both countries. As discussed above, the analysis consists of four market centres for both southern Nepal and northern India. The estimation is done separately for each administrative region, but two regions in western Nepal (e.g., mid-western and far-western regions) are merged into one centre (e.g., Nepalgunj) because of only one market centre for price data available in these two regions. However, the data on yield variability are the same as used in ecological belt. Household data from NLSS are separated on the basis of administrative development regions, which were done by ecological belts in the first CV estimation of the agricultural income. In the first part of CV estimation, ecological belt divides the country vertically, while administrative region divides the country horizontally.

The results of agricultural income CV on the basis of administrative region ranged from 2.52 to 3.22 for actual, from 2.43 to 4.07 for no market integration, and from 1.74 to 3.35 for full market integration with India are found to be different as well as smaller than the CVs calculated in the ecological belts. The percentages of CVs are found to be low among all administrative regions. However, the impact of different scenarios varies among different regions. For instance, CVs of agricultural income are found to be high due to domestic shocks in the far-mid western and the western regions, while higher variability of CVs due to full market integration with India is found to be high in the eastern and the central regions of Nepal. These results are perhaps due to the region specific characteristics and the volume of trade with Indian markets in different regions. It may be due to the share of particular commodity in the specific region. Because the variability of CVs in different scenarios in different regions is relatively low. This difference may be due to higher Indian price CVs appearing more influential in the respective market of the region. For instance, the higher CVs of Indian chicken, maize and potatoes prices of Indian markets may have influential role to increase the CVs due to full market integration in the eastern region, while domestic price CVs may be more acute in the variability of agricultural income in the far-mid western region of Nepal.

The CVs are further estimated based on the share of agricultural income in the total household income by dividing into three categories (e.g., greater than 65 percent, 30-65 percent, and less than 30 percent) both by ecological belts and by administrative regions with an aim to explore the impact of price volatility on household with different income composition. The results are found to be relatively high variability due to domestic shocks as before. Higher instability in household income is found in households having more than 65 percent share of agricultural income which ranged from 11.22 to 13.08 in ecological belts and 7.60 to 12.93 in administrative regions. The CVs are relatively high in hilly and mountain regions than in *Terai,* the southern part of Nepal, perhaps due to higher share of these commodities in the total income compared to *Terai* belt. In addition to this, the CVs between 30 to 65 percentage shares of agricultural income vary from 6.34 to 9.91 in ecological belts and from 6.21 to 7.83 in administrative regions, while the CVs are less than 2 for below 30 percent agricultural income share households both in ecological belts and in administrative regions. The domestic price and production shocks are found to be high in all ecological belts, as well as far-mid and western regions and full market integration is found to be high in the central and the eastern regions. This is perhaps due to open border between Nepal and India, which often reduces instability than restricted trade and closed border (Chapoto and Jayne 2006).

The overall result indicates that domestic shocks have higher influences in agricultural income instability combined with the higher share of agricultural income in the total household income. Northern part of Nepal (e.g., mountain and hills) is relatively more affected by the price and production variability perhaps due to higher dependency on rainfed agriculture and less market integration with India because of limited transportation linkages. The simulation result shows that higher integration of agricultural markets with India would reduce the income uncertainty of farmers in the far-mid western and the western regions, but increase in the central and the eastern regions, widely supporting geographical heterogeneity that differs the degree of integration with domestic, as well as Indian prices in different ecological belts and administrative regions.

4.7 Conclusions

Commodity price risks and instability are perennial issues that have been received considerable attention by many policy makers and economists for decades. An important question is whether increased exposure to Indian markets reduces the domestic price volatility and thereby improves the welfare of agricultural households. Evidence on this issue can have a profound impact on policy implications to the countries adopting market liberalization policies of the type initiated during the 1990's.

This paper attempts to examine the impact of price volatility in the agricultural household income instability in Nepal, applying a recent analytical framework developed by Rapsomanikis and Sarris (2005) that allows both price and yield variations to calculate the agricultural household income variance by extending the analysis of market integration with regional partners, as well as with the world markets. Indeed, India is the largest trade partner and has a dominant role in Nepalese trade, so that the study on Nepalese market integration with India seems to be more important than with the world markets. Moreover, this study further extended this research by looking the impact of market integration on producers' income instability across different regions of Nepal that are adjacent to cities in India separately. The analysis of market integration between Nepal and India as well as across adjacent cities between two countries can provide better insights of market integration within the region.

The study calculates the Coefficient of Variation (CV) of agricultural income based on the price transmission coefficients by time series price and yield data using VAR and autoregressive models (depending on whether the particular commodity is internationally traded) and the share of agricultural income in the total household income, as well as the share of major crops in the agricultural income using cross-section data from the Nepal Living Standard Survey 2003/04. This study estimates the agricultural income instability under three scenarios: no exposure, actual exposure, and full exposure to Indian markets, that allow exploration of the extent of impact of price shocks on agricultural income variability in different ecological belts, as well as administrative regions at different levels of agricultural production shares in total income of farm households.

Nepalese agricultural income instability appears to increase with domestic shocks rather than full exposure to Indian markets. The extent of these shocks is relatively higher in less developed regions where geographical heterogeneity is more pervasive. However, the results from VAR models, specifically the estimated price transmission coefficients, show that Nepalese commodity prices such as chicken and potatoes in the eastern region and chicken in the western region follow the prices of the respective region of Indian markets. Agricultural income variability is found to be higher in those households which have higher share of agricultural products (more than 65 percent) in the total income, followed by the households sharing 30 to 65 percent of agricultural products in total income. On the other hand, poor households have slightly higher CVs, but the difference with non poor is low perhaps due to low variation of these commodities in the share in the total household income. High variation of CVs among ecological belts may be perhaps due to higher share of agricultural products in the total household income.

The estimated CVs of agricultural income ranged from 3.64 to 6.71 percent in ecological belts and from 1.74 to 4.07 in administrative regions among the poor and the non-poor households, while the CVs vary from 11.22 to 13.08 and from 7.60 to 12.93 among households with higher share of agricultural products in total household incomes in the ecological belts and in the administrative regions respectively. However, the variation of CV declines with the lower share of agricultural products in the total income. The CVs are found to be relatively high due to domestic shocks, followed by full exposure and actual exposure to Indian markets. In general, agricultural income instability is slightly higher in poor than in non-poor households, probably due to the larger share of agricultural production in the total household income.

The results can have significant implications for government in formulating risk coping strategies for rural agricultural households in Nepal. Since income instability seems to be influenced more by production shocks to the households combined with higher share of agricultural products in the total household income, policies should be taken into account on how rural farm households cope with such risks. For a country such as Nepal where spatial market integration is a challenging task, focus should be on the integration of both domestic and international markets through the reduction of trade imbalance and the investment in transportation, irrigation, and other infrastructures that can reduce the extent of price and production variability. Higher integration of domestic market through investment on infrastructure would further enhance farmers' access to resources and lead to higher integration with regional and world markets, and thereby reduce income instability. Market integration is important to make goods (e.g., foodgrain) available and to keep price stable, because well-integrated markets assume that prices of comparable goods do not behave independently. Moreover, in well-integrated markets, price changes in one location are consistently related to price changes in other locations, in which market agents are able to interact among different markets.

The study concentrates more on the staple food crops in order to analyse the impact of price volatility on agricultural income instability. Further studies would be interesting to analyse income instability for cash crops (e.g., tea, tobacco and other high value and cash crops) depending households. Such studies would help understanding of whether domestic markets follow the world markets, particularly in context of more commercialization farming.

APPENDIX-4.1

Figure 4. 1: Crop yield variability

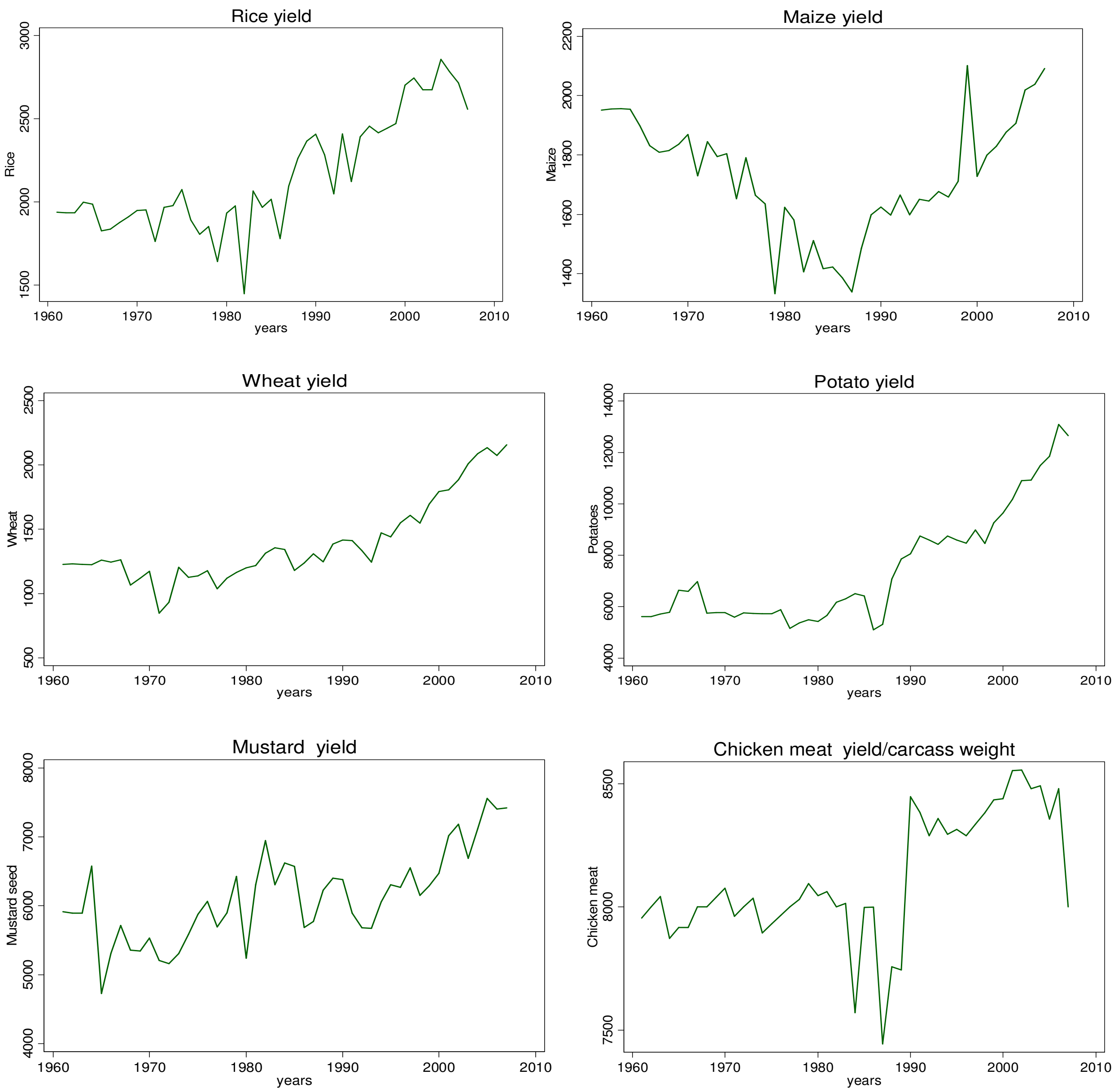

Figure 4.2: Nepalese and Indian price variability

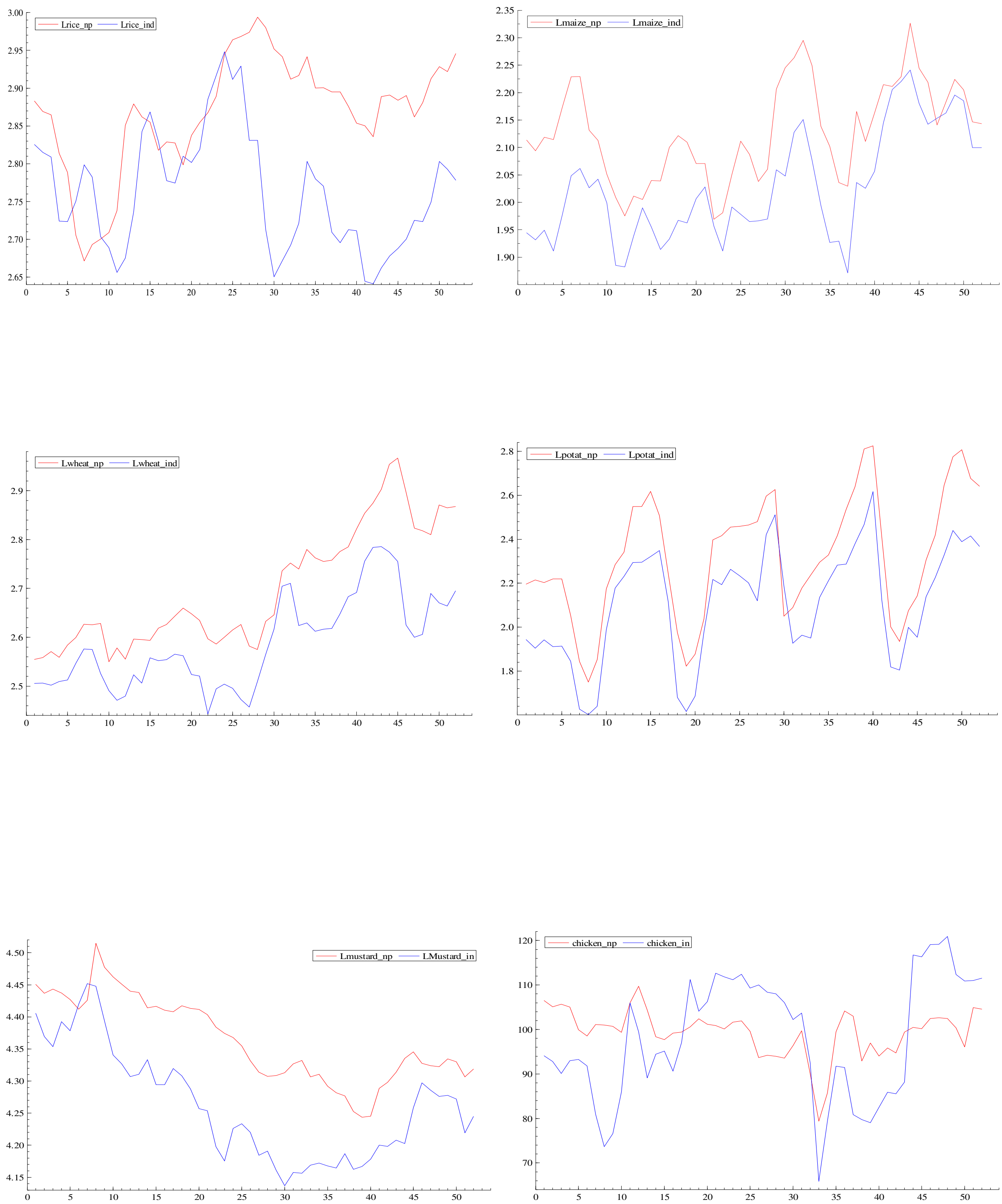

Table 4.4: Time series analysis for market integration and commodity price variability of Nepal and India

	Rice		Maize		Wheat	
	P^d	**P^I**	**P^d**	**P^I**	**P^d**	**P^I**
Statistical properties	I (1)	I (1)	I (0)	I (1)	I (1)	I (1)
Market integration: causality*	na		na		na	
Coefficient of variation of domestic prices	**0.08**		**0.20**		**0.08**	
Coefficient of variation of Indian prices	**0.12**		**0.13**		**0.10**	
Coefficient of variation of yields§	**0.22**		**0.22**		**0.21**	
	Potato		**Mustard Oil**		**Chicken**	
	P^d	**P^I**	**P^d**	**P^I**	**P^d**	**P^I**
Statistical properties	I (0)	I (1)	I (1)	I (1)	I (0)	I (1)
Market integration: causality*	na		na		na	
Coefficient of variation of domestic prices	**0.61**		**0.05**		**0.13**	
Coefficient of variation of Indian prices	**0.42**		**0.06**		**0.23**	
Coefficient of variation of yields	**0.19**		**0.18**		**0.06**	

Note: All coefficients of variation of Indian prices are estimated by means of AR models; § coefficients of variation of yields are same for all; na: not applicable; * estimated only from bivariate VAR models

Table 4.5: Time series analysis for market integration and commodity price variability of Biratnagar, Nepal-Purnia, India

	Rice		Maize		Wheat	
	P^d	P^I	P^d	P^I	P^d	P^I
Statistical properties	I (1)	I (1)	I (0)	I (0)	I (1)	I (1)
Market integration: causality*	na		*P^I does not Granger cause P^d*		na	
Coefficient of variation of domestic (Biratnagar) prices	**0.25**		**0.26**		**0.12**	
Coefficient of variation of Purnia (India) prices	**0.18**		**0.35**		**0.13**	
	Potato		**Mustard Oil**		**Chicken**	
	P^d	P^I	P^d	P^I	P^d	P^I
Statistical properties	I (0)	I(0)	I (1)	I (1)	I (0)	I (1)
Market integration: causality*	*P^I Granger cause P^d*		na		na	
Coefficient of variation of domestic (Biratnagar) prices	**0.27**		**0.12**		**0.26**	
Coefficient of variation of Purnia (India) prices	**0.54**		**0.16**		**0.40**	

Note: All coefficients of variation of Indian prices are estimated by means of AR models; § coefficients of variations of yields are same for all; na: not applicable; * estimated only from bivariate VAR models

Table 4.6: Time series analysis for market integration and commodity price variability of Birgunj, Nepal-Muzaffarpur, India

	Rice		Maize		Wheat	
	P^d	P^I	P^d	P^I	P^d	P^I
Statistical properties	I (1)	I (1)	I (0)	I (0)	I (1)	I (1)
Market integration: causality*	*na*		*P^I does not Granger cause P^d*		na	
Coefficient of variation of domestic (Birgunj) prices	**0.25**		**0.23**		**0.15**	
Coefficient of variation of Muzaffarpur (India) prices	**0.24**		**0.23**		**0.14**	
	Potato		**Mustard Oil**		**Chicken**	
	P^d	P^I	P^d	P^I	P^d	P^I
Statistical properties	I (0)	I (0)	I (1)	I (1)	I (0)	I (1)
Market integration: causality*	*P^I does not Granger cause P^d*		na		na	
Coefficient of variation of domestic (Birgunj) prices	**0.71**		**0.09**		**0.17**	
Coefficient of variation of Muzaffarpur (India) prices	**0.65**		**0.12**		**0.35**	

Note: All coefficients of variation of Indian prices are estimated by means of AR models; § coefficients of variations of yields are same for all; na: not applicable; * estimated only from bivariate VAR models

Table 4.7: Time series analysis for market integration and commodity price variability of Bhairahawa, Nepal-Gorakhpur, India

	Rice		Maize		Wheat	
	P^d	P^I	P^d	P^I	P^d	P^I
Statistical properties	I (1)	I (1)	I (0)	I (1)	I (1)	I (1)
Market integration: causality*	na		na		na	
Coefficient of variation of domestic (Bhairahawa) prices	**0.17**		**0.18**		**0.13**	
Coefficient of variation of Gorakhpur (India) prices	**0.18**		**0.24**		**0.20**	
	Potato		**Mustard Oil**		**Chicken**	
	P^d	P^I	P^d	P^I	P^d	P^I
Statistical properties	I (1)	I (1)	I (1)	I (1)	I (0)	I (0)
Market integration: causality*	na		na		*P^I Granger cause P^d*	
Coefficient of variation of domestic (Bhairahawa) prices	**0.38**		**0.09**		**0.25**	
Coefficient of variation of Gorakhpur (India) prices	**0.50**		**0.17**		**0.39**	

Note: All coefficients of variation of Indian prices are estimated by means of AR models; § coefficients of variation of yields are same for all; na: not applicable; * estimated only from bivariate VAR models

Table 4.8: Time series analysis for market integration and commodity price variability of Nepalgunj, Nepal-Bahraich, India

	Rice		Maize		Wheat	
	P^d	P^I	P^d	P^I	P^d	P^I
Statistical properties	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)
Market integration: causality*	na		na		na	
Coefficient of variation of domestic(Nepalgunj) prices	**0.21**		**0.17**		**0.16**	
Coefficient of variation of Bahraich (Indian) prices	**0.19**		**0.20**		**0.12**	
	Potato		**Mustard Oil**		**Chicken**	
	P^d	P^I	P^d	P^I	P^d	P^I
Statistical properties	I (1)	I (0)	I (1)	I (0)	I (0)	I (0)
Market integration: causality*	na		na		*P^I does not Granger cause P^d*	
Coefficient of variation of domestic(Nepalgunj) prices	**0.60**		**0.12**		**0.25**	
Coefficient of variation of Bahraich (Indian) prices	**0.62**		**0.23**		**0.16**	

Note: All coefficients of variation of Indian prices are estimated by means of AR models; § coefficients of variation of yields are same for all; na: not applicable¸* estimated only from bivariate VAR models

Table 4.11: Coefficient Variations (CVs) of agricultural income by ecological belt (in different income composition)

Ecological belt	Mountain			Hill			*Terai* (southern plain)		
Share of agriculture in total household income	>65%	30-65%	<30%	>65%	30-65%	<30%	>65%	30-65%	<30%
Actual CV's	12.39	7.04	1.86	12.67	7.58	1.75	11.22	6.21	1.23
CV's in isolation (no market with India)	12.79	7.27	1.92	13.08	7.83	1.81	11.59	6.41	1.27
CVs with full market integration	12.61	7.17	1.89	12.90	7.71	1.78	11.42	6.32	1.26

Note: CVs are in percentages

Table 12: Coefficient Variations (CVs) of agricultural income by administrative region (in different income composition)

Administrative region*	Eastern			Central			Western			Mid-far western		
Share of agriculture in total household income	>65%	30-65%	<30%	>65%	30-65%	<30%	>65%	30-65%	<30%	>65%	30-65%	<30%
Actual CV's	7.60	4.49	0.94	10.18	5.66	1.22	12.10	7.21	1.22	9.94	5.60	1.44
CV's in isolation (no market with India)	9.57	5.45	1.18	9.81	5.45	1.17	12.74	7.65	1.69	12.55	7.08	1.47
CVs with full market integration	10.66	6.29	1.32	12.93	7.18	1.54	7.18	4.31	0.95	9.37	5.28	1.42

Note: CVs are in percentages; * these CVs are calculated from the prices of adjacent cities.

APPENDIX-4.2

4.2A: Variance Decomposition

This section deals with the process of computing variance decomposition which determines how much of the forecast error variance of each of the variable can be explained by exogenous shocks to the other variables.

Let P_{it}^{I} denotes Indian price and p_{it}^{d} denotes the domestic price for a commodity *i* collected in an (2×1) vector $P_{it} = (P_{it}^{I}, P_{it}^{d})'$. Suppose that Vector Autorergression (VAR) of order *k* consists of a system and each price in the system is regressed on a constant term and *k* of its own lagged terms, as well as the lagged terms of the other price[43]:

(4.1A) $$P_{it} = c + A_1 P_{it-1} + A_{it-2} + \dots\dots + A_k P_{it-k} + \varepsilon_{it}$$

where c denotes an (2×1) of constants and A_j an (2×2) matrix of autoregressive coefficients for *j*=1,2,...*k*. ε_{it} is an (2×1) vector of random errors, or VAR innovations which are defined as the difference between P_{it} and its linear projection can be written as:

$$\varepsilon_{it} = P_{it} - \hat{E}(P_{it} / P_{it-1}, P_{it-2}, \dots.)$$

and,

(4.2A) $$E(\boldsymbol{\varepsilon}_{it}) = \mathbf{0}$$
$$E(\boldsymbol{\varepsilon}_{it}\boldsymbol{\varepsilon}'_{i\tau}) = \begin{cases} \boldsymbol{\Sigma} = \begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{bmatrix} & \text{for } t=\tau \\ \mathbf{0} & \text{otherwise} \end{cases}$$

where $\boldsymbol{\Sigma}$ is positive definite, in general, this will not be diagonal with the elements of $\boldsymbol{\varepsilon}_{it}, \varepsilon_{it}^{I}$ and ε_{it}^{d}, being contemporaneously correlated. Using lag operator, VAR can expressed as:

(4.3A) $$\left[I_2 - A_1(L) - A_2(L^2) + \dots.. + A_k(L^K)\right]P_{it} = c + \varepsilon_{it}$$

If VAR is considered as a vector generalisation of modelling a single time series, say $P^{d}{}_{it}$ in term of an autoregression. In a like approach to autoregressions which have moving average representation, then VARs can be presented as Vector Moving Average (VMA):

(4.4A) $$P_{it} = \mu + \sum_{j=0}^{\infty} \Phi_j \varepsilon_{it-j}$$

[43] Methodology, mathematical notations and interpretations are heavily drawn from Rapsomanikis and Sarris (2005).

where Φ_j denotes a (2×2) matrix of moving average coefficients j=1, 2,….., ∞ and these can be calculated recursively as:

(4.5A)
$$\Phi_1 = I_2$$
$$\Phi_i = \sum_{j=1}^{i} \Phi_{i-j} A_j$$

From (4.1A) and (4.2A) systems described above, the assumption is that *k* lags are sufficient to show all the dynamic relationships between the elements P_{it} , i.e. p_{it}^d and P_{it},

The system described by (4.1A) and (4.2A) is based on the assumption that *k* lags are sufficient to summarise all the dynamic relationships between the elements P_{it} , that is $p_{it}{}^d$ and p_{it}, whereas the VMA (∞) is described by (4.4A), suggesting that the fundamental innovation for P_{it} is $\boldsymbol{\varepsilon}_{it}$. In detail, the matrix Φ_s can be described as:

(4.6A)
$$\frac{\partial p_{t+s}}{\partial \varepsilon_t} = \Phi_s$$

with row *i* and column *j* of Φ_s reflecting the impact of an one unit increase in the innovation of the j^{th} variable has on the value of the i^{th} variable at time t+s and holds the innovation of the i^{th} variable constant.

The h-step forecast error can be shown by:

(4.7A)
$$P_{it+h} - \hat{E}(P_{it+h}) = \sum_{j=0}^{\infty} \Phi_j (\varepsilon_{it+h-j} - \hat{E}(\varepsilon_{it+h-j})) = \sum_{j=0}^{h-1} \Phi_j (\varepsilon_{it+h-j})$$

and the forecast variance can be calculated by:

(4.8A)
$$\text{var}(P_{it+h} \mid P_{it}) = E(P_{it+h} - \hat{E}(P_{it+h}))^2 = \sum_{j=0}^{h-1} \Phi_j \Sigma \Phi_j^{'} .$$

Under the condition of equation (4.8A), it is possible to estimate forecast variance decomposition to individual components that relate to the part of the variance which is attributed to the VAR innovations ε_{it}^d and ε_{it}^I. However, if the innovations are contemporaneously correlated, then this decomposition is not meaningful. In this case, there needs to be a decomposition which is based on orthoganalized shocks that can imply ordering of both variables ε_{it}^d and ε_{it}^I that contained in P_{it} . For this, the contemporaneous value of p_{it}^d does not have a contemporaneous effects on P_{it}^I .

This type of problem is often achieved by orthogonalisation of the innovation through the Cholecki decomposition of the $\boldsymbol{\Sigma}$ matrix. This system shows that any real symmetric positive define matrix, there exists a unique lower triangular matrix **C** along its principal diagonal and a unique diagonal matrix D with positive entries along its principal diagonal which is usually an identity matrix. This can be shown as:

(4.9A) $\Sigma = CDC'$

Using C, a vector of innovation can be constructed as:

(4.10A) $\mu_{it} = C^{-1}\varepsilon_{it}$

These innovations are orthogonal since the covariance matrix is diagonal such as:

(4.11A) $E(\mu_{it}\mu'_{it}) = C^{-1}\Sigma C^{-1'} = D$

Based on this equation, the VMA (∞) representation in equation (4.4A) can be expressed as:

(4.12A) $p_{it} = \mu + \sum_{j=0}^{\infty}(\Phi_j C)\mu_{it-j} = \mu + \sum_{j=0}^{\infty}\Theta_j \mu_{it-j}$

where,

$$\mathbf{\Theta}_j = (\mathbf{\Phi}_j \mathbf{C}) = \begin{pmatrix} \Theta_{11,j} & \Theta_{12,j} \\ \Theta_{21,j} & \Theta_{22,j} \end{pmatrix},$$

based on this interpretation, the forecast variance can be calculated as in the equation (4.8A):

(4.13A) $\mathrm{var}(P_{it+h} \mid P_{it}) = E(P_{it+h} - \hat{E}(P_{it+h}))^2 = \sum_{j=0}^{h-1}\Theta_j \Theta_j^{'}$

where $\Theta_j \Theta_j^{'}$ positive definite (for detail see, Rapsomanikis and Sarris, 2005).

From this expression, the h-step ahead forecast variance for each of element of $\boldsymbol{p_{it}}$ can be written as:

(4.14A) $\mathrm{var}(P_{it+h}^{I} \mid P_{it}) = \sum_{j=0}^{h-1}\Theta_{11,j}^2 + \sum_{j=0}^{h-1}\Theta_{12,j}^2$

and

(4.15A) $\mathrm{var}(P_{it+h}^{d} \mid P_{it}) = \sum_{j=0}^{h-1}\Theta_{21,j}^2 + \sum_{j=0}^{h-1}\Theta_{22,j}^2$

The h-step ahead forecast variance of the domestic price p_{it}^{d} that is attributable to shocks in the Indian price is given by

(4.16A) $\mathrm{var}(P_{it+h}^{d} \mid P_{it}^{I}) = \sum_{j=0}^{h-1}\Theta_{21,j}^2$

and the h-step ahead forecast variance of the domestic price p_{it}^{d} that is attributable to shocks in the domestic price itself is given by

(4.17A) $\mathrm{var}(P_{it+h}^{d} \mid P_{it}^{d}) = \sum_{j=0}^{h-1}\Theta_{22,j}^2$

4.2B: Removing trends and system variation

If the time series data are not stationary, then the process of the h-step ahead forecast may depend on the statistical properties of the particular price series. Because, non stationary properties may contain different stochastic or deterministic trends. Statistical properties of price series data are normally indentified be testing Augmented Dickey-Fuller and the Phillips and Perron test. If the test results show that the series are stationary [or I(0)], then the data generating process for stationary series is assumed to follow an Autoregressive(AR) process, as follows:

(4.1B) $$P_{it} = \alpha_0 + \sum_{j=1}^{n} \alpha_n P_{it-n} + \mu_{it}$$

where $\mu_t \sim iid\left(0, \sigma_\mu^2\right)$

Estimation of AR(1) or AR(2)] may depend on whether data fit for the particular model. After fitting data for AR(1) or AR(2), the conditional variance of the process for *j* steps ahead is calculated as follows:

(4.2B) $$Var(P_{t+j}) = \alpha_0(1 + \alpha_1^2 + \alpha_1^4 + \alpha_1^6 + ... + \alpha_1^{2(j-1)})$$

For the conditional mean, the process of *j* steps ahead is calculated by forward iteration and given by the value of the forecasts function of the AR(1) process is followed by:

(4.3B) $$E_t(P_{t+j}) = \alpha_0(1 + \alpha_1 + \alpha_1^2 + + ... + \alpha_1^{j-1}) + \alpha_1^j y_t \, ,$$

on the other hand, if the price series is non stationary and unit root, then the data generation process is assumed to follow a random walk with a drift, as follows:

(4.4B) $$P_t = \alpha_0 + P_{t-1} + \eta_t$$

where $\eta_t \sim iid\left(0, \sigma_\eta^2\right)$.

For this, the conditional variance of the process for *j* steps ahead is calculated by:

(4.5B) $$Var_t\left(p_{t+j}\right) = j\sigma_\eta^2 \, ,$$

while in the case of the conditional mean, the random walk process for *j* steps ahead is calculated by forward iteration, as follows:

(4.6B) $$E_t\left(p_{t+j}\right) = y_t + \alpha_0 j$$

Estimation of Autoregressive models both Nepalese and Indian commodity prices:

```
Lprice_ind: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2    -0.5958      0.97189  0.04685     -1.381  0.1741    -6.044
  1     -1.134      0.94931  0.04731      1.748  0.0872    -6.043  0.1741
  0    -0.7079      0.96868  0.04833                       -6.019  0.0925

EQ( 1) Modelling DLprice_ind by OLS (using final price.in7)
       The estimation sample is: 3 to 52

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLprice_ind_1        0.212023     0.1430     1.48   0.145   0.0438
Constant           0.00387947   0.006791    0.571   0.570   0.0068

sigma               0.0475694  RSS              0.108616919
R^2                 0.0438178  F(1,48) =        2.2 [0.145]
log-likelihood        82.3519  DW                      1.86
no. of observations        50  no. of parameters          2
mean(DLprice_ind)     0.005254  var(DLprice_ind)   0.00227189

12-step forecasts for DLprice_ind (SE based on error variance only)
   Horizon      Forecast       (SE)
        53   -0.00634234    0.04757
        54    0.00253475    0.04863
        55    0.00441690    0.04867
        56    0.00481596    0.04868
        57    0.00490057    0.04868
        58    0.00491851    0.04868
        59    0.00492231    0.04868
        60    0.00492312    0.04868
        61    0.00492329    0.04868
        62    0.00492332    0.04868
        63    0.00492333    0.04868
        64    0.00492333    0.04868

Lmaize_ind: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2     -2.129      0.81856  0.05318    0.05618  0.9554    -5.790
  1     -2.275      0.82023  0.05261      1.313  0.1956    -5.831  0.9554
  0     -1.982      0.84786  0.05301                       -5.835  0.4362

EQ( 4) Modelling DLmaize_ind by OLS (using final price.in7)
       The estimation sample is: 4 to 52

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLmaize_ind_1        0.102016     0.1450    0.704   0.485   0.0104
Constant           0.00272143   0.007857    0.346   0.731   0.0025

sigma               0.0548919  RSS              0.141616833
R^2                 0.0104214  F(1,47) =      0.495 [0.485]
log-likelihood          73.71  DW                      1.96
no. of observations        49  no. of parameters          2
mean(DLmaize_ind)   0.00307164  var(DLmaize_ind)   0.00292058

12-step forecasts for DLmaize_ind (SE based on error variance only)
   Horizon      Forecast       (SE)
        53    0.00271440    0.05489
```

54	0.00299834	0.05518
55	0.00302731	0.05518
56	0.00303027	0.05518
57	0.00303057	0.05518
58	0.00303060	0.05518
59	0.00303060	0.05518
60	0.00303060	0.05518
61	0.00303060	0.05518
62	0.00303060	0.05518
63	0.00303060	0.05518
64	0.00303060	0.05518

Lwheat_ind: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-1.877	0.87774	0.03944	0.3739	0.7103	-6.388	
1	-1.864	0.88451	0.03907	1.835	0.0729	-6.425	0.7103
0	-1.469	0.90891	0.04005			-6.395	0.1902

EQ(2) Modelling DLwheat_ind by OLS (using final price.in7)
The estimation sample is: 4 to 52

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLwheat_ind_1	0.210073	0.1482	1.42	0.163	0.0419
DLwheat_ind_2	-0.0222504	0.1483	-0.150	0.881	0.0005
Constant	0.00334408	0.005820	0.575	0.568	0.0071

sigma	0.0405127	RSS	0.0754987054
R^2	0.0422971	F(2,46) =	1.016 [0.370]
log-likelihood	89.1208	DW	2
no. of observations	49	no. of parameters	3
mean(DLwheat_ind)	0.00394589	var(DLwheat_ind)	0.00160884

12-step forecasts for DLwheat_ind (SE based on error variance only)

Horizon	Forecast	(SE)
53	0.0100086	0.04051
54	0.00475528	0.04140
55	0.00412034	0.04141
56	0.00410384	0.04141
57	0.00411450	0.04141
58	0.00411711	0.04141
59	0.00411742	0.04141
60	0.00411743	0.04141
61	0.00411742	0.04141
62	0.00411742	0.04141
63	0.00411742	0.04141
64	0.00411742	0.04141

Lpotat_ind: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-3.248*	0.67292	0.1449	-0.1686	0.8668	-3.785	
1	-3.941**	0.66412	0.1434	4.027	0.0002	-3.825	0.8668
0	-2.360	0.78293	0.1650			-3.564	0.0011

EQ(1) Modelling Lpotat_ind by OLS (using final price.in7)
The estimation sample is: 4 to 52

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Lpotat_ind_1	1.17911	0.1268	9.30	0.000	0.6528
Lpotat_ind_2	-0.514989	0.1279	-4.03	0.000	0.2606
Constant	0.712108	0.1805	3.94	0.000	0.2527

sigma	0.143376	RSS	0.945608605
R^2	0.709064	F(2,46) =	56.06 [0.000]**
log-likelihood	27.1918	DW	1.96
no. of observations	49	no. of parameters	3
mean(Lpotat_ind)	2.11894	var(Lpotat_ind)	0.0663312

EQ(2) Modelling DLpotat_ind by OLS (using final price.in7)
The estimation sample is: 4 to 52

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLpotat_ind_1	0.435334	0.1417	3.07	0.004	0.1703
DLpotat_ind_2	-0.278838	0.1416	-1.97	0.055	0.0778
Constant	0.00668036	0.02281	0.293	0.771	0.0019

sigma	0.159249	RSS	1.16657481
R^2	0.184486	F(2,46) =	5.203 [0.009]**
log-likelihood	22.0468	DW	2.09
no. of observations	49	no. of parameters	3
mean(DLpotat_ind)	0.00868351	var(DLpotat_ind)	0.0291934

12-step forecasts for DLpotat_ind (SE based on error variance only)

Horizon	Forecast	(SE)
53	-0.0212166	0.1592
54	0.0106669	0.1737
55	0.0172400	0.1743
56	0.0112112	0.1761
57	0.00675381	0.1763
58	0.00649442	0.1763
59	0.00762439	0.1764
60	0.00818863	0.1764
61	0.00811918	0.1764
62	0.00793162	0.1764
63	0.00786933	0.1764
64	0.00789451	0.1764

Lchicken_in: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-1.846	0.81536	0.08844	-1.575	0.1223	-4.773	
1	-2.611	0.75495	0.08985	1.387	0.1721	-4.760	0.1223
0	-2.255	0.79860	0.09073			-4.760	0.1190

EQ(1) Modelling DLchicken_in by OLS (using final price.in7)
The estimation sample is: 4 to 52

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLchicken_in_1	0.0997690	0.1388	0.719	0.476	0.0111
DLchicken_in_2	-0.334202	0.1387	-2.41	0.020	0.1120
Constant	0.00511519	0.01298	0.394	0.695	0.0034

sigma	0.0907206	RSS	0.378590077
R^2	0.116979	F(2,46) =	3.047 [0.057]
log-likelihood	49.6185	DW	2.01
no. of observations	49	no. of parameters	3
mean(DLchicken_in)	0.00435856	var(DLchicken_in)	0.00874988

12-step forecasts for DLchicken_in (SE based on error variance only)

Horizon	Forecast	(SE)
53	0.00531048	0.09072

```
        54    0.00404373    0.09117
        55    0.00374386    0.09580
        56    0.00413729    0.09598
        57    0.00427676    0.09643
        58    0.00415919    0.09647
        59    0.00410085    0.09651
        60    0.00413432    0.09652
        61    0.00415716    0.09652
        62    0.00414825    0.09652
        63    0.00413973    0.09653
        64    0.00414186    0.09653

Loil_in: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2     -1.423       0.93398  0.02670    -0.9382  0.3532    -7.168
  1     -1.520       0.92989  0.02667     0.9275  0.3585    -7.189  0.3532
  0     -1.430       0.93453  0.02663                       -7.211  0.4263

EQ( 2) Modelling DLoil_in by OLS (using final price.in7)
       The estimation sample is: 3 to 52

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLoil_in_1           0.119710     0.1427    0.839   0.406   0.0144
Constant          -0.00203979   0.003826   -0.533   0.596   0.0059

sigma               0.0267907  RSS             0.0344516212
R^2                   0.01444  F(1,48) =      0.7033 [0.406]
log-likelihood        111.059  DW                      1.95
no. of observations        50  no. of parameters          2
mean(DLoil_in)     -0.0024862  var(DLoil_in)     0.000699128

12-step forecasts for DLoil_in (SE based on error variance only)
   Horizon      Forecast       (SE)
        53    0.00105054    0.02679
        54   -0.00191403    0.02698
        55   -0.00226892    0.02698
        56   -0.00231141    0.02698
        57   -0.00231649    0.02698
        58   -0.00231710    0.02698
        59   -0.00231717    0.02698
        60   -0.00231718    0.02698
        61   -0.00231718    0.02698
        62   -0.00231718    0.02698
        63   -0.00231718    0.02698
        64   -0.00231718    0.02698

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EQ(11) Modelling Lrice_np by OLS (using final price.in7)
       The estimation sample is: 4 to 52

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
Lrice_np_1            1.26322     0.1387     9.11   0.000   0.6433
Lrice_np_2          -0.363257     0.1395    -2.60   0.012   0.1285
Constant             0.287935     0.1592     1.81   0.077   0.0664

sigma               0.0292265  RSS             0.0392927601
R^2                  0.867434  F(2,46) =     150.5 [0.000]**
log-likelihood        105.121  DW                      1.99
no. of observations        49  no. of parameters          3
mean(Lrice_np)        2.86717  var(Lrice_np)      0.00604899
```

```
EQ(12) Modelling DLrice_np by OLS (using final price.in7)
       The estimation sample is: 4 to 52

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLrice_np_1          0.336149     0.1454     2.31   0.025   0.1062
DLrice_np_2          0.106724     0.1508    0.708   0.483   0.0110
Constant             0.322894     0.1675     1.93   0.060   0.0763
Lrice_np_1          -0.112266    0.05846    -1.92   0.061   0.0758

sigma               0.0293865  RSS              0.0388604705
R^2                  0.163885  F(3,45) =       2.94 [0.043]*
log-likelihood        105.392  DW                       1.95
no. of observations        49  no. of parameters           4
mean(DLrice_np)    0.00165513  var(DLrice_np)    0.000948518

EQ(13) Modelling DLrice_np by OLS (using final price.in7)
       The estimation sample is: 4 to 52

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLrice_np_1          0.303086     0.1485     2.04   0.047   0.0830
DLrice_np_2         0.0210958     0.1483    0.142   0.887   0.0004
Constant           0.00130968   0.004323    0.303   0.763   0.0020

sigma               0.0302331  RSS              0.0420457437
R^2                 0.0953507  F(2,46) =       2.424 [0.100]
log-likelihood        103.462  DW                       1.93
no. of observations        49  no. of parameters           3
mean(DLrice_np)    0.00165513  var(DLrice_np)    0.000948518

12-step forecasts for DLrice_np (SE based on error variance only)
   Horizon      Forecast       (SE)
        53    0.00843580    0.03023
        54    0.00437201    0.03159
        55    0.00281274    0.03178
        56    0.00225441    0.03180
        57    0.00205230    0.03180
        58    0.00197926    0.03180
        59    0.00195286    0.03180
        60    0.00194332    0.03180
        61    0.00193987    0.03180
        62    0.00193862    0.03180
        63    0.00193817    0.03180
        64    0.00193801    0.03180

EQ( 1) Modelling Lmaize_np by OLS (using final price.in7)
       The estimation sample is: 4 to 52

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
Lmaize_np_1          0.986864     0.1485     6.65   0.000   0.4955
Lmaize_np_2         -0.172644     0.2080   -0.830   0.411   0.0151
Lmaize_np_3        -0.0845022     0.1503   -0.562   0.577   0.0070
Constant             0.575714     0.2087     2.76   0.008   0.1447

sigma               0.0537805  RSS               0.130155275
R^2                  0.669128  F(3,45) =     30.33 [0.000]**
log-likelihood        75.7778  DW                          2
no. of observations        49  no. of parameters           4
mean(Lmaize_np)       2.13031  var(Lmaize_np)     0.00802797

12-step forecasts for Lmaize_np (SE based on error variance only)
```

Horizon	Forecast	(SE)
53	2.13390	0.05378
54	2.13015	0.07556
55	2.12837	0.08698
56	2.12805	0.09163
57	2.12835	0.09311
58	2.12887	0.09343
59	2.12934	0.09345
60	2.12970	0.09346
61	2.12993	0.09347
62	2.13005	0.09348
63	2.13010	0.09349
64	2.13011	0.09349

Lwheat_np: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-0.9836	0.96033	0.03249	0.6100	0.5450	-6.776	
1	-0.8891	0.96505	0.03226	1.039	0.3044	-6.808	0.5450
0	-0.7318	0.97158	0.03229			-6.826	0.4932

EQ(1) Modelling DLwheat_np by OLS (using final price.in7)
The estimation sample is: 4 to 52

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLwheat_np_1	0.123322	0.1471	0.838	0.406	0.0151
DLwheat_np_2	0.0632658	0.1473	0.430	0.670	0.0040
Constant	0.00488304	0.004800	1.02	0.314	0.0220

sigma	0.032475	RSS	0.0485126842
R^2	0.0212474	F(2,46) =	0.4993 [0.610]
log-likelihood	99.9569	DW	1.96
no. of observations	49	no. of parameters	3
mean(DLwheat_np)	0.0060613	var(DLwheat_np)	0.00101155

12-step forecasts for DLwheat_np (SE based on error variance only)

Horizon	Forecast	(SE)
53	0.00489000	0.03247
54	0.00568304	0.03272
55	0.00589325	0.03282
56	0.00596935	0.03282
57	0.00599203	0.03283
58	0.00599965	0.03283
59	0.00600202	0.03283
60	0.00600279	0.03283
61	0.00600304	0.03283
62	0.00600312	0.03283
63	0.00600314	0.03283
64	0.00600315	0.03283

Lpotat_np: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-3.531*	0.67148	0.1431	0.4367	0.6644	-3.810	
1	-4.004**	0.69424	0.1419	4.763	0.0000	-3.847	0.6644
0	-2.108	0.81673	0.1715			-3.486	0.0001

EQ(1) Modelling Lpotat_np by OLS (using final price.in7)
The estimation sample is: 3 to 52

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Lpotat_np_1	1.27842	0.1195	10.7	0.000	0.7088

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Lpotat_np_2	-0.582379	0.1214	-4.80	0.000	0.3287
Constant	0.706989	0.1758	4.02	0.000	0.2561

sigma	0.140598	RSS	0.929081628
R^2	0.767356	F(2,47) =	77.51 [0.000]**
log-likelihood	28.6926	DW	2.05
no. of observations	50	no. of parameters	3
mean(Lpotat_np)	2.32485	var(Lpotat_np)	0.0798714

12-step forecasts for Lpotat_np (SE based on error variance only)

Horizon	Forecast	(SE)
53	2.52458	0.1406
54	2.39641	0.2282
55	2.30035	0.2719
56	2.25219	0.2847
57	2.24657	0.2856
58	2.26742	0.2864
59	2.29736	0.2891
60	2.32349	0.2917
61	2.33946	0.2929
62	2.34465	0.2931
63	2.34200	0.2931
64	2.33557	0.2932

Loil_np: ADF tests (T=49, Constant; 5%=-2.92 1%=-3.57)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-1.319	0.94224	0.01977	-0.3754	0.7092	-7.769	
1	-1.380	0.94048	0.01959	0.5039	0.6168	-7.807	0.7092
0	-1.337	0.94325	0.01943			-7.842	0.8235

EQ(1) Modelling DLoil_np by OLS (using final price.in7)
The estimation sample is: 4 to 52

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLoil_np_1	0.0523943	0.1476	0.355	0.724	0.0027
DLoil_np_2	-0.0767700	0.1489	-0.516	0.609	0.0057
Constant	-0.00259920	0.002894	-0.898	0.374	0.0172

sigma	0.0199289	RSS	0.0182694606
R^2	0.00800902	F(2,46) =	0.1857 [0.831]
log-likelihood	123.883	DW	1.98
no. of observations	49	no. of parameters	3
mean(DLoil_np)	-0.0025499	var(DLoil_np)	0.000375856

12-step forecasts for DLoil_np (SE based on error variance only)

Horizon	Forecast	(SE)
53	-0.000169156	0.01993
54	-0.00352250	0.01996
55	-0.00277078	0.02001
56	-0.00247395	0.02001
57	-0.00251611	0.02001
58	-0.00254111	0.02001
59	-0.00253918	0.02001
60	-0.00253716	0.02001
61	-0.00253720	0.02001
62	-0.00253736	0.02001
63	-0.00253737	0.02001
64	-0.00253735	0.02001

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-3.090*	0.59181	0.03919	-1.574	0.1225	-6.400	

```
  1     -4.441**     0.48638  0.03982      2.894  0.0058    -6.388  0.1225
  0     -3.295*      0.62935  0.04283                         -6.261  0.0069

EQ( 1) Modelling Lchicken_np by OLS (using final price.in7)
       The estimation sample is: 3 to 52

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
Lchicken_np_1        0.883910     0.1352     6.54   0.000   0.4762
Lchicken_np_2       -0.374477     0.1343    -2.79   0.008   0.1419
Constant              2.25415     0.5222     4.32   0.000   0.2839

sigma               0.0398561  RSS              0.0746598284
R^2                  0.495701  F(2,47) =      23.1 [0.000]**
log-likelihood         91.724  DW                       1.82
no. of observations        50  no. of parameters           3
mean(Lchicken_np)      4.59486  var(Lchicken_np)   0.00296094

12-step forecasts for Lchicken_np (SE based on error variance only)
   Horizon      Forecast       (SE)
        53       4.62160    0.03986
        54       4.59801    0.05319
        55       4.58769    0.05561
        56       4.58741    0.05562
        57       4.59102    0.05585
        58       4.59432    0.05607
        59       4.59589    0.05612
        60       4.59603    0.05612
        61       4.59558    0.05612
        62       4.59512    0.05613
        63       4.59489    0.05613
        64       4.59485    0.05613

-----------------------------------------------------------------------

Unit-root tests (using yield.in7)
The sample is 1964 - 2007

Lrice: ADF tests (T=44, Constant; 5%=-2.93 1%=-3.58)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2    -0.5070       0.95180  0.08801     -1.839  0.0734    -4.774
  1     -1.053       0.90136  0.09053     -2.976  0.0049    -4.738  0.0734
  0     -2.094       0.80083  0.09863                         -4.588  0.0040

EQ( 1) Modelling Lrice by OLS (using yield.in7)
       The estimation sample is: 1963 to 2007

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
Lrice_1              0.284610     0.1492     1.91   0.063   0.0815
Lrice_2              0.279794     0.1468     1.91   0.064   0.0814
Constant              3.23158      1.158     2.79   0.008   0.1596
Trend              0.00454395   0.001741     2.61   0.013   0.1424

sigma                0.083877  RSS               0.288449588
R^2                  0.739611  F(3,41) =     38.82 [0.000]**
log-likelihood        49.7705  DW                       2.12
no. of observations        45  no. of parameters           4
mean(Lrice)           7.66668  var(Lrice)           0.024617

12-step forecasts for Lrice (SE based on error variance only)
   Horizon      Forecast       (SE)
      2008       7.89526    0.08388
```

2009	7.89672	0.08721
2010	7.91531	0.09231
2011	7.92555	0.09357
2012	7.93821	0.09444
2013	7.94922	0.09477
2014	7.96044	0.09495
2015	7.97126	0.09503
2016	7.98202	0.09507
2017	7.99265	0.09509
2018	8.00324	0.09510
2019	8.01377	0.09510

Lmaize: ADF tests (T=44, Constant; 5%=-2.93 1%=-3.58)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-0.9146	0.90563	0.06953	-0.8437	0.4039	-5.245	
1	-1.169	0.88370	0.06929	-2.518	0.0158	-5.273	0.4039
0	-2.075	0.79501	0.07356			-5.175	0.0396

EQ(1) Modelling Lmaize by OLS (using yield.in7)
The estimation sample is: 1963 to 2007

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Lmaize_1	0.483502	0.1420	3.41	0.001	0.2205
Lmaize_2	0.425817	0.1456	2.92	0.006	0.1726
Constant	0.642243	0.7093	0.906	0.370	0.0196
Trend	0.00137092	0.0007848	1.75	0.088	0.0693

sigma	0.0668859	RSS	0.183422928
R^2	0.692781	F(3,41) =	30.82 [0.000]**
log-likelihood	59.9568	DW	2.2
no. of observations	45	no. of parameters	4
mean(Lmaize)	7.44092	var(Lmaize)	0.0132676

12-step forecasts for Lmaize (SE based on error variance only)

Horizon	Forecast	(SE)
2008	7.64924	0.06689
2009	7.66336	0.07429
2010	7.67322	0.08641
2011	7.68537	0.09326
2012	7.69681	0.09988
2013	7.70889	0.1050
2014	7.72097	0.1094
2015	7.73333	0.1131
2016	7.74582	0.1162
2017	7.75849	0.1189
2018	7.77130	0.1213
2019	7.78427	0.1233

Lwheat: ADF tests (T=44, Constant; 5%=-2.93 1%=-3.58)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	0.8935	1.0600	0.08277	-2.873	0.0065	-4.897	
1	-0.1200	0.99182	0.08979	-1.268	0.2118	-4.755	0.0065
0	-0.5574	0.96379	0.09044			-4.762	0.0109

EQ(3) Modelling DLwheat by OLS (using yield.in7)
The estimation sample is: 1964 to 2007

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLwheat_1	-0.354291	0.1405	-2.52	0.016	0.1371
DLwheat_2	-0.461358	0.1414	-3.26	0.002	0.2102
Constant	-0.0307846	0.02705	-1.14	0.262	0.0314

```
Trend              0.00210084  0.0009752     2.15   0.037   0.1040

sigma                0.079128  RSS               0.25044969
R^2                  0.276354  F(3,40) =     5.092 [0.004]**
log-likelihood        51.2778  DW                       1.9
no. of observations        44  no. of parameters          4
mean(DLwheat)        0.012789  var(DLwheat)      0.00786577

12-step forecasts for DLwheat (SE based on error variance only)
   Horizon      Forecast       (SE)
      2008     0.0694815    0.07913
      2009     0.0297188    0.08395
      2010     0.0316724    0.08805
      2011     0.0514259    0.09085
      2012     0.0456270    0.09095
      2013     0.0406689    0.09172
      2014     0.0472017    0.09174
      2015     0.0492755    0.09186
      2016     0.0476276    0.09190
      2017     0.0493555    0.09191
      2018     0.0516044    0.09193
      2019     0.0521113    0.09193

Lpotatoes: ADF tests (T=44, Constant; 5%=-2.93 1%=-3.58)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2     0.1682        1.0089  0.08197    -0.9385  0.3536    -4.916
  1    -0.1181       0.99407  0.08185     0.2322  0.8176    -4.940  0.3536
  0   -0.04418       0.99793  0.08092                       -4.984  0.6301

EQ(1) Modelling DLpotatoes by OLS (using yield.in7)
       The estimation sample is: 1964 to 2007

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLpotatoes_1       0.00360332     0.1573   0.0229   0.982   0.0000
DLpotatoes_2        -0.177965     0.1583    -1.12   0.267   0.0306
Constant          -0.00947574    0.02732   -0.347   0.731   0.0030
Trend              0.00119621  0.0009861     1.21   0.232   0.0355

sigma               0.0805304  RSS              0.259405915
R^2                 0.0568806  F(3,40) =      0.8041 [0.499]
log-likelihood        50.5048  DW                      2.02
no. of observations        44  no. of parameters          4
mean(DLpotatoes)    0.0180736  var(DLpotatoes)   0.00625116

12-step forecasts for DLpotatoes (SE based on error variance only)
   Horizon      Forecast       (SE)
      2008     0.0300522    0.08053
      2009     0.0552305    0.08053
      2010     0.0451854    0.08180
      2011     0.0418645    0.08180
      2012     0.0448365    0.08184
      2013     0.0466344    0.08184
      2014     0.0473082    0.08184
      2015     0.0481868    0.08184
      2016     0.0492663    0.08184
      2017     0.0503100    0.08184
      2018     0.0513179    0.08184
      2019     0.0523320    0.08184


Lchickenmeat: ADF tests (T=43, Constant; 5%=-2.93 1%=-3.59)
```

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-1.796	0.77802	0.02319	-0.1802	0.8579	-7.440	
1	-1.960	0.77144	0.02290	-1.517	0.1371	-7.486	0.8579
0	-2.718	0.70303	0.02326			-7.476	0.3306

EQ(1) Modelling DLchickenmeat by OLS (using yield.in7)
The estimation sample is: 1963 to 2007

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLchickenmeat_1	-0.371734	0.1551	-2.40	0.021	0.1203
Constant	0.00191374	0.007638	0.251	0.803	0.0015
Trend	-5.53904e-005	0.0002714	-0.204	0.839	0.0010

sigma	0.0236182	RSS	0.0234283644
R^2	0.122069	F(2,42) =	2.92 [0.065]
log-likelihood	106.258	DW	1.97
no. of observations	45	no. of parameters	3
mean(DLchickenmeat)	0	var(DLchickenmeat)	0.00059302

EQ(2) Modelling DLchickenmeat by OLS (using yield.in7)
The estimation sample is: 1964 to 2007

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLchickenmeat_1	-0.416439	0.1680	-2.48	0.017	0.1332
DLchickenmeat_2	-0.126051	0.1684	-0.749	0.458	0.0138
Constant	0.00128216	0.008124	0.158	0.875	0.0006
Trend	-2.78790e-005	0.0002858	-0.0976	0.923	0.0002

sigma	0.024015	RSS	0.0230688462
R^2	0.134589	F(3,40) =	2.074 [0.119]
log-likelihood	103.743	DW	1.86
no. of observations	44	no. of parameters	4
mean(DLchickenmeat)	-0.000121832	var(DLchickenmeat)	0.00060583

12-step forecasts for DLchickenmeat (SE based on error variance only)

Horizon	Forecast	(SE)
2008	0.0223677	0.02402
2009	-0.00205386	0.02601
2010	-0.00207594	0.02604
2011	0.000983725	0.02605
2012	-0.000315535	0.02606
2013	-0.000188025	0.02606
2014	-0.000105231	0.02606
2015	-0.000183661	0.02606
2016	-0.000189315	0.02606
2017	-0.000204954	0.02606
2018	-0.000225607	0.02606
2019	-0.000242914	0.02606

Lmustardseed: ADF tests (T=44, Constant; 5%=-2.93 1%=-3.58)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-0.5318	0.92596	0.07736	-2.437	0.0194	-5.032	
1	-1.635	0.78183	0.08188	-1.424	0.1621	-4.939	0.0194
0	-2.568	0.69323	0.08288			-4.936	0.0239

EQ(1) Modelling Lmustardseed by OLS (using yield.in7)
The estimation sample is: 1963 to 2007

```
                  Coefficient  Std.Error  t-value  t-prob Part.R^2
Lmustardseed_1       0.307181     0.1551     1.98   0.054   0.0873
Lmustardseed_2      0.0290760     0.1543    0.188   0.851   0.0009
Constant              5.68129      1.534     3.70   0.001   0.2506
Trend              0.00421024   0.001265     3.33   0.002   0.2126

sigma               0.0726836  RSS             0.216599214
R^2                  0.584267  F(3,41) =     19.21 [0.000]**
log-likelihood        56.2161  DW                     2.03
no. of observations        45  no. of parameters         4
mean(Lmustardseed)      8.71523  var(Lmustardseed)    0.0115779

EQ( 2) Modelling DLmustardseed by OLS (using yield.in7)
       The estimation sample is: 1963 to 2007

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLmustardseed_1     -0.358468     0.1441    -2.49   0.017   0.1284
Constant           -0.0103034    0.02687   -0.384   0.703   0.0035
Trend             0.000689182  0.0009558    0.721   0.475   0.0122

sigma               0.0829953  RSS             0.289304894
R^2                  0.133316  F(2,42) =       3.23 [0.050]*
log-likelihood        49.7038  DW                     2.31
no. of observations        45  no. of parameters         3
mean(DLmustardseed)   0.00513462  var(DLmustardseed)   0.00741793

12-step forecasts for DLmustardseed (SE based on error variance only)
   Horizon      Forecast       (SE)
      2008     0.0428875    0.07630
      2009     0.0129428    0.08593
      2010     0.0113178    0.08696
      2011     0.0265141    0.09033
      2012     0.0204465    0.09058
      2013     0.0179430    0.09087
      2014     0.0230147    0.09113
      2015     0.0225822    0.09113
      2016     0.0216451    0.09117
      2017     0.0234083    0.09119
      2018     0.0239960    0.09119
      2019     0.0239962    0.09119
--------------------------------------------------------------------
```

Correlation coefficients of yields (P values are in parentheses and are conditional).

```
pwcorr rico mais  what patate chikhat mustard, sig

            ricehat   maizhat   whethat potathat chikhat oilhat

ricehat     1.0000


maizhat     0.6384   1.0000
            (0.0000)

Whethat     0.4812   0.6187   1.0000
            (0.0006) (0.0000)

potathat    0.6057   0.7670   0.6939   1.0000
            (0.0000) (0.0000) (0.0000)

chikhat     0.2960   0.4713   0.2219   0.4455   1.0000
            (0.0434) (0.0008) (0.1338) 0.0017)
```

oilhat	0.0362	0.1015	0.4847	0.2005	-0.0660	1.0000
	(0.8090)	(0.4973)	(0.0006)	(0.1765)	(0.6593)	

Conditional correlation coefficients of Nepalese commodity prices (P values are in parentheses).

```
pwcorr rice_rnp maz_rnp wheat_rnp  potat_rnp chick_rnp oil_rnp, sig
```

	rice_rnp	maz_rnp	whea~rnp	pota~rnp	chick_~p	oil_rnp
rice_rnp	1.0000					
maz_rnp	0.2656	1.0000				
	0.0623					
wheat_rnp	0.6674	0.6483	1.0000			
	(0.000)	(0.000)				
potat_rnp	0.4724	-0.2046	0.0862	1.0000		
	(0.0005)	(0.1542)	(0.5518)			
chick_rnp	-0.1037	-0.3071	-0.0729	-0.1366	1.0000	
	(0.4737)	(0.0300)	(0.6150)	(0.3442)		
oil_rnp	-0.6667	-0.3191	-0.6187	-0.3936	0.3499	1.0000
	(0.000)	(0.0239)	(0.000)	(0.0047)	(0.0127)	

Conditional correlation coefficients of Indian commodity prices (P values are in parentheses).

```
pwcorr  rice_rin maz_rin wheat_rin potat_rin chick_rin oil_rin, sig
```

	rice_rin	maz_rin	wheat_~n	potat_~n	chick_~n	oil_rin
rice_rin	1.0000					
maz_rin	0.5594	1.0000				
	(0.000)					
wheat_rin	0.5567	0.7759	1.0000			
	(0.000)	(0.000)				
potat_rin	0.4493	-0.0590	-0.0306	1.0000		
	(0.0011)	(0.6842)	(0.8327)			
chick_rin	0.4040	0.2082	-0.0404	0.1687	1.0000	
	(0.0036)	(0.0681)	(0.7803)	(0.2415)		
oil_rin	-0.5038	-0.1754	-0.3960	-0.3384	-0.1899	1.0000
	(0.0002)	(0.2231)	(0.0044)	(0.0162)	(0.1865)	

Unit root tests of world prices and Nepalese prices (yearly data)

```
Unit-root tests (using price_data.in7)
The sample is 1971 - 1999

Lrice_n: ADF tests (T=29, Constant; 5%=-2.97 1%=-3.68)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2    -0.8549       0.91496  0.07953     -3.396  0.0023    -4.936
  1     -1.276       0.85214  0.09428    -0.7671  0.4499    -4.625  0.0023
  0     -1.428       0.83792  0.09355                       -4.672  0.0066

Lwheat_n: ADF tests (T=29, Constant; 5%=-2.97 1%=-3.68)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2    -0.9204       0.91326   0.1132     -1.219  0.2343    -4.229
  1     -1.137       0.89344   0.1143    -0.6451  0.5245    -4.241  0.2343
  0     -1.313       0.88093   0.1130                       -4.294  0.3986

Lmaize_n: ADF tests (T=29, Constant; 5%=-2.97 1%=-3.68)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2    -0.8951       0.90933  0.08719     -1.905  0.0683    -4.752
  1     -1.187       0.87577  0.09149     -1.609  0.1197    -4.685  0.0683
  0     -1.577       0.83515  0.09414                       -4.659  0.0561

Lrice_w: ADF tests (T=29, Constant; 5%=-2.97 1%=-3.68)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2     -1.880       0.70196   0.2078    -0.8805  0.3870    -3.015
  1     -2.613       0.63619   0.2069      1.732  0.0950    -3.053  0.3870
  0     -2.043       0.72678   0.2145                       -3.013  0.1742

Lwheat_w: ADF tests (T=29, Constant; 5%=-2.97 1%=-3.68)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2     -3.157*      0.39835   0.1705     0.4510  0.6559    -3.411
  1     -3.469*      0.44280   0.1679      1.891  0.0699    -3.471  0.6559
  0     -2.805       0.57682   0.1757                       -3.412  0.1806

Lmaize_w: ADF tests (T=29, Constant; 5%=-2.97 1%=-3.68)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  2     -2.347       0.50562   0.1785    0.04994  0.9606    -3.319
  1     -2.696       0.51064   0.1750      1.066  0.2964    -3.388  0.9606
  0     -2.479       0.60047   0.1755                       -3.414  0.5853
```

VAR Models and Granger causality tests

```
var  lpot_brt lpot_purni

Vector autoregression

Sample:  2003m9  2007m10                          No. of obs      =        50
Log likelihood =  42.04557                        AIC             = -1.281823
FPE            =  .0009527                        HQIC            = -1.136201
Det(Sigma_ml)  =  .0006377                        SBIC            =  -.899418

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
lpot_brt             5      .216671   0.7412   143.2201   0.0000
lpot_purni           5      .175342   0.6738   103.2802   0.0000
----------------------------------------------------------------
------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
lpot_brt     |
```

```
    lpot_brt |
         L1. |    .885604   .1804738     4.91   0.000     .5318819    1.239326
         L2. |  -.2104381   .1694707    -1.24   0.214    -.5425946    .1217184
  lpot_purni |
         L1. |   .5176788    .223237     2.32   0.020     .0801424    .9552152
         L2. |  -.5256516   .2272512    -2.31   0.021    -.9710557   -.0802475
       _cons |   .7554861   .2453305     3.08   0.002     .2746472    1.236325
-------------+----------------------------------------------------------------
lpot_purni   |
    lpot_brt |
         L1. |   .2925827    .146049     2.00   0.045      .006332    .5788335
         L2. |  -.0242675   .1371447    -0.18   0.860    -.2930662    .2445312
  lpot_purni |
         L1. |   .8031545   .1806552     4.45   0.000     .4490768    1.157232
         L2. |  -.5949238   .1839037    -3.23   0.001    -.9553685   -.2344791
       _cons |   1.065431   .1985345     5.37   0.000     .6763109    1.454552
------------------------------------------------------------------------------
```

. vargranger

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
lpot_brt	lpot_purni	7.7286	2	0.021
lpot_brt	ALL	7.7286	2	0.021
lpot_purni	lpot_brt	4.9136	2	0.086
lpot_purni	ALL	4.9136	2	0.086

fcast compute potato, step(12)

. irf ctable (potato lpot_brt lpot_purni fevd, ci stderror) (potato lpot_purni lpot_brt fevd, ci stderror), step(12)

(1) step	(1) fevd	(1) Lower	(1) Upper	(2) S.E.	(2) fevd	(2) Lower	(2) Upper	S.E.
0	0	0	0	0	0	0	0	0
1	.454507	.250637	.658377	.104017	0	0	0	0
2	.585952	.373224	.79868	.108537	.038917	-.029375	.107209	.034844
3	.659787	.443608	.875966	.110298	.04164	-.054245	.137526	.048922
4	.66666	.452157	.881164	.109443	.040281	-.039101	.119663	.040502
5	.651803	.431649	.871957	.112326	.055383	-.027607	.138373	.042343
6	.648506	.427438	.869574	.112792	.068612	-.032478	.169703	.051578
7	.652904	.431242	.874565	.113095	.071351	-.032982	.175684	.053232
8	.655372	.431615	.879129	.114164	.07068	-.032532	.173893	.05266
9	.65505	.429923	.880177	.114863	.071161	-.033499	.17582	.053399
10	.654448	.429351	.879546	.114848	.072207	-.034811	.179226	.054602
11	.65449	.429623	.879357	.11473	.072707	-.035192	.180607	.055052
12	.654727	.429687	.879766	.114818	.072735	-.035074	.180545	.055006

var lmaz_brj lmaz_mujf

Vector autoregression

```
Sample:  2003m9  2007m10               No. of obs      =   50
Log likelihood =   142.513             AIC             =  -5.30052
FPE            =  .0000171             HQIC            =  -5.154899
Det(Sigma_ml)  =  .0000115             SBIC            =  -4.918116
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
lmaz_brj	5	.073215	0.5483	60.68858	0.0000
lmaz_mujf	5	.075674	0.5194	54.03084	0.0000

```
Coef.  Std. Err.    z      P>z     [95% Conf.  Interval]

lmaz_brj
lmaz_brj
L1.    .8143354     .2024836     4.02  0.000     .4174748  1.211196
L2.   -.1663968     .2072056     -0.80  0.422    -.5725123  .2397188
lmaz_mujf
L1.    .0756055     .1969697     0.38  0.701    -.3104479  .461659
L2.   -.0722391     .192646      -0.37  0.708    -.4498184  .3053401
_cons    .7431571   .2188234     3.40  0.001      .314271  1.172043

lmaz_mujf
lmaz_brj
L1.    .5204523     .2092849     2.49  0.013     .1102614  .9306432
L2.   -.2469707     .2141655     -1.15  0.249    -.6667274  .1727861
lmaz_mujf
L1.     .411996     .2035858     2.02  0.043     .0129752  .8110168
L2.   -.0519567     .1991169     -0.26  0.794    -.4422186  .3383053
_cons    .7172456   .2261736     3.17  0.002     .2739536  1.160538
```

```
var  lpot_brj lpot_mujf

Vector autoregression

Sample:  2003m9  2007m10                        No. of obs      =        50
Log likelihood =  32.71775                      AIC             = -.9087101
FPE            =  .0013835                      HQIC            = -.7630883
Det(Sigma_ml)  =  .0009262                      SBIC            = -.5263055

Equation           Parms      RMSE     R-sq      chi2     P>chi2

lpot_brj             5     .210373   0.5643    64.7548   0.0000
lpot_mujf            5     .177603   0.6632   98.44087   0.0000


Coef.   Std. Err.      z    P>z     [95% Conf. Interval]

lpot_brj
lpot_brj
L1.    .7301616   .1529524     4.77   0.000     .4303803    1.029943
L2.   -.2631568   .1696237    -1.55   0.121    -.5956132    .0692996
lpot_mujf
L1.    .3592998   .1770517     2.03   0.042     .0122848    .7063149
L2.   -.1681558   .1587433    -1.06   0.289     -.479287    .1429754
_cons    .8077114   .2515611     3.21   0.001     .3146606    1.300762

lpot_mujf
lpot_brj
L1.    .5424633   .1291265     4.20   0.000       .28938    .7955466
L2.   -.3229974   .1432009    -2.26   0.024     -.603666   -.0423289
lpot_mujf
L1.    .5886261   .1494718     3.94   0.000     .2956668    .8815855
L2.   -.0662017   .1340153    -0.49   0.621     -.328867    .1964635
_cons    .5662877   .2123746     2.67   0.008     .1500411    .9825342
```

```
. vargranger
Granger causality Wald tests
+------------------------------------------------------------------+
Equation           Excluded    chi2     df Prob > chi2
--------------------------------------+---------------------------
lpot_brj         lpot_mujf   4.1878     2    0.123
lpot_brj               ALL   4.1878     2    0.123
--------------------------------------+---------------------------
lpot_mujf           lpot_brj   18.384     2    0.000
lpot_mujf                ALL   18.384     2    0.000
+------------------------------------------------------------------+
```

```
var  lchick_sidrt lchick_gorak

Vector autoregression

Sample:  2003m9  2007m10                         No. of obs      =        50
Log likelihood =  103.2431                       AIC             = -3.729725
FPE            =  .0000824                       HQIC            = -3.584104
Det(Sigma_ml)  =  .0000551                       SBIC            = -3.347321

Equation           Parms      RMSE     R-sq      chi2     P>chi2

lchick_sidrt          5     .061858   0.3940   32.50868   0.0000
lchick_gorak          5     .142632   0.3026   21.69531   0.0002


Coef.   Std. Err.      z    P>z     [95% Conf. Interval]

lchick_sidrt
lchick_sidrt
L1.    .4061367   .1501154     2.71   0.007      .111916    .7003574
L2.   -.0615828   .1351702    -0.46   0.649    -.3265116     .203346
lchick_gorak
L1.    .1705375   .0635002     2.69   0.007     .0460794    .2949955
L2.   -.0182926   .0676767    -0.27   0.787    -.1509365    .1143513
_cons    2.282347   .5615253     4.06   0.000     1.181778    3.382916

lchick_gorak
lchick_sidrt
L1.    .1314815   .3461321     0.38   0.704     -.546925     .809888
L2.   -.2250651   .3116721    -0.72   0.470    -.8359311    .3858008
lchick_gorak
L1.    .5947384   .1464171     4.06   0.000     .3077662    .8817106
L2.   -.2273582   .1560472    -1.46   0.145    -.5332051    .0784887
_cons    3.277287   1.294751     2.53   0.011     .7396223    5.814951


. vargranger

Granger causality Wald tests
+------------------------------------------------------------------+
Equation           Excluded    chi2     df Prob > chi2
--------------------------------------+---------------------------
lchick_sidrt       lchick_gorak   7.8075     2    0.020
lchick_sidrt                ALL   7.8075     2    0.020
--------------------------------------+---------------------------
lchick_gorak       lchick_sidrt   .52542     2    0.769
lchick_gorak                ALL   .52542     2    0.769
+------------------------------------------------------------------+

irf ctable (lchick_sidrt lchick_gorak lchick_gorak fevd, ci stderror)
(lchick_sidrt    lchick_sidrt     lchick_gorak     fevd, ci    stderror),
      individual  step(12)
Table 1

+-----------------------------------------------------+
(1)         (1)         (1)         (1)
step     fevd       Lower       Upper        S.E.
--------+--------------------------------------------
0        0          0           0            0
1        .874619    .702936     1.0463       .087595
2        .857349    .654264     1.06043      .103617
3        .859231    .656052     1.06241      .103665
4        .854386    .65148      1.05729      .103526
5        .851535    .645514     1.05756      .105115
6        .851178    .644394     1.05796      .105504
7        .851198    .644432     1.05796      .105495
8        .85115     .644334     1.05797      .105521
9        .851122    .644254     1.05799      .105547
```

```
10       .851118     .644239     1.058       .105552
11       .851118     .64424      1.058       .105552
12       .851117     .644238     1.058       .105552
+--------------------------------------------------------+
95% lower and upper bounds reported
(1) irfname = lchick_sidrt, impulse = lchick_gorak, and response = lchick_gorak

. var   lchick_npg lchick_bah
Vector autoregression

Sample:  2003m9  2007m10                          No. of obs      =        50
Log likelihood =  137.8837                        AIC             = -5.115348
FPE            =  .0000206                        HQIC            = -4.969726
Det(Sigma_ml)  =  .0000138                        SBIC            = -4.732944

Equation           Parms      RMSE     R-sq      chi2     P>chi2

lchick_npg            5     .048562   0.3949   32.63668   0.0000
lchick_bah            5     .085628   0.4032   33.78343   0.0000


Coef.   Std. Err.      z    P>z     [95% Conf. Interval]

lchick_npg
lchick_npg
L1.    .7039263   .1397543     5.04   0.000     .4300128    .9778397
L2.   -.2007361   .1384705    -1.45   0.147    -.4721334    .0706611
lchick_bah
L1.     .062513   .0805345     0.78   0.438    -.0953317    .2203576
L2.   -.0240422   .0817865    -0.29   0.769    -.1843409    .1362564
_cons    2.110853   .5859647     3.60   0.000     .9623835    3.259323

lchick_bah
lchick_npg
L1.    .0641319   .2464279     0.26   0.795    -.4188579    .5471217
L2.   -.0869394   .2441642    -0.36   0.722    -.5654924    .3916136
lchick_bah
L1.    .6925058   .1420059     4.88   0.000     .4141794    .9708323
L2.   -.0989965   .1442136    -0.69   0.492      -.38165    .1836571
_cons    1.953052   1.033228     1.89   0.059    -.0720368    3.978141

vargranger

Granger causality Wald tests
+------------------------------------------------------------------+
Equation           Excluded    chi2     df Prob > chi2
--------------------------------------+---------------------------
lchick_npg         lchick_bah   .65118     2    0.722
lchick_npg                ALL   .65118     2    0.722
--------------------------------------+---------------------------
lchick_bah         lchick_npg   .13107     2    0.937
lchick_bah                ALL   .13107     2    0.937
+------------------------------------------------------------------+
```

Transmission coefficients:

```
varbasic chihat chihatg, lags(1/1) step(1) nograph

Vector autoregression

Sample: 2003m10  2007m11                          No. of obs      =        50
Log likelihood =  178.0489                        AIC             = -6.881957
FPE            =  3.52e-06                        HQIC            = -6.794584
Det(Sigma_ml)  =  2.77e-06                        SBIC            = -6.652514

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
chihat               3     .039816   0.3186   23.37723   0.0000
chihatg              3     .086673   0.1113   6.263325   0.0436
----------------------------------------------------------------
------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
chihat       |
      chihat |
         L1. |   .2405351   .1708062     1.41   0.159    -.0942388    .5753091
     chihatg |
         L1. |    .189135   .0906783     2.09   0.037     .0114087    .3668612
       _cons |    2.58711    .547266     4.73   0.000     1.514489    3.659732
-------------+----------------------------------------------------------------
chihatg      |
      chihat |
         L1. |  -.7117464   .3718196    -1.91   0.056    -1.440499    .0170067
     chihatg |
         L1. |    .493581   .1973933     2.50   0.012     .1066973    .8804647
       _cons |    5.50815   1.191317     4.62   0.000     3.173212    7.843087
------------------------------------------------------------------------------
Where chihat is predicted value of chiken price of Bhairahawa, Nepal and chihatg is
the predicted value of chicken price of Gorakhpur, India.
```

CHAPTER 5

MIGRATION, REMITTANCES AND HOUSEHOLD LABOUR ALLOCATION

5.1 Introduction

Flows of international remittances have tremendously increased during the last decade exceeding all spending on development aid (Salimano, 2003). The data show that officially reported flows of remittances to developing countries have been approximately 20 percent higher than official development assistance (ODA). In 2005, the total amount of remittances received by all developing countries was US$ 188 billion-twice the amount of official assistance to developing countries[44]. Remittance accounts the second most source of external funding in developing countries, following by Foreign Direct Investment (Adams and Page, 2005). The data further reveal that remittances have been increasing on average by 15 percent annually in developing countries since 2000. Therefore, the impact of remittances on receiving countries is of great significance and has received considerable attention from many policy makers and development strategists in particular with regard to their impact on the economy of developing countries.

Remittance income is also rapidly growing in Nepal with an increase in the rate of migration for foreign employment. It has now become a major part of the economy and an important source of livelihoods for many people living in rural areas (Thieme, 2004). The trend of migration from rural to urban areas and abroad has also intensified during the last decade due to the Maoist insurgency beginning from 1996, which cost the lives of over 13,000 people and displace internally more than 100 thousand people[45]. Massive flows of rural and semi-urban people, escaping the internal conflict and seeking better opportunities, left for foreign countries to support their families in the home country. According to DLEP (2007), the number of Nepalese people migrating overseas for employment increased by 12.5 percent in the fiscal year of 2006/07. International labour migration is a widespread livelihood strategy in many parts of rural Nepal (Thieme and Wyss, 2005). As a re-

[44] This inflow of remittance includes only from formal channels such as banks and international remittance transfer agencies (i.e. Western Union Money Transfers and Money gram International). Remittances through informal channels could add at least 50 percent to the globally recorded flows (WB 2006).

[45] Maoist insurgency had begun in February 1996 with an aim to establish communist state in Nepal, and accorded peace deal with government in May 2006.

sult, international remittances have exceeded the combined shares of tourism, foreign aid and export in national income. An understanding of the impact of remittance on the economy and other markets will be critical for policy implications in Nepal.

It is widely recognized that international remittances can be more stable than other external flows, and can play a vital role in the economic development of low income countries. They are also considered as an alternative source of non-farm income that could enhance welfare and reduce the poverty level in many low-income countries. Adams and Page (2005) state that international migration and remittance can significantly reduce the level, depth, and severity of poverty in the developing world. For instance, in Nepal, despite the stagnation in agricultural and industrial sectors during the last decade due to political instability and civil wars, the poverty level has declined from 42 percent in 1996 to 31.1 percent in 2004, primarily due to the sharp increase in international remittances (CBS, 2004). In addition, international remittances have also resulted in an improvement in the balance of payments up to US$138.4615 million and foreign currency reserves up to US$1.2 billion (World Bank 2005). At present, Nepal ranks 14th in 2006 among the top 20 remittance recipient countries in terms of the percentage share of Gross Domestic Product (IMF, 2007).

Remittance income can affect the receiving country's economy in many spheres both at the macro and micro levels. At the macro level, the flow of remittances can influence the determination of inflation, exchange, and interest rates, as well as the growth rate of the country. At the micro level, an increase in the flow of remittances can contribute to reducing liquidity constraints of the household, which often prevail in most developing countries, particularly in rural areas. Relaxation of such liquidity constraints can facilitate the commercialization and modernization of agriculture through the adoption of capital intensive technologies and innovation. It has been suggested in the literature that remittance recipient households may increase both the consumption of leisure and investment in human capital of their children (Acosta, 2006). In relation to the labour supply decisions of the recipient households, as a source of non-labour income, remittances may ease budget constraints, raise reservation wages, and, through an income effect, reduce the employment likelihood and hours worked by remittance receiving individuals[46]. However, the existence of incomplete labour markets in most developing countries, where there is often presume imperfect substitutability between family and hired labour, may complicate the application of traditional labour

[46] This concept is based on the neo-classical model of labour and leisure choice, and is drawn form the popular book (Labour Supply) of Killingworth (1983).

economic theory. Such incomplete labour markets can change the composition of household labour supply, because migrants usually come from productive and working age members of the remittance-receiving households. Consequently, this can create labour shortage in the rural areas, if migration is affordable to households from all income levels. In this context, members from remittance-receiving households may increase their work hours to compensate for or satisfy the labour requirements given the absent of their migrant members. For those reasons, the relationship between remittance income and the work hours of remittance-receiving households is ambiguous in labour supply models.

The effects of remittances on the economy of receiving countries can be both direct and indirect. For example, it can directly promote investment and job creation, and indirectly via its long-term positive effects on economic growth. More specifically, resources provided by remittances can subsequently support consumption, housing, education, and small business formation (IMF, 2005b). Empirical findings on remittances and their impact on receiving households, particularly the allocation decisions of household labour would be helpful to get a better understanding of this nexus.

At the same time, there are a number of controversies on the impact of remittances as a flow of resources in developing countries. The literature suggests that as remittance income is mostly used for consumption smoothing, an increase in the flow of remittances could lead to a culture of dependency and possibly idleness (Kapur, 2003). A 1992 review of the findings of thirty seven community studies regarding the impact of remittance income were "remarkably unanimous in condemning international migration as a palliative that improves the well-being of particular families, but does not lead to sustained economic growth within sending communities" (Duran and Massey, 1992). It has also been stated in the literature that labour migration is neither a short cut to development nor a panacea for the sending countries' economic ills (Ghosh, 1996). However, the impact of remittances and labour migration cannot simply be written of an account of a few negative impacts in the receiving country's economy. Its impact may depend on how the receiving household utilizes the flow of remittances received from labour migration.

The study of the migration decision and the impact of remittances on recipient households is growing during the recent decade. However, there is still limited number of studies estimating labour allocation decisions of remittance-receiving households (see next section for detail literature review). In Nepal, the study of migration and remittances is still in the initial stage and is increasing with an increase in the volume of remittances in the GDP. However, most studies are descriptive in nature (for example: Chhetry, 1999; Sheddon, Adhikari and Gurung, 2000; and Kumar, 2003 etc.), where their focus is primarily on socio-economic composition, particularly dealing with the condition and the process of migration, the flow of remittance income and problems faced by migrant workers both in the country of origin and abroad. Few studies have also analysed the impact of remittance income on poverty reduction (Lokshin, Bontch-Osmolovski and Glinskaya, 2007) and the effect of male labour migration on the female employment patterns (Lokshin and Glinskaya, 2008). There is still a gap in the literature, especially the impact of remittances on labour allocation decisions of receiving households in Nepal.

This study, thus, intends to fill this gap by examining the effect of remittances on recipient households'' labour allocation in different sectors such as on-farm, off-farm, and self-employment activities. This study has many novelties, particularly in the Nepalese context. First, it applies more recent theoretical framework which enables to capture the household and region specific characteristics in the model. Second it uses panel data. The use of panel data which is not so often in the studies of migration and remittances is also a significant contribution, because study using panel data can enable to solve the problems of endogeneity and selection bias to some extent and provide more robust results.

The chapter is structured as follows. The literature review of migration and remittances and their impact on household welfare is presented in 5.2. An overview of migration and remittances in Nepal is given in Section 5.3. This mainly focuses on the historical development of migration and the status of remittance flows in Nepal. Section 5.4 provides the theoretical framework dealing with the farm household model developed by Singh, Squire and Strauss (1986) and further extended by de Janvry, Fafchamps and Sadoulet (1991) under missing and incomplete factor markets. Description and sources of data are provided in Section 5.5 with some descriptive statistics focusing on the limitations of data. Section 5.6 presents the econometric models used for the analysis of data, particularly the zero inflated Poisson model and the Tobit model. Empirical evidences from the various equations are given in Section 5.7, while Section 5.8 provides the discussion of results in relation to the theory. Concluding remarks of the study and further studies are given in Section 5.9.

5.2 Literature on migration and remittances

The research on the migration process and the role of remittances has been spurred during the past couple of decades due to the massive flow of migration from developing to developed countries, as well as from rural to urban areas. The study on migration and remittances is due to the fact that the scale, scope, and complexity of international migration have grown considerably, inviting states and other stakeholders to take greater notice of the challenges and opportunities presented by human mobility today (GCIM, 2005). Moreover, migration has become an essential, inevitable and potentially beneficial component of the economic and social life for many low-income countries. It is obviously a matter of concern for policy makers and economists regarding the social and economic consequences from migration and remittances both in the country of destination and in the country of origin.

In general, there are various forms of human migration both voluntary (e.g., usually undertaken in search of better life) and involuntary (e.g., slave trade, trafficking in human beings, and ethnic cleansing) migration from one place to another, where labour migration constitutes the major part of it. Migrant labour represents roughly 200 million people, which cover about 3 percent of the world population (IMO, 2008). In addition, the flow of remittances into developing countries amounted to $265 billion in 2007, exceeding more than double the amount of official assistance developing counties received[47]. These remittances are considered more stable than volatile capital flows as portfolio investment and international bank credit (Solimano, 2003). Remittances to developing countries have increased on an average by 15 percent annually since 2000. Several studies explain that the countries receiving higher amount of remittances have grown more rapidly than the average for developing countries in Latin America, the Caribbean, and the East Asia and Pacific regions (Gupta, Pattillo and Wagh, 2007). Hence, the migration out of rural areas or developing world is accelerating, making internal and international migration potentially, one of the most important development and policy issues of the start of the twenty-first century (Taylor and Martin, 2001). This section, therefore, attempts to shed light in the literature on the determinants of migration, the impact of remittances on household economy and the growing literature in agricultural and development economics, and examines the theoretical models analysing the effect of migration and remittances on household welfare.

A number of studies on migration have been proposed to explain its extent, to define its dominant characteristics, and particularly to evaluate its contribution to the economic development (see, Sjaastad, 1962; Arnold and Shah, 1986; Stahl, 1986a; Hugo and Singhanetra-Renard, 1987; Goss and Lindquist, 1995; Ghatak, Levine and Wheatley Price, 1996; Taylor, 1999; Taylor and Martin, 2001). There is also a shift in the analytical approach for the research on labour migration.

[47] Information on remittance transfer is based on the International Monetary Fund. This amount includes only the migrant transfer series from the IMF Balance of Payments database.

For instance, the neoclassical approach concentrates more on differentials in wages and employment conditions between countries, as well as on migration costs, as the migration decision is an individual decision of income maximization. On the other hand, the "new economics of labour migration" assumes that the migration decision is not an individual decision, but rather a collective decision of both migrant and non-migrant family members in order to maximize income of the households, minimize risk and loosen liquidity constraints created by various inadequacies of markets, including incomplete or missing factor markets. The different models have different research objectives and characteristics; however there are some similarities in dealing with migration decisions and its impact on local economy. The remainder of this section sets out the different economic models for labour migration and remittances, the neoclassical approach and the new economic approach of labour migration in particular.

5.2.1 The neoclassical approach to labour migration

Lewis's (1954) seminal paper on development economics with unlimited supplies of labour is often considered as pioneering work in migration related research and analysis, where the author presents a structural change model on how labour transfers in a dual economy. This model concentrates more on the assumption that many developing countries have a dual economic structure consisting of both traditional agricultural sector and modern industrial sector in which labour is surplus in traditional agriculture and this surplus labour can be shifted into modern industrial sector. Migration from rural to urban or industrialized sector is caused by geographic differences in the supply of and demand for labour. It is also a transfer process of the surplus labour from low productivity agriculture to a high productivity modern sector, while the source of capital in the industrial sector is profits from the low wages paid to an unlimited supply of surplus labour from traditional agriculture. However, Lewis did not suggest an explicit migration model, rather provided a description of a technologically advanced, expanding modern industrial sector (Williamson, 1988).

Ranis and Fei (1961) subsequently formalized and modified the Lewis model in a two-sector analysis. Ranis and Fei's model adds the micro-foundations to the Lewis model, considering the case when surplus labour comes to an end and also provides a link back to neoclassical growth theory. The model develops the hypothesis that part of the savings required for growth, as well as 'surplus labour', is supplied by agriculture. The model shows that the modern sector can continue to pay the transferred workers subsistence wage because of the unlimited supply of labour from traditional agriculture sector in which the process will continue until the surplus labour in the traditional sector is used up. In this situation, the workers in the traditional sector would also be paid in accordance with their marginal product rather than a subsistence wage. The basic idea of the model is that migration leads to an optimal spatial allocation of labour and eventually wage rates will be equalized across regional markets. Despite its popularity for some modelling purposes, the model is criticized in several ways. Taylor and Martin (2001) explain that the wage driven neoclassical analysis of rural out migration has largely been discredited. Todaro (1969) puts the view that the urban formal-sector wages are fixed and migration tends to persist and even accelerates in the face of high and rising urban employment in the Least Developed Countries. Rosenzweig (1978) also documented his view on the model as persistent differences in wage rates for comparable agricultural tasks across geographical areas. Hong (2000) raised the question of silence towards the implication of a passive role for agriculture such as ignoring the role of agricultural modernization on national economy and labour markets.

The Harris and Todaro (HT) model initially proposed by Todaro (1969) and further restated by Harris and Todaro (1970) is an alternative neoclassical migration model developed with some refinements of Lewis and Ranis-Fei models. This model has become an important element in regional and labour economic analysis of migration flows (Greenwood et al., 1991). The model reveals that the perspective migrants' decision whether or not to move depends on an expected-income maximization objective. The HT model is the classical framework for analysing migration and labour-market equilibrium, where the model comprises a developed urban or industrial sector and an undeveloped rural sector and where a migration equilibrium is achieved through unemployment in the developed urban sector (Ghatak, Levine and Wheatley Price, 1996). The equilibrium occurs when the actual wage in the traditional agricultural sector equals the expected wage in the modern sector. The major assumptions of the model which is based on neoclassical theory[48] are as follows (as in Bardhan and Udry, 1999):

1) There is a competitive rural labour market.
2) Modern firms can hire labour in urban sector and the wage paid to hired labour is fixed above the market-clearing level, either by restrictive union activity or by government policy on wages.
3) Urban residents are eligible to apply for jobs in modern firms and jobs will be allocated on lottery basis in case of more applicants than the number of posts required.

[48] Though the model is based on neoclassical assumptions, but in the case of micro sense, the model is slightly departure from the neoclassical assumption of the existence of full employment situation and wage differentials between urban and rural sectors. However, the HT model assumes individual independence for migration which is based on rational behaviour.

4) There is also an 'informal sector' in which urban residents can use their labour time for subsistence in case of not being employed in formal sector.

Let w_u and w_r be the wages in urban and rural sectors respectively. Let L_u be the urban employment and $L_u = \overline{L}_u$ refers the condition of no migration. Let L_n be the total urban labour force and then $M.\overline{L}_n$ is the number of equilibrium with migrants, where M is the migration rate. If the number of migrants as a proportion of the initial rural population, $\overline{L}_r$, then $L_n = \overline{L}_u + M.\overline{L}_r$. The HT two-sector general equilibrium model is based on the future expected income from migration, which is written as[49]:

(5.1) $$\int_0^{\infty} [pw_u + (1-p)w_{\pi}]e^{-\delta t} dt - C = \frac{1}{\delta}[pw_u + (1-p)w_{\pi}] - C ,$$

where p is the probability of urban employment and w_{π} denotes urban earnings if unemployed or employed in informal sector. C is migration cost, and δ is the discount rate. If the migrant were to remain in the rural sector, then future income of the migrant in comparison to (5.1) would be:

(5.2) $$\int_0^{\infty} w_{\pi} e^{-\delta t} dt = \frac{1}{\delta} w_r ,$$

the migrant's decision to go urban or modern sector depends on the difference between expected benefits from employment prospects and the migration costs, if p=1, i.e.

(5.3) $$\frac{1}{\delta} w_u - C > \frac{1}{\delta} w_r \text{ or } \quad w_u - w_r > \delta C ,$$

then the probability of employment is given by

(5.4) $$p = \frac{\overline{L}_u}{L_n} = \frac{\overline{L}_u}{\overline{L}_u + M.\overline{L}_r} ,$$

showing that migrants compete with incumbent urban employed population on equal terms. So when M rises, p falls and migration can take places until the expected income from migration equals the cost of migration, i.e.

(5.5) $$pw_u + (1-p)w_{\pi} - w_r = \delta C$$

If we substitute p, the migration rate (M) is given by

(5.6) $$M = \left[\frac{w_u - w_r - \delta C}{\delta C - w_{\pi} + w_r} \right] \frac{\overline{L}_u}{\overline{L}_n} ,$$

this equation shows that $w_{\pi} - w_r < \delta C$ for M >0, otherwise there is no incentive to migrate from rural areas for urban unemployment.

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[49] The basic idea and procedure for this model are drawn from Ghatak, Levine and Wheatley Price (1996).

Comparative analysis of the equation (5.6) gives also the following outcomes:

(5.7) $$\frac{\partial M}{\partial w_u} > 0;\ \frac{\partial M}{\partial w_r} < 0;\ \frac{\partial M}{\partial \overline{L}_u} > 0;\ \frac{\partial M}{\partial C} < 0,$$

the desire relations reveal that the marginal increase in urban wage or decrease in rural wage will increase migration rate. Likewise, an increase in urban employment will also increase migration, while an increase in the cost of migration may reduce migration rate.

The HT model that remains the most simple and powerful model and explains a number of aspects of structural transformation in at least some low income countries (Bardhan and Udry, 1999), gives some paradoxes. For instance, the policy to increase employment in industrial or urban sector will increase the migration rate and then may raise urban unemployment. In addition to this, any decrease in migration costs may also enhance the rate of migration. According to Ghatak et al. (1996), a policy implication of the HT model is that reduction of migration flow needs to raise the opportunity cost of migration (i.e. $w_r + \delta C$).

Many authors put their views on the validity of the HT model. Allen (2001) considers the HT model as an innovative but not a revolutionary one. Petrov (2007) believes that the HT model may have universal applications, if conditions and factors of labour migration are similar to those assumed in the model. However, many critics oppose a number of restrict assumptions in the model. Taylor and Martin (2001) emphasize on the role of investment in the job search and reject the lottery mechanism of the job allocation rules embedded in the Todaro model. Gallup (1997) mentions that the assumption of fixed wage and fixed migrants' future earning is implausible, because wage rates and earnings are dynamic process. Raimondos (2003) comments the creation of new jobs in the urban sector imminently leads to urban unemployment and even reduced national product (known as the Todaro Paradox). From the empirical point of view, Blanchflower and Oswald (1994) estimated the wage curve from numerous countries in order to test the HT model's assumption of positive relationship between regional wages and regional unemployment and found negative relationship between wages and unemployment.

It is discussed in the literature that the question of migration selectivity in the neoclassical and Todaro worlds is analysed by merging migration theories with human capital theory (Taylor and Martin, 2001), arising from the early contributions of Mincer (1974) and Becker (1975) on urban-rural wage (or expected earnings) differentials. For instance, higher wage differentials combined with lower migration costs may increase migration rates. In perfect neoclassical models for the human-capital (e.g., Sjaastad, 1962), wages of prospective migrant origins and destinations are assumed to be a function of individuals' skills that affect their productivity in the two sectors, and also in a Todaro model, human capital characteristics of individuals can have influence on both their wages and their likelihood of obtaining a job in the destination. Moreover, migration decisions may take place where human capital can be acquired more efficiently, and where the return to human capital is highest (Dustmann Fadlon and Weiss, 2009). The human capital model is dynamic and provides the migration theories presented above with a micro grounding, permitting tests of a far richer set of migration determinants and impacts (Taylor and Martin, 2001). The inclusion of human capital formation in the migration models allows the economist to offer a human capital explanation of migrants-natives difference in labour market outcomes, which depend on future earnings, expectation with respect to unemployment and human capital investment (Jellal and Wolff, 2003).

5.2.2 New economics of labour migration

The "new economics of labour migration" (NELM) developed by Stark and Bloom (1985) and further elaborated by Stark (1991) have emerged as an alternative approach to analyse the labour migration theories and the model has challenged many assumptions and conclusions of neoclassical theory. The NELM theory asserts that migration decisions are not only made by individual actors but also by both migrant and non-migrant members of the household. A key insight of NELM is that migration decisions are made by larger units of related people – typically families or households-in which people act collectively not only to maximize expected income, but also to minimize risks and to loosen constraints associated with a variety of market failures, apart from those in the labour market (Stark and Levhari, 1982; Stark, 1984; Katz and Stark, 1986; Stark, 1991, Massey et al, 1993; Taylor, 1999; Taylor et al., 2003). This new approach seems to be more subtle view of migration and development, linking causes and consequences of migration more explicitly, and in which both positive and negative development responses are possible (Hass, 2007).

Moreover, the NELM is an attempt to shift away from the neoclassical assumption of individual decision of migration as a response to the urban-rural differential in wages (or future earnings) towards the collective decisions related to income smoothing strategies of the household. This idea came at the time when there is widespread thinking on the academic arena regarding the joint household model instead of individual model of migration due to continuous interaction between migrants and rural households (Taylor and Martin, 2001). Stark (1991) revitalized this academic thinking on migration from the developing world by placing the behaviour of individual migrants within a wider social context and considering the household rather than the individual as the most appropriate decision making unit (Taylor, 1999). This idea has received wide response due to its explanatory power as compared with the neoclassical model by focusing on a household's decision to send migrants in a context where migration serves to mitigate the impact of insurance and market imperfections on emitting households. Stark (1991) has discussed the new economics of labour migration in terms of three major premises.

First, Stark (1991) explains that migration is not the outcome of individual optimizing behaviour, but rather of the rational behaviour of a group of persons, such as a family, focusing on migration research from individual independence to mutual interdependence. Remittances are not unintended by-products, but the result of both implicit and explicit intra-family exchanges. Stark also opposes the standard human capital theory that posits, regarding the demand for labour, that the performance of individual migrant in the destination labour market is a result of skill levels and endowments. He suggests instead that the preferences and constraints of the sending households are the important factors for the determination of destination labour market performance. Therefore, migration is not an individual but a family decision in which the family arrangement is made for migration and remittances so that familial considerations of "intra-familial trade in risk, coinsurance arrangements, devices to handle principal agent problems, moral hazard problems, and contract enforcement" all influence the migrant's performance in the destination labour market.

Secondly, Stark argues that migration is not merely a response of wage differentials, but rather an assessment of relative wealth within a given reference group, and people may induce to take migration decision if they are worse off than their groups. The NELM implies that income uncertainty and relative deprivation (as in the relative deprivation theory) will be major factors in migration decision (Stark and Taylor, 1991; Stark, 1991). Therefore the model incorporates the possibility that families pool risks across migrant and non-migrant family members. The returns from migrant children and the size and composition of human capital investments in children are also incorporated as associated phenomena for migration analysis. A number of studies tested the relative deprivation hypothesis in Mexico and found some evidence in favour of the hypothesis where relative deprivation is an important factor in international migration between Mexico and U.S. (Stark and Taylor, 1989 and 1991).

Finally, the NELM posits that migration normally occurs due to incomplete or missing markets in the given area, particularly in low income countries. People in low income countries may not be able to invest, diversify, and benefit from the process of industrialization due to pervasive market failures that constrained rural households from accessing to resources and markets[50]. Therefore migration from rural to urban or industrialized sector is the way to get benefits from industrialization.

The study on the role of migrant's remittances in receiving households' welfare and production is relatively new topic in the migration and remittances literature, particularly applying the theoretical basis of the NELM. Previous studies of migration mostly dealt with migrants in isolation of the family and community contexts from which they come, and how remittances influence the expenditure of remittance receiving households (Taylor, 1999). There are limited studies on how migrant remittances affect investment and consumption expenditures by migrant sending households. The theoretical approach[51] of NELM which considers the family or household as the unit of analysis and family members are assumed to act collectively to maximize expected income and also to loosen constraints associated with missing markets, insurance, and other markets, fits neatly with the literature on agricultural household models, both neoclassical (e.g., Barnum and Square, 1979; Singh et al., 1986) and in the context of incomplete or missing markets (e.g., Strauss, 1986; de Janvry, Fafchamps and Sadoulet, 1991). Moreover, the nonseparable agricultural household model for the NELM approach seems to be a useful means under the assumption of risks and market imperfections (Taylor and Martin, 2001). Few studies test the NELM hypothesis, exploring the extent to which participation of migration loosens the risk constraints on household-farm investments (e.g., Taylor, 1992; Taylor and Wyatt, 1996; Benjamin and Brandt, 1998).

There is substantial amount of literature on migration and the impact of remittances on receiving countries (see, review papers Massey et al., 1993; Goss and Lindquist, 1995; Taylor, 1999; Hass, 2007). However, there are limited studies on the impact of remittances on household labour allocation of remittance-receiving households. The empirical evidence on the relationship between remittance income and labour supply decisions of remittance-receiving households is a comparatively new area of studies in economics. Stark and Bloom[52] (1985) were the first who examined the impact of labour migration and raised several theoretical issues for empirical examination. However, credit goes to Funkhauser (1992) for the first empirical examination between remittance and

[50] In regard to missing markets, Stark (1991) provides an example of a rural family living in Maine, the United States, where an individual can have access to benefit of the industrialization process of California's Silicon Valley by buying shares on the New York Stock Exchange. This access may not be possible in low income countries due to the existence of incomplete and missing markets.

[51] The theoretical framework of agricultural household model (AHM) has already described in the first section of this Chapter (i.e. Chapter 2) as a general form and detailed AHM for labour allocation decision of remittance-receiving households has elaborated in the theoretical framework. Hence this section does not explain about the AHM, but rather deals with the literature using AHM in relation to remittances and household labour allocation.

[52] The seminal paper of New Economics of Labour Migration (NELM) was pioneered by Stark (1982), where the author had explained a lot of methodological and theoretical ideas before NELM. The author claimed that the outcome was the result of over 12 years intensive research in this area.

household labour supply. The author estimated the impact of migrant's remittances on participation in the wage labour force and self-employment for male and female non-migrants by applying a probit model. His empirical findings show that the relationship of remittances with wage labour force participation is negative, while it is positive for self-employment. Likewise, another study undertaken by Airola (2005) in Mexico relating weekly hours of the household head to remittance income shows a negative sign for labour hours. More recently, Acosta (2006) has examined the economic effects of international remittance on household spending decisions on human capital, child and adults both male and female labour allocation. The results show a positive impact of remittance on investing in the human capital of children. However, it has negative impact on adult female labour supply, but positive with male labour supply. With respect to the impact of remittances on labour supply, Kim (2007) observed some impact of remittances on labour force participation in Jamaica. The findings show a higher reservation wages of household with remittance income, implying that remittance-receiving households are moving out of labour force, or being less enthusiastic about finding jobs.

5.2.3 Labour migration and remittances in Nepal: present status and research gaps

Despite a long history of labour migration in Nepal[53], the studies on migration and remittances have hitherto been conducted by sociologists, demographers, and geographers and not by economists. Their focus was more concentrated on the socioeconomic patterns, trends and constraints faced by the migrants. These studies have shown various reasons of migration including oppressive land and labour policies, and debt due to demand for compulsory and unpaid labour, particular in the 19th century (Krengel, 1997; Hoffmann, 2001) and internal conflict in Nepal, especially after 1995 (e.g., NIDS, 2003b). Some studies show the reason for migration to India as a historical continuation[54] (Thieme and Wyss, 2005); to Gulf countries as wage differential between South Asia and Gulf countries (Graner and Gurung, 2003); and to Japan as a culture of migration and remittance economy among Tibeto-Burman ethnic groups (Yamanaka, 2000 and 2001). Moreover, the results of household level multivariate analysis show that the probability of outward migration is found to be high among less educated households and more internal migration to urban areas among educated households (World Bank, 2006).

[53] For detailed information about migration history in Nepal, see Section 3.

[54] Historically, India is the main destination for Nepalese workers. It is primarily due to 1950 treaty between Nepal and India that allows people from both countries travel and work freely without any travel restriction.

There are other studies examining the role of remittances in household economy and some studies show remittances as a part of livelihood strategy in Nepal (Von Furer-Haimendorf, 1995; Cameron et al., 1998; Blaikie et al., 2002; Soliva et al., 2003). Likewise, a number of studies carried out to identify the amount of remittance flows received from informal sources in Nepal show much higher amount of remittances received from undocumented channels in Nepal (Subedi, 1991; von der Heide and Hoffmann, 2001; Gurung, 2001 and 2003; Sheddon et al., 2001 and 2002; Graner and Gurung, 2003). Most of these studies also conclude that an increase in illegal and unofficial Nepalese migrant workers abroad will increase the undocumented flow of remittances. There are also some case studies analysing the status of Nepalese migrant workers on particular destination from Nepal to Japan (Yamanaka, 2000 and 2001), in the United States (Dhungel, 1999), in India (Upreti, 2002). Several studies have been conducted to analyse the migration process at individual and household levels either in Nepal (e.g., Hoffmann, 2001; Regmi and Tisdel, 2002; Wyss, 2004; Thieme and Wyss, 2005) or in India (e.g., Thieme and Muller-Boker, 2004; Thieme et al., 2003), or both in India and Nepal (e.g., Pfaff, 1995; Thieme, 2003, 2006).

Few papers in the literature employ econometric models, let alone discuss problems of endogeneity and selection biases which are often prevalent in migration and remittance literature. For instance, Milligan and Bohora (2007) examined the impact of remittances on child labour and child education in Nepal, using the Heckman's two-step analysis. They found positive contribution of remittances on child welfare but not much more than equal amount of income from other sources. Likewise, Lokshin et al. (2007) examined the impact of remittance income on poverty reduction using NLSS I &II data. They found a positive impact of remittance income on living standards of the households with a migrant member. Recently, Lokshin and Glinskaya (2008) examine the effect of male labour migration for work on female employment patterns and their results show a negative impact on the level of market work participation by the women left behind. In Nepal, there seems to be a research gap, particularly focusing on the theory of NELM and using various econometric models that address the problems of endogeneity and selection biases, where panel data are often useful to minimize such problems in the analysis. This study to some extent will help to fill this gap in economic literature that applies a number of econometric models to examine the labour allocation decisions of remittance-receiving households in Nepal.

This study thus intends to shed light on how remittance-receiving households allocate their resources in different household activities, focusing particularly on labour hour allocation. I use panel data from the NLSSs conducted in 1995/96 and 2003/04. I examine which effect (i.e. traditional labour economic theory through an income effect or incomplete factor markets) is stronger in the allocation of household labour in remittance receiving household in Nepal through the application of a number of econometric models.

5.3 Migration and remittances in Nepal

Nepal has more than 200 years of history of international labour migration, over which Nepalese have sought work abroad to improve their livelihoods. In the early nineteenth century, the first Nepalese men, especially people from hilly regions, migrated to Lahore (in today's Pakistan) to join the army of the Sikh ruler, Ranjit Singh (Thieme and Wyss, 2005), and this trend has given the nickname "*Lahure*"[55] for all those employed in foreign armies. Nevertheless, the history of modern Nepal came only after Gurkha[56] rulers conquered the previous small tiny states and created the present united Nepal, then after the establishment of united Nepal, the rulers tried to increase the size of country through invading Tibet and the nearby present Indian Territory. During the process of expanding and strengthening the country, the Gurkhas had wars with the British India Company, popularly known as Anglo-Nepal war of 1814 to 1816. During that war, the British India rulers were impressed with brevity and skill of Nepalese soldiers, and then the treaty of 1816 empowered the British ruler to set up three Gurkha regiments in their army (Seddon, Adhikari and Gurung, 2001). Since then, Gurkha regiments have been part of the regular British and Indian armies even after independence of India from Britain. The British army remains the most reliable source of remittances in Nepal, and Gurkha regiments provide lucrative jobs for many young Nepalese.

Apart from joining Gurkha regiments, Nepalese workers also went to work in tea plantations, construction, coal mining and land reclamation in the different regions of India such as Assam, Bengal, Darjeeling, Garhwal and Kumaon (Hoffmann 2001). This migration process occurred due to an existence of feudal systems in Nepal, where labour exploitation was extremely high during that period. So, oppressed people went to nearby area of Nepal for better livelihoods, which came to be known at present as Indian Nepalese. Presently there are a large number of Nepali origin people settled permanently in Darjeeling, Assam, Meghalaya, and Sikkim of east India and Uttarakhand and Simala states of North West India, and Bhutan. In addition, the trend of seeking

[55] Initially the nickname of "*Lahure*" became after going to Lahore, Pakistan (one who goes to Lahore) to join in the Sikh ruler, Ranjit Singh army, but now "*Lahure*" is commonly used to those persons who are going abroad for work both in civilian or in government jobs like British and Indian Gurkha regiments.

[56] Nepal was divided into several tiny states (called as 22 and 24 states) and Gurkha was one of them. Gurkha ruler (ancestor of the present king of Nepal) started to expand the territories conquering all small states during the 18th century and established a modern Nepal. So Gurkha is also used sometimes as synonymous to Nepal because the Gurkha rulers created a modern Nepal.

job opportunities in other countries has further increased in Nepal due to poor employment opportunities and low wage rates within the country. Migration to Gulf countries and South-East Asian countries intensified after political change in 1990 when the government provided travel documents and passports more easily than had the previous autocratic regime. The flow of migrants has increased rapidly during past decade due to political conflict and civil wars that have limited the employment opportunities in the country.

The data from the 2001 Population census show that 3.3 percent (762,181) of the total population was absent from Nepal, the majority of them being male (89 percent). Of these, more than 77.6 percent are living in the South Asian region, especially in India, while the Middle East is the second most largest population living outside Nepal (14.5 percent), followed by East and South-East Asia (4.5 percent), where a significant number of Nepalese are living in Hong Kong Special Region of China under the legal provisions known as Identity (ID) card holders for which applies to those people born during their parent's service in Hong Kong as part of the Gurkha army at the time of British rule (before 1997). [57] The remaining Nepalese emigrants are to be found in the rest of the world.

Several studies suggest that the number of Nepalese living abroad is approximately 1.5 percent higher than official data (see, Kollmair et al., 2006), because of the exclusion of large number of illegal immigrants in the surveys. The report from NLSS II (CBS, 2004) shows that 4.6 percent of total sample population is abroad, which is higher than in the population census 2001. In addition, the reports from individual case studies show 4.7 percent of total population abroad in Nepal (Kollmair et al., 2006). This could be due to increasing number of migrant workers in Nepal, where the official data show the flow of migrant workers is increased by an average 10 percent annually during last decade.

The flow of international remittances to Nepal has consistently increased from US$3 million in 1993 to US$ 1,211 million in 2005, but the sharp increase in remittance inflows started only in 2001[58](IMF, 2006). Moreover, there is widespread speculation that remittances inflow from the informal sector is much higher (50 percent) than the flow from the formal sector. Remittances inflow

[57] This provision was made between Chinese and British governments to provide permanent resident permits to those Nepalese who were born in Hong Kong during the time of British rule. At that time, British Gurkha regiments were established in Hong Kong. Gurkha armies used to bring their families in Hong Kong during their service period and gave birth their children.

[58] Detailed information on the flow of remittances and on the percentage share of remittances in the GDP is presented in graphs (see Figure 5.1 and 5.2 in appendix).

from India mostly comes from the informal sector due to small amounts of money and the inaccessibility of money transfer services in most rural areas of Nepal.

5.4 Theoretical framework

The theoretical framework for this study draws from the insights of the New Economics of Labour Migration (Stark and Bloom, 1985) plus a couple of other studies (Stark, 1982; Vijvergberg, 1992; Hoddinott, 1994; Damon, 2008). These theoretical approaches assume that migration decisions are made jointly by the migrant and by non migrants, particularly the remaining members in the households. Stark (1982), one of the pioneers in this area, mentioned migration decisions in farm households as a strategy to overcome constraints on production and investment activities as a result of missing or incomplete credit and insurance markets in rural areas. This part outlines the theoretical framework drawn upon to investigate the effect of migration and remittances on household labour allocation in different sectors such as on-farm, off-farm and self-employment, using agricultural household models developed by Singh, Squire and Strauss (1986) and further extended by de Janvry, Fafchamps and Sadoulet (1991) under missing and incomplete markets and by Damon (2008) for migration and remittances. The central theme of the model is to illustrate the linkages between migration and household labour composition.

To concentrate on the role of migration and remittances in household labour supply responses, this study assumes that the migration decision is taken by the migrant and some group of non-migrant members as an implicit contractual arrangement between the two parties who share both costs and returns[59], the latter realised as migrants send remittances to non-migrant members in the country of origin. To capture this logic in a standard utility maximization problem, we assume that both migrants and non-migrants household members[60] jointly choose their consumption (C^i), where i refers non-migrants (n) and migrants (m), and their respective time endowment (T^i) between on-farm work (F^i), market work (X^i), and leisure (L^i). The time endowment of migrant is divided between wage labour (N^i) and leisure. Time allocated to market work by non-migrant members yields the wage income. Moreover, the production decisions of the non-migrant's farm

[59] Implicit contractual arrangement is regarded as part of a longer-term agreement between prospective migrant and non-migrant family members, where costs and benefits are to be shared (Hoddinott, 1992). The data from the Nepal Living Standard Surveys on remittances support this assumption that more than 93 percent of remittance-receiving individuals were the family members of migrants.

[60] For simplicity, the model assumes two members (male and female) in the household, where adult male migrated from the home and adult female stayed at home. This assumption seems valid in the context that more than 95 percent migrants are male in Nepal. However, this assumption is relaxed in the empirical analysis in which there could have adult male and children in the family (see Damon, 2008).

household may also depend on a number of other factors such as $\left(w^n, w^m, \overline{A}, Y\right)$, where w^n is domestic wage rates, w^m is the wage rates of the migrant's working destination or country, $\overline{A}$ is household initial endowment such as land and other farm equipments assumed to be fixed, and Y is the non-labour income such as pensions, allowances and other interest rates. The household maximizes its utility at period t choosing from $\{C, F, X, N, H, Y, R\}$, where H is hired labour hours and R is level of remittances. In this paper, the household is considered as a homogenous unit (i.e. unitary model) that does not allow any bargaining between migrant and non-migrant household members. However, this paper presents the household model under the assumptions of both perfect and imperfect markets. Under these specifications, the maximization problem of farm household under perfect markets can be set as follows:

$$\underset{\{C, F, X, N, H, Y, R\}}{Max} \quad U^n\{C^n, L^n\} + U^m\{C^m, L^m\}, \tag{5.8}$$

subject to the following constraints:

$$C^n = f(F^n, H, \overline{A}) + w^n(T^n - L^n) + Y + R \text{ and} \tag{5.9}$$

$$C^m = w^m N^m - R, \tag{5.10}$$

where U^n and U^m are utility functions of non-migrant and migrant members respectively, which are assumed to be additively separable, monotonically increasing and strictly concave. $f(F^n, H, \overline{A})$ is the household production function. Household total income is the sum of agricultural products, family wage income, minus cost of hired labour, plus non-labour income and remittances. Remittances (R) are assumed as a function of wage rates of migrant's working destination, the number of migrants from the particular household and other individual and household specific characteristics that determine the level of remittances. The price of consumption goods is normalized at unity. In addition to budget constraints, household also faces time constraints which are as follows:

$$T^n = L^n + F^n + X^n \quad \text{and} \tag{5.11}$$

$$T^m = L^m + N^m. \tag{5.12}$$

These four equations (5.9 to 5.12) can be combined into one "full budget" constraint, which is expressed as:

$$\begin{aligned} C = C^n + C^m &= f\left(X^n + H^n\right) + Y + w^n N^n + w^m N^m - w^n H^n \\ &= f\left(X^n + H^n\right) + Y + w^n\left(T^n - L^n - X^n - H^n\right) + w^m\left(T^m - L^m\right) \\ &= f\left(T^n - L^n + H\right) + Y - w^n H + w^m\left(T^m - L^m\right) \end{aligned} \tag{5.13}$$

where C is the total consumption of migrants and non-migrants members[61] and $H = H^n - N^n$ (i.e. net labour hired in). Since the model assumes perfect substitution between household and hired labour, only the net amount matters. The expression (5.8) can be maximized subject to full budget constraints (5.13) using the Lagrange multiplier (λ):

(5.14) $$\ell = U^n\left(C^n, L^n\right) + U^m\left(C^m, L^m\right) - \lambda\left[C^n + C^m - f\left(T^n - L^n + H\right) - Y - w^n H - w^m\left(T^m - L^m\right)\right]$$

The First Order Conditions (subscripts indicate derivatives) are:

(5.15)
$$\frac{\partial \ell}{\partial C^n} = U_C^n - \lambda = 0$$
$$\frac{\partial \ell}{\partial C^m} = U_C^m - \lambda = 0$$
$$\frac{\partial \ell}{\partial L^n} = U_L^n - \lambda f' = 0$$
$$\frac{\partial \ell}{\partial L^m} = U_L^m - \lambda w^m = 0$$
$$\frac{\partial \ell}{\partial H} = \lambda\left(f' - w^n\right) = 0$$

These First Order Conditions (FOCs) can provide many insights. For instance, the first two equations equate marginal utilities of consumption across migrants and non-migrants, while the final FOC shows that the marginal product of both household and hired labour is equal to the domestic wage rate. Combining the last and third FOCs, marginal utility of non-migrant leisure equals the domestic wage rate, whereas the ratio of the marginal utilities of non-migrant leisure and consumption (combining the first and third FOCs) is equal to the domestic wage rate. Similarly, combining the third and fourth FOCs, the marginal utilities of migrant and non-migrant leisure are equal to the ratio of the respective wage rates.

As the model is based on the assumption of perfect markets, the household will not face any labour or liquidity constraint due to migration of family members abroad or even in urban areas and an increase in income from remittances or any other sources should not affect production decisions. The model therefore generates separability between production and migration decisions. However, an increase in household income (e.g., remittance income) may increase the consumption of the household (e.g., leisure). This simple solution for the maximization problem yields the structural demand function for leisure.

(5.16) $$L^{i*} = L\left\{w^n, w^m, Y, R(.)\right\}.$$

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[61] C_t^i is the sum of total household consumption (i.e. $P_i C_t^i$, where P_i is the price of commodities both market and non market) that should be equal to total household income. For simplicity, price is normalized by unity.

Equation (5.16) tells that the demand for leisure is the function of domestic wages, wage rates of migrants' destination, non-labour income, household's initial endowment (i.e. $\overline{A}$), and remittance income.

Labour supply equations for households' on-farm, off-farm and hired labour derived from the same way as in the equation (5.16) are as follows:

(5.17) $$F^{n^*} = F\ \{w^n, Y, R(.)\},$$

(5.18) $$X^{n^*} = X\ \{w^n, Y, R(.)\}, \text{ and}$$

(5.19) $$H^* = H\ \{w^n, Y, R(.)\}.$$

The labour supply response of non-migrant's work hours will be affected by domestic wage rates, non-labour income, level of remittances, and household's initial endowment (i.e. land in this case). In order to understand the relationship between work hours and remittances, we can analyse the comparative static by differentiating F^{n^*}, X^{n^*} and H^* with respect to migrants' wage rate (w^m).

(5.20) $$\frac{\partial F}{\partial w^m} = \frac{\partial F}{\partial R}\frac{\partial R}{\partial w^m},$$

(5.21) $$\frac{\partial X}{\partial w^m} = \frac{\partial X}{\partial R}\frac{\partial R}{\partial w^m}, \text{ and}$$

(5.22) $$\frac{\partial H}{\partial w^m} = \frac{\partial H}{\partial R}\frac{\partial R}{\partial w^m}.$$

The relationship between non-migrants' work hours and remittances under the assumption of perfect markets depends on the type of goods (i.e. leisure). For instance, if leisure is a normal good, then $\frac{\partial F}{\partial R} < 0$ and $\frac{\partial X}{\partial R} < 0$ (i.e. non-migrant family members will buy more leisure with an increase in the level of remittances), while the level of remittances will increase with an increase in the wage rate of migrant members so that $\frac{\partial R}{\partial w^m} > 0$. Furthermore, an increase in the wage rate of working destination will also increase the work hours of migrant members. On the other hand, if remittances increase the leisure of non-migrants' members, then household will buy more hired labour in order to compensate households' leisure. The relationship between hired labour and remittances would be positive (i.e. $\frac{\partial H}{\partial R} > 0$).

The agricultural household model discussed above is based on the assumption of perfect markets (i.e. traditional neoclassical model), implying that production decisions are independent of consumption decisions of a farm household. Perfect factor markets are also assumed to exhibit zero transaction costs. Under this scenario, all markets exist for the household and all prices are determined exogenously in those markets and hence there is no independent role for unobserved shadow prices and incomes.

A growing number of contributions to the literature claim that, in the developing country context, rural households are systematically exposed to market imperfections and constraints, referred to as "failures" and their behaviour cannot be understood without reference to the specificity of these failures (Thorbecke, 1993). Under the assumption of market imperfections, the agricultural household model becomes non-separable, implying that household's decisions regarding production (e.g., use of inputs, choice of activities, desired production level) are affected by its consumption characteristics such as consumption preferences and demographic composition (de Janvry and Sadoulet, 2006). Indeed, households in many resources poor economies may face missing markets for some goods, resulting in a mixture of tradables and non-tradables at the household level (Taylor and Adlemen, 2003). In these circumstances, farmers often encounter constraints, in particular in relation to credit and labour, that limit their ability to capture the potential benefits from the farm sector. In the presence of missing and incomplete factor markets, wage and farm income are often considered as endogenous, especially for those households which do not participate or partially participate in the market. The behaviour of households hence needs specialization of the particular type of failure to which household is confronted (de Janvry and Sadoulet, 2006). To incorporate the missing markets into the agricultural household model, it is convenient to specify its linkages with factor markets. The agricultural household model is often modified by adding credit and labour constraints as a limited access to these markets due to incomplete and missing markets.

Consider now the model given in (5.8) constraining by working capital in the following form:

(5.23) $$w^n H \leq K + Y + R = K + Y + w^m N^m - C^m = K + Y + w^m \left(T^m - L^m\right) - C^m,$$

where K is the working capital available to the household. This equation reveals that net labour hired in is less or equal to the total capital (e.g., working capital available plus non-labour income, and remittance income) which is equal to migrant' total income minus consumption. All notations expressed in (5.13) are the same here as well. However, the constraint included in the equation involves only migrant but not non-migrant' leisure and consumption. Including these additional constraints, the maximization problem then becomes:

(5.24)

$$\ell = U^n\left(C^n, L^n\right) + U^m\left(C^m, L^m\right) - \lambda\left[C^n + C^m - f\left(T^n - L^n + H\right) - Y - w^n H - w^m\left(T^m - L^m\right)\right]$$
$$-\mu\left[w^n H - K - Y - w^m\left(T^m - L^m\right) + C^m\right]$$

where, μ is the Lagrange multiplier associated with the total capital ($\mu \geq 0$ according to whether or not the constraint). The FOCs are as follows:

(5.25)
$$\begin{aligned}
\frac{\partial \ell}{\partial C^n} &= U_C^n - \lambda = 0 \\
\frac{\partial \ell}{\partial C^m} &= U_C^m - (\lambda + \mu) = 0 \\
\frac{\partial \ell}{\partial L^n} &= U_L^n - \lambda f' = 0 \\
\frac{\partial \ell}{\partial L^m} &= U_L^m - (\lambda + \mu) w^m = 0 \\
\frac{\partial \ell}{\partial H} &= \lambda f' - (\lambda + \mu) w^n = 0
\end{aligned},$$

the FOCs give many insights. From the first two FOCs, $\frac{U_c^m}{U_c^n} = 1 + \frac{\mu}{\lambda}$ so if $\mu > 0$, marginal utility is higher and consumption is lower for migrants than non-migrants. This is because, migrants need to remit more (hence consume less) to provide additional working capital. The final FOC equates the marginal product of both household and hired labour to $\left(1 + \frac{\mu}{\lambda}\right) w^n$. If $\mu > 0$, marginal product exceeds the wage rate. The household would like to hire more labour but is constrained by lack of capital. Combining the fifth and third FOCs, $\frac{U_L^m}{U_L^n} = 1 + \frac{\mu}{\lambda}$ so if $\mu > 0$, marginal utility is higher and leisure is lower for migrants than non-migrants. This is because migrants need more remit (and hence work more) to provide additional working capital. Likewise, combining the first and third FOCs, and the ratio of the marginal utilities of non-migrant leisure and consumption is equal to the domestic wage rate as previously and combining the third and fourth FOCs, the marginal utilities of migrant and non-migrant leisure are equal to the ratio of the respective wage rates as previously.

Now suppose the constraint is $H \leq \bar{H}$. Alternatively, if the constraint is on supplying labour, then this becomes $H \geq \bar{H}$. The maximization problem is:

(5.26)
$$\ell = U^n\left(C^n, L^n\right) + U^m\left(C^m, L^m\right) - \lambda\left[C^n + C^m - f\left(T^n - L^n + H\right) - Y - w^n H - w^m\left(T^m - L^m\right)\right] - \mu\left(H - \bar{H}\right)$$

the FOCs are:

$$\frac{\partial \ell}{\partial C^n} = U_C^n - \lambda = 0$$

(5.27)
$$\frac{\partial \ell}{\partial C^m} = U_C^m - \lambda = 0$$

$$\frac{\partial \ell}{\partial L^n} = U_L^n - \lambda f' = 0$$

$$\frac{\partial \ell}{\partial L^m} = U_L^m - \lambda w^m = 0$$

$$\frac{\partial \ell}{\partial H} = \lambda\left(f' - w^n\right) - \mu = 0$$

from these equations, the final FOC implies $f' = w^n + \frac{\mu}{\lambda}$. If the household is constrained in hiring labour ($\mu > 0$), marginal product will exceed the wage rate. If instead, it is constrained in supplying labour ($\mu < 0$), marginal product will be lower than the wage rate.

The Lagrange function for maximization of the model by pooling capital and labour constraints can be written as:

(5.28)
$$Max \quad \begin{array}{l} U^n(C^n, L^n) + U^m(C^m, L^m) - \lambda\left[C^n + C^m - f(T^n - L^n + H)\right] \\ -\mu^i\left[w^n H - K - Y - w^m(T^m - L^m) + C^m - (H - \overline{H})\right] \end{array}$$

The FOCs for marginal rate of substitution between leisure and consumption for non-migrants show that $\frac{\partial U^n / \partial L^n}{\partial U^n / \partial C^n} = w^n + \frac{\mu^i}{\lambda} = w^*$, where λ is the shadow value associated with production, and the Lagrange multiplier μ^i is the shadow values of credit and labour. w^* is called the shadow wage or opportunity cost of time which is market wage plus(or minus, depending on μ^i) shadow values for binding constraints.

Prices of commodities and wage rates become endogenous in case of household facing the working capital or labour constraints of which can be seen from the equations (5.23) to (5.28). The total income of the household depends on the shadow value and therefore is converted into shadow income, referred as $\Lambda^* (= \pi^*(w^* T) + Y + K + R)$. In this case, demand and supply satisfy the equilibrium through endogenous prices (i.e. shadow price or value). The demand for leisure from the equation[62] (5.28) is:

(5.29)
$$L^* = L\left\{w^*, \Lambda^*(.)\right\}.$$

[62] Detailed analysis of household model has been given in Chapter 6 (141-175pp) of the book entitled "Quantitative Development Policy Analysis" by Sadoulet and de Janvry (1995). See also in Chapter 2.

Equation (5.29) tells that the demand for leisure is the function of shadow wage, shadow income (Λ^*) of household production that includes both labour and non-labour income, remittances, and working capital. Under the equation (5.29), labour supply can be defined as the total hours in productive activities, as opposed to market hours alone as founded in traditional labour supply model using the observed wages (Huffman, 1980; Rosenzweig, 1980). Labour supply equations where F^{n*}, X^{n*}, S^{n*} and H^* denote the total hours of works in on-farm, off-farm and self-employment activities and hired labour respectively, derived from the same way as in equation (5.29) are as follows:

(5.30) $$F^{n*} = F\left\{w^*, \Lambda^*(.)\right\},$$

(5.31) $$X^{n*} = X\left\{w^*, \Lambda^*(.)\right\},$$

(5.32) $$S^{n*} = S\left\{w^*, \Lambda^*(.)\right\}, \text{ and}$$

(5.33) $$H_t^* = H\left\{w^*, \Lambda^*(.)\right\}.$$

The labour supply function derived from shadow wages and shadow income is different than the traditional one with the observed wages and full income. Shadow wages and shadow income are considered as endogenous variables in the non-separable (or non-recursive) model. In the traditional labour supply model (assumed as the recursive model), wage rate and income are exogenous and all households are assumed to be price takers. The relationship between household labour allocation and wages (w^*) is determined by the shadow income (Λ^*) associated with other endogenous variables such as the level of remittances (R) and credit and labour constraints. In order to understand this explanation, we can analyse the comparative static by differentiating F^{n*}, X^{n*} and H^* with respect to migrant' wage rates (w^m).

(5.34) $$\frac{\partial F}{\partial w^m} = \left\{\frac{\partial F}{\partial \Lambda^*}\frac{\partial \Lambda^*}{\partial R} + \frac{\partial F}{\partial R}\right\}\frac{\partial R}{\partial w^m} \text{ and}$$

(5.35) $$\frac{\partial X}{\partial w^m} = \left\{\frac{\partial X}{\partial \Lambda^*}\frac{\partial \Lambda^*}{\partial R} + \frac{\partial X}{\partial R}\right\}\frac{\partial R}{\partial w^m}.$$

Under the assumption of missing factor markets, ambiguities grow with the number of endogenous variables in the model (Taylor and Adlemen, 2003). The relationship between households' labour allocation among different sectors and remittances may depend on the constraint faced by the particular household. For instance, if the household is constrained by working capital, remittances ease the budget constraints, then we assume that $\frac{\partial \Lambda^*}{\partial R} > 0$. An increase in the level of remittances encourages households to invest more in on-farm that will increase the marginal product of farm labour (F), suggesting that the relationship between F and Λ^* would be positive. As we know $\frac{\partial R}{\partial w^m} > 0$ (i.e. an increase in migrant's wage will increase remittances), in this case, the relationship between on-farm (or self-employment activities) labour supply and remittances would be positive $\left\{ i.e. \ \frac{\partial F}{\partial R} > 0 \text{ and } \frac{\partial S}{\partial R} > 0 \right\}$ (that is, an increase in the investment through increase in remittances would increase work hours in on-farm sector and self-employment activities), if new technologies are more labour-intensive. Households may also buy more time of hired labour to compensate labour loss due to migration that leads to positive relationship between remittances and hired labour $\left\{ i.e. \ \frac{\partial H}{\partial R} > 0 \right\}$, even if the labour market is partially functioning.

Likewise, in the case of off-farm work (5.35), if remittances loosen the liquidity constraint and increase the marginal product of labour in on-farm sector, then $\frac{\partial X}{\partial \Lambda^*} < 0$. If we assume that family labour is a perfect substitute to hired labour, then, $\frac{\partial X}{\partial R} < 0$, meaning that an increase in remittances will decrease off-farm work hours and will buy more leisure. If family labour is not perfect substitute to hired labour due to missing labour markets, non-migrant members may reallocate their labour hours back to on-farm to compensate their labour loss due to migration $\left[\text{i.e.} \frac{\partial X}{\partial R} < 0 \right]$, particularly in the case of more investment in farm sector through easing liquidity constraints by remittance income. Conclusively, an increase in remittances will decrease the work hours in off-farm sectors both in the case of perfect substitution as well as imperfect substitution between family and hired labour.

As we discussed above, migration decisions are made by the migrant and other non-migrant household members. If we substitute equations (5.30 to 5.33) into utility function (5.8), then we can obtain household's indirect utility function characterizing the household's decision of whether or not to send a migrant.

(5.36) $$M^* = V\{w^*, w^m, \Lambda^*(.)\} - V\{w^*, \Lambda^*(.)\},$$

where $M = 1$ if $M^* > 0$ and $M = 0$ if $M^* \leq 0$.

The model implies that migration process occurs, if the indirect utility of resource-constrained household with a migrant member is greater than if this member stays at home. It can also be possible that household takes migration decision to come out from poverty trap, meaning that burden of credit may be more critical than the labour loss due to migration.

Given the theoretical structure of the model of labour supply and welfare, the expected signs between labour supply and remittances could be negative, if remittance income substitutes to other non-labour income of household that reduces the pool of family and hired labour work hours. On the other hand, the relationship could be reversed, if remittances relax the credit constraints that induce investment on farm sector or self-employment activities, which increase household labour and hired labour hours. Moreover, the conventional model suggests that work hours of labour will increase with the off-farm wage, if leisure is a normal good. Due to the intrinsic endogeneity and selectivity involved in decisions surrounding migration, there is the potential for reverse causality, as hours worked may influence emigrants' decision to send remittances home.

5.5 Data and descriptive statistics

The data used for the analysis of the impact of remittance on household work hour's allocation is from the Nepal Living Standard Survey (NLSS) carried out by the Central Bureau of Statistics, Government of Nepal with financial and technical assistance from the World Bank. The NLSS was conducted in 1995/96 and 2003/04 consisting the detailed information of income and expenditure on both food and non-food items, demographic composition, wages both in kind and in cash, and transfer of remittances.

NLSSs have wide level of data set providing the information of demographic characteristics, household activities both farm and off-farm, education and literacy, employment status both farm and off-farm, wage rates and remittances covering administrative and ecological zones. For the purpose of this study, information includes the time allocation of household members in farm, off-farm and self-employed, remittance income and other socio-economic characteristics.

The survey includes the detailed information on remittance receiving households both from rural and urban, as well as internal and external migration including their amount and the frequency. Information also includes remittance received in both cash and kind, and different remittance sending channels (i.e. financial institutions, *Hundi*[63], person, and others).

[63] *Hundi* refers to financial instruments evolved on the Indian sub-continent used in trade and credit transactions. They were used: (i) as remittance instruments (to transfer funds from one place to another); (ii) as credit instruments (to borrow money); and (ii) for trade transactions (as bills of exchange) [Source: http://www.rbi.org.in/currency/museum/m-hundi.html]. This system is common in Nepal especially among illegal immigrants, who do not have legal documents to send remittances to the country of origin. According to Wikipedia, *Hundi* is an informal value transfer system based

The study on the household labour allocation behaviour will depend on the information related to remittance-receiving households, implying that the analysis will cover only those households who reported receiving remittances in the previous year. So, the analysis will exclude those households, which did not receive any remittance even though they had a migrant member in the family due to either recent departure in abroad for work, or due to the migrant being unable to send money by other reasons. It could also be possible that households did not report their remittance income because of afraid of taxes.

The data from the NLSS conducted in 1996/97 and 2003/04 show that more than 23 percent and 30 percent of the total 3373 and 3912 sampled households received remittances from internal or external sources respectively. In the panel data, out of 962 sample households, 21.5 percent households received remittances in 1996/97, and this figure increased by 33.47 percent in 2003/04. The average amount of remittance also increased by NRs. (Nepalese Rupees) 15,160 to NRs. 34,698 from 1995/96 to 2003/04 with an increment of the share of remittances in total household income (from 26.6 percent to 35.4 percent). Per capita remittance income has also significantly increased by NRs. 625 in 1995/96 to NRs. 2100 in 2003/04. Individual profiles of the migrants using data from NLSS II show that about 97 percent aged between 15-44 years are male, while only 51 percent of recipients are males. The survey report further shows that remittance flows are very high in rural areas than urban areas. According to NLSSs, 72.6 percent and 75.1 percent of remittance receiving households are from rural areas in 1995/96 and 2003/04 respectively.

Descriptive statistics used for the analysis of the impact of remittance income on the allocation of work hours of remittance-receiving households are given in Table 5.1. Remittance income is measured as the income received by sample households both from internal migrants and those who have migrated abroad, where other income (or non-labour income) includes pensions, allowances and dividends. Work hours are the aggregate time spent by each household in different activities such as on-farm, off-farm and self employment activities, and hired labour. Land is total farm size either owned, or rented or sharecropped by the household and measured in hectares, while the value of the livestock is the total value of livestock owned by households during the survey. Farm size and the value of the livestock are often included in labour supply model, assuming that

on performance and honour of a huge network of money brokers which are primarily located in the Middle East, Africa and Asia.

such variables could have effect on household labour allocation. Moreover, the number of children below 6 years and senior population may also matter for the time allocation of households.

The data further reveal that out of total remittance-receiving households, about 28.5 percent and 36 percent of households in NLSS I and II are headed by females, but this figure is quite low in the total samples of both remittance receiving and non-receiving households (12.68 percent in 1995/96 and 18.92 percent in 2003/04).

The panel data show some change in the work hour allocation in different sectors, indicating a shift from the farm sector to off-farm sectors among the remittance-receiving households. There is also a slight change in average family size from 6.27 to 5.64. The data show some positive changes in remittance income and non-labour income over the last 7 years of the first NLSS. In addition, farm size decreased over the time covered by NLSS I and NLSS II.

5.6 Econometric specification

The econometric model for this analysis assumes that the household decision for migration is purely based on the objective of utility maximization. Decision to migrate is often done by both migrant and non-migrant family members by sharing costs and returns as an implicit contractual arrangement between two parties as discussed by Stark (1991). In other words, patterns of remittances could be better to explain as an intertemporal contractual arrangement between migrant and other family members than as the result of purely altruistic considerations as explained by Stark and Bloom (1985) in their seminal paper of "The New Economics of Labour Migration". Remittances in this context may not be considered as random, and are modelled as the outcome of a joint utility maximization made by the prospective migrant and other non-migrant household members (Hoddinott, 1994). It is also reasonable to assume that households decide migration and remittances jointly with other income activities as a part of their livelihood strategies (Stark and Bloom, 1985). In other words, migration decisions, remittances, and other household activities like expenditure, labour allocation, and school attendance are usually made simultaneously (McKenzie and Sasin, 2007). Such complicated relations have raised a number of methodological issues relating to the application of econometric models, particularly identification issues in the context of standard OLS techniques in the presence of simultaneity that can manifest themselves in the problem of endogeneity in the labour supply model.

Furthermore, sample selection bias and omitted variables are common problems in migration and remittance analyses which can affect the estimated labour supply model. For instance, there are fundamental differences between migrants and non-migrants, and selection of only migrants can result in a bias sample. This gives rise to the problem of selection bias[64]. This sample selection of migration may be a problem of omitted variable bias, arising from the exclusion of both observable and unobservable characteristics of non-migrants in the model.

The instrumental variable (IV) technique is the most common way to address the problem of endogeneity between labour hours, remittances and migration. In addition, the literature also suggests that the use of panel data can significantly reduce those biases arising from omitted variables (including unobservable individual and household characteristics), selection biases, and endogeneity and can control for household level unobserved effects (e.g., see Stark, 1991 for detail). Because panel data allow to control for issues of time-invariant unobservable characteristics, as well as to address biases by taking differences (McKenzie and Sasin, 2007). The labour supply equation we estimate attempts to take into account the endogeneity problem using panel data from NLSSs conducted in 1995/96 and 2003/04.

Due to the presence of pervasive endogeneity in the migration decisions, there is a need to address this problem in the model. The general approach to address such problem is to find good instruments for remittances[65]. Previous studies usually used probit models for binary variable of migration in order to find the inverse Mill's ratio, which is considered as an instrument of migration decisions. Then the equations on household work hours are estimated by two-stage least squares using the inverse Mill's ratio of migration decisions as an instrument for remittance equation. However, this study applies the count regression model, because the number of migrants is an integer, where about 6 percent sample households have more than one migrant member in the family. Count regression models have several advantages over other specification (Taylor, Rozelle and Brauw, 2003). Among many count regression models, we estimate zero inflated Poisson (ZIP) model due to the high incidence of zero counts in the panel data set in order to find the best instruments for remittances (for equation 5.40), and predicted value of migrants also includes in the model to control endogeneity. However, the model does not include the inverse Mill's ratio in remittance equation as exogenous variable (5.40) due to possible bias in the estimation of the inverse Mill's ratio in the presence of higher number of zero count. On the other hand, zero-inflated Poisson regression models introduced by Lambert (1992) are a useful class of models for excessive count data that account for the zeros by the non-migrant households. The density function is:

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[64] McKenzie and Sasin (2007) have given an example of healthier, educated and wealthier household regarding this issue. They point out as positive selection if such households might be more likely to migrate and as negative selection, if less likely to migrate.

[65] Migration is also a function of households and other socio-economic characteristics, and written as $M_{it} = \delta_0 + X_{it}\delta_1 + \pi_{it} + \omega_i$. The functional form reflects that the number of migrants from a household should always be a non-negative integer.

(5.37) $$g(m)=\begin{cases} f_1(0)+(1-f_1(0))f_2(0), & if \quad m=0, \\ (1\text{-}f_1(0))f_2(0), & if \quad m>0. \end{cases}$$

Where, $f_1(0)$ is a logit model and $f_2(0)$ can be either a Poisson or a Negative Binomial Density (Cameron and Trivedi, 2005).

The number of migrants in the household is the dependent variable for ZIP model with a set of exogenous variables that induce to migrate. These exogenous variables are assumed to be correlated with migration and not to be correlated with error terms. As explained before, the migration equation for this analysis is:

(5.38) $$M_{it}=\delta_0+X_{it}\delta_1+\upsilon_i,$$

where X_{it} is the vector of exogenous variables such as percentage of migrants from the district, per capita household income without remittances and migrant belonging rural or urban (dummy). In addition, the model includes a number of demographic variables, specifically family size, the dependent ratio (i.e. number of dependent divided by adult members), age and sex (1=female) of the household head. It is often assumed that family size and other democratic characteristics do matter in the presence of incomplete factor markets in most developing countries such as Nepal. The education level of the household head has also included in the model as a proxy for educational status of the household, implying that higher educated household can have effect on migration decisions. After the estimation of the Zero Inflated Poisson model, variables which are significant in the ZIP model (equation 5.38), are used as instruments for remittance equation (5.40), when applying two-stage least squares regression for equation (5.39).

In order to estimate labour allocation decisions of remittance-receiving households, two types of equations such as sector specific (i.e. farm, off-farm, self-employment) time allocation (5.39) and individual time allocation (labour and leisure) of household members (5.41) are applied. The functional form of labour supply equation for instrumental variables regression which is the main interest of this analysis is expressed as follows:

(5.39) $$H_{it}=\beta_0+Z_{it}\beta_1+\beta_2R_{it}+\eta_{it}+\varepsilon_i,$$

where, H_{it} is a measure of labour hours allocated for on-farm, off-farm, self-employment and hired, combined with aggregate of all, Z_{it} is the vector of household characteristics, R_{it} is the level of remittances received by the household, and η_{it} and ε_i are respectively the household specific and aggregate error terms. As discussed above, the level of remittances received by households is considered as endogenous, because migration and remittances are endogenously determined together with other income sources. To control the problem of endogeneity, the equation of remittance income is instrumented by a set of exogenous variables, which are supposed to be correlated with remittances, but not to be correlated with labour hours of the household. The equation for remittances is:

(5.40) $$R_{it}=\alpha_0+X_{it}\alpha_1+\alpha_2M_{it}+\eta'_{it}+\varepsilon'_i,$$

where X_{it} is the vector of exogenous variables such as percentage of migrants from the district, the number of migrants from the household, working region of migrant and region belonging to migrants in the country of origin. M_{it} is the number of migrants from the household.

The dependent variables in the regression model (equation 5.39) are the total hours of household's work on farm, off-farm and self employment activities, and total work hours of hired labour with a set of exogenous variables, specifically household size, farm size, non-labour income, value of livestock, off-farm wages, dependent ratio, number of children (< 6 years) and the number of elderly members (65^+ years) in the household, and the sex of household head.

A growing body of evidences suggests that the labour supply response of individual members may not necessarily give the same response at aggregate levels even within the same household, perhaps due to difference in responses among gender, or the regions or the amount of remittances. For instance, Rodriguez and Tiongson (2001) estimated probit models for the participation of labour force in Manila, and they obtained higher probabilities (about double) of reducing work by women than men among the households with migrant members. The further application of labour supply responses by gender in remittance-receiving households will give more insights to understand the relationship between remittance income and the hours of work. The study also estimates labour supply models of remittance-receiving households by gender based on the demographic characteristics.

The labour supply equation[66] of Tobit model for time allocation decisions of males and females in the remittance-receiving households follows as:

(5.41) $$L_i^* = \gamma_0 + \gamma_1 R + \gamma_2 Z_i + \omega_i ,$$

where $\omega_i \sim N(0, \sigma^2)$ and $L_i = \max(0, L_i^*)$, and L measures the individual work hours of remittance receiving households with sample i (i=1,……n). R is the per capita remittance income of the household, and Z_i is the set of exogenous variables, particularly demographic characteristics of the individual and average non-labour income. The dependent variable $L = L^*$, if = $L^* \geq 0$, and L=0, if $L^* < 0$, implying that work hours of some individuals are reported as zero. Use of the OLS method for this model will give biased and inconsistent estimates of the impact of remittances on the household work hours.

The Tobit model, which can address the problem of the partially discrete and particularly continuous nature (i.e. censored) of dependent variable, would be a better choice against OLS. In addition, Tobit model with instrumental variables for remittances will give unbiased and consistent estimates with taking into account the presences of a number of zeros in the dependent variable (e.g., censored at zero). The model, thus, uses Amemiya Generalized Least Square (AGLS) as de-

[66] The theoretical idea for this model is mainly drawn from the papers of Amuedo-Dorantes and Pozo (2006), and Acosta (2006).

scribed by Amuedo-Dorantes and Pozo (2006) with endogenous regressors. The instruments for remittances are the same as before used in equation (5.32) and (5.33) for migration decisions, where the dependent variable is the zero inflated continuous variable, measuring the work hours of individual members of remittance receiving households.

5.7 Empirical results

5.7.1 Migration decision of the households

As discussed earlier regarding migration and remittances as joint decisions of migrants and non-migrant family members, it is plausible to examine the variables of household and other social characteristics that may induce migration. In econometric literature, there are a number of count models, such as the Poisson Regression Model (PRM), the Negative Binomial Regression Model (NBRM), the Zero Inflated Poisson (ZIP), and the Zero Inflated Negative Binomial (ZINB). There are also various tests in order to select the preferred count model in the data set. The common processes for the selection of the best model in the data set are often done by tests, such as the tests of Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC)[67] and the Vuong test[68]. Table 5.3 displays econometric results of the factors that encourage to take migration decisions, as well as the test results for the selection of preferred model. The estimated parameters were consistent in all most all models (e.g., ZIP, PRM, NBRM and ZINB) with some exceptions, but the estimated parameters applying the ZIP model seem to be more compatible with the theory than other count models for our interest. A number of tests were also done for the selection of preferred model to the analysis of migration decisions. For this, the smaller values of AIC and BIC in ZIP model allow to conclude that the ZIP is more preferred than other models. The result of Likelihood Ratio (LR) test[69] of $\alpha = 0$ for the NBRM against the PRM is insignificant, suggesting that the PRM is favourable over the NBRM. Likewise, the result of the Vuong test ($z = 3.70, p < 0.0001$) for the ZIP model against the PRM is significant at 99 percent confidence level, implying that the ZIP model is preferred to the PRM. We also estimated random effect models for the PRM and the

[67] AIC is a measure of the goodness of fit of an estimated statistical model and BIC is also a criterion for model selection which is closely related to AIC. All these being equal, the model with the smaller AIC and BIC is considered as a better fitting model. For detail, see Long and Freese (2001).

[68] Vuong (1989) test is a likelihood ratio test for model selection and non-nested hypotheses. Vuong test statistics allow both models to have explanatory power, but provides direction concerning which of the two is closer to the true data generating process.

[69] The likelihood ratio test examines the null hypothesis of $\alpha = 0$. The LR statistics follows the Chi-squared distribution with one degree of freedom. If the null hypothesis is rejected, the NBRM is favoured to the PRM.

NBRM and tested panel data against pooled data in order to control unobserved effects in panel data. The result of LR test of α ($\chi^2_{(1)}$=0.00 with $P_{value} = 1.00$) does not reject the null hypothesis, suggesting that panel estimators are not significantly different from pooled estimators, which allows to use pooled estimators for the analysis of migration decision. After conduction of various tests to select the preferred model for the analysis of migration decision, the following part only presents the results of the ZIP model.

The LR χ^2 test which is same as F-statistics in OLS shows that the model has explanatory power. The parameters estimated in the ZIP model can be interpreted as the effect of the variables on the probability of expected number of migrants from the household, for example, the significant and positive sign of family size imply that an increase in the number of family member will on average increase the probability of migrating by 7 percent. Likewise, residence in the district with the higher migration rate also encourages migration, perhaps due to social and economic impact in the society (i.e. network effects). The sex of the household head is significant and positive, implying that female head households are more likely to have sent migrants out. This is in line with the observations that female-headed households increased by 19.27 percent of the total sample households by 39.77 percent of remittance-receiving households. In addition, the rural dummy shows that people from rural areas are more likely to migrate in compared to urban inhabitants. The intuition may be that this is due to fewer off-farm employment opportunities and possible lower wages in rural areas in comparison to urban areas. The significant and positive sign of the age of household head also indicate a high percentage of migrants are relatively young and that this may lead them to work more for senior family members who remain at home. Household per capita income also shows a positive relation to migration, suggesting that household income from own businesses, such as income from farm sector and other non-farm sectors, does affect migration decisions, but the magnitude of coefficient is relatively low. The education level of household head has no effect on migration decisions. The dependence ratio of the household also does not show any impact on migration decisions.

5.7.2 Time allocations of remittance-receiving households

Table 5.4 gives estimates for the impact of remittances on household labour allocation, particularly on farm, off-farm, self-employment activities, as well as hired labour. Models use the same explanatory variables. Remittance income, the main focus of interest in this study, is considered as endogenous. As discussed above, remittance income depends on the number of migrants in the households. So, the presumption that migrant families are systematically different from non-migrants in observable (wealth) and non-observable (ability and income shocks) characteristics complicates the identification of the effect of remittances using standard Ordinary Least Square (OLS) (Acosta, 2006). The instrumental variables method (IV) is the most common way to control the problem of endogeneity. Instrumental variables[70] for remittance income include the number of migrants from the household, percentage rate of migration from the district, family size, sex of female head household (dummy), per capita income calculated by household production, and region (rural or urban). The econometric models were estimated two years of panel data (1996 and 2004) of 962 households. Out of this sample, only 529 households (207 from the survey year of 1995/96 and 322 from the survey year of 2003/04) received remittances. This result is thus based on the panel data of 529 observations. The results of Wald Chi-squares which are same as F-statistics in OLS, are significant in all models, showing explanatory power in the model. R-square (overall) values are between 0.07 to 0.14 which are normal in two-stage random effects models.

The coefficient of remittances in the equation for total household labour supply is significant at 10 percent level with a negative sign, supporting the contention that remittance income is a substitute of non-labour income (e.g. pensions, allowances etc.). It implies that the level of remittances is more likely to result to a decrease total work hours of remittance-receiving households. This result is also supported by the coefficients of farm work hours of household, suggesting that remittance income decreases the hours of work on farm sector of remittance-receiving households, which is similar to the result of Acosta (2006) for adult female labour supply in El Salvador. Remittances also decrease off-farm work hours as well as self-work hours, but the coefficients are not significantly different from zero, which is contrary to the results of Amuedo-Dorantes and Pozo (2006) and Funkhouser (1992). However, the coefficient of hired labour shows those remittance-receiving households are more likely to increase work hours of hired labour. This result is to some extent in favour of the view that factor markets are incomplete and that remittances relax liquidity constraint so that household can hire more labour in the case of inadequate family labour.

The result of the relationship between household work hours and non-labour income does not support the hypothesis of the traditional labour supply model except hired labour hours, where

[70] Instrumental variables are the same variables, which were significant with positive sign in Zero-Inflated Poisson (ZIP) model. The intuition to include these variables as instruments for remittance equation is that such variables can induce to migrate.

higher non-labour income is more likely to reduce the work hours of household, if leisure is normal good. But it may be possible for liquidity-constrained households that non-labour income increases the opportunity for self-employment, because it lifts household budget constraint, particularly in the presence of missing credit markets, as viewed by Funkhouser (1992). However, the coefficients of non-labour income for all models are not statistically significant.

The estimated coefficients of farm size measured in hectares give rise to mixed results in different equations. As usual, farm size increases the hours of work on the farm sector. In addition, farm size has also positive effect on self employment activities and hired labour hours, perhaps due to the fact that Nepal is an agrarian country where the agricultural sector is the primary means of livelihood for the majority of people and the main sector for self employment activities. On the other hand, farm size does not show any effect on the aggregate and off-farm work hours at least in these models. However, the value of livestock is significant in all equations except that of the farm work. The results show that higher livestock value is more likely to increase the hours of work on off-farm and hired labours, and decrease farm and self employment. This result is a bit surprising for developing countries such as Nepal, where livestock and farms are often considered as complementary goods for farm households.

Demographic variables give almost the same results for household work hours showing that higher family size is more likely to lead higher work hours, while a higher number of children under six years and the adult above 65 years are more likely to reduce hours of work in different activities. Moreover, a higher dependency ratio also reduces total work hours of the household, and increases the hours of hired labour. Female-headed households have relatively high working hours than households headed by their male counterparts, but this effect is not significantly different from zero. The result shows that family member has significant role in the labour market in Nepal.

Finally, the coefficient of off-farm wages shows an *a priori* result that higher wage in the off-farm sector is more likely to increase the total work hours as well as off farm work hours of the sample households. Contrary to this, higher off-farm wage rates draw the labour hours away from the farm sector and self-employment activities, possibly due to higher attractiveness of the off-farm sectors, but most of the coefficients are not significantly different from zero except that for off-farm work hours. The result also shows that higher off-farm wage reduces farm labour hours. This is perhaps due to higher opportunity cost in the off-farm sector than farm sector.

5.7.3 Instrumental variable Tobit models

The results of the instrumental variable Tobit (IV-Tobit) models for men and women, and pooled of both are given in Table 5.5. The models use the same explanatory variables for all equations in order to explore gender differences in hours worked, taking remittance income as endogenous. The results of a Wald test for exogeneity are significant, implying that remittances are indeed endogenous. Most of the significant explanatory variables for both men and women show the same effects with previous models. For instance, the results do not show significant differences of the hours of work between men and women with per capita remittance income and non-labour per capita income, implying that an increase in remittance income is more likely to reduce work hours for both men and women, which is consistent with the results of aggregate household work hours in different sectors (see in Table 5.4). However, per capita non labour income increases the labour hours of both men and women, but the coefficients of both remittances and non labour income are very small in magnitude. Moreover, the level of education also increases the hours of work for both, showing that higher educated people are more likely to increase the hours of work than relatively lower educated people. The coefficient of age shows a positive for men, implying higher work hours with higher age. However, for females work hours, education and age do not show any significant effect. The number of children below six years reduces the hours of work for men but not for women, but the coefficients are not significant at any required level. In addition, the coefficients of ethnicity[71] do not show any significant effects either for males or for females. The result is also the same for the coefficients of senior citizens (>65 years). The coefficient of the rural dummy shows that individuals from rural areas are likely to work more than urban individuals. In addition, larger family size is likely to reduce the individual work hours. The coefficients for a female headed household are negative for women, but not significant for men.

The result of pooled men and women shows the same effect as in men and women, indicating consistency and robustness in our models. For instance, remittance income is more likely to reduce work hours of remittance-receiving household members. In general, rural people work more than urban people and higher family size reduces the individual work hours of remittance- receiving households.

[71] The variable ethnicity measures the so-called caste groups in Hindu religion. Caste Systems are traditional and hereditary systems of social classification that evolved due to the enormous diversity in India and Nepal. The systems divides into four major castes from highest to lowest like Brahmin (i.e. Vedic priest), Kshetriyas (warriors and rulers), Vaishyas (merchants), and Shudras (artisans).

5.8 Discussion of the results

A number of examinations related to migration decisions and remittances with the hours of work in their receiving households tested using NLSS panel data. The study tried to capture the methodological issues related to migration decisions and the impact of remittances on household work hours, and a number of econometric models such as the Zero-Inflated Poisson model for migration decisions, random effect instrumental variables for household aggregate work hours in different sectors (i.e. farm, off-farm, self employment, and hired labour) and the Instrumental Variables Tobit (IV-Tobit) for the labour supply of working age men and women as well as pooled of men and women were used to explore the impact of remittances on the labour supply decisions in remittance-receiving households.

The results from the different models especially that for the impact of remittances on the hours of work in recipient households are consistent with remittances, as remittances decrease both aggregate and individual hours of work in remittance-receiving households, implying that leisure is a normal good. In other words, the income effect appears to be dominant in our data, where an increase in remittances decreases the hours of work. The result also shows that higher remittance income increases the hours of work of hired labour by relaxing the liquidity constraint, indicating an existence of partly missing credit markets in Nepal, rural areas in particular. From a development prospective, remittances create positive externalities in neighbouring families or villages by hiring more labour, as pointed out by Acosta (2006). In contrast to this, the results of non-labour income are surprising both at the aggregate and individual levels, showing that non labour income increases household work hours. Nevertheless, these coefficients are not statistically significant. Further investigation may be needed to understand this relation.

Consistent with the hypothesis, demographic characteristics such as family size, have shown the result as expected that larger family size leads to higher work hours in all sectors, but reduces individual work hours. However, the number of children under six years does not show significant effects in household work hours, but family members over 65 years normally reduce work hours for women and increase for men with some exceptions. The possible explanation is that the adult female members have to spend more time taking care of their children and senior citizens that reduces to the hours of work on farm and off-farm sectors, which is also consistent with the result of dependency ratio.

Farm size and livestock, which are key characteristics of rural settings, have given rise to mixed results, implying that higher farm size leads to higher work hours on farm sector, self employment activities and hired labour, but not in off-farm sectors. However, the result of the value of livestock, which shows a positive relation with off-farm work hours and negative with farm work hours, is counter-intuitive. More investigation is needed to justify this result.

5.9 Conclusions

Remittances are becoming a stable source of income for many people living in developing countries. Policy-makers in Nepal have sought to explore the opportunities in developed and middle-income countries, especially in South East Asia and the Gulf countries to absorb their surplus labour to improve living standards. This policy is popular to some extent due to increasing impact of migration and remittances on the living conditions of the remittance-receiving households in Nepal. Due to enormous effects of remittances on receiving countries both at the macro and the micro levels, it is obviously a matter of interest for economists.

The study attempts to explain the impact of remittance income on the hours of work in remittance-receiving households both individual as well as sectoral levels in Nepal using panel data from the Nepal Living Standard Surveys conducted in 1995/96 and 2003/04. The study estimates first a Zero Inflated Poisson (ZIP) model in order to find out the factors that motivate to migrate. We then examine econometric models of household work hours in various sectors (such as farm, off-farm, self-employment activities, hired labour and the aggregate of all) with remittance income and other explanatory variables to measure the effects of labour hour allocation in remittance receiving households which are the primary interest of this study. The level of remittance income is assumed to be an endogenous variable because of multiple effects of migration and remittances on living standards and human capital outcomes. We apply the instrumental variables method to control the endogeneity problem in the model. Econometric models for working age men and women (16-65 years) are also estimated to examine the effect of remittances on work hours of recipient households in the country of origin applying an IV-Tobit model.

The result of the ZIP model shows several factors as motivating migration from Nepal. For instance, people from rural areas and the district with higher percentage of migration rate have higher probabilities of migration. Households with larger family size and income per capita without remittances have also a higher probability to migrate. Female-headed households are more likely to have sent migrants out. Large number of children and higher level of education in the household reduce the probability of migration. This finding supports the view that multiple factors affect for migration decisions.

The empirical analysis of the impact of remittances on the allocation of labour hours in different sectors implies that remittance income increases the consumption of leisure in almost all sectors, the exception being that of hired labour in remittance-receiving households. However the results do not show any significant effect in the hours of work on off-farm and self- employment activities, implying that remittance income appears to be a substitute for non-labour income in the sample households. The evidence in relation to non-labour income is inconsistent with the traditional theory of labour economics, suggesting that leisure is not a normal good. The coefficient of hiring labour with remittances suggests that remittance income relaxes the budget constraint and then raises the hours of hired labour to meet the labour demand in the migrant's household. By contrast, households with higher non-labour income prefer to work themselves rather than to hire labour.

Econometric results of the impact of remittances on the labour supply of men and women aged between 16-65 years in remittance-receiving households show that remittances increase the hours of leisure of individual members. However, individuals having higher non-labour income are more likely to increase their hours of work.

Further studies should focus on the impact of remittances on different income level of households residing in different ecological zones. Information on migrant characteristics could be useful to obtain better insights on the impact of remittances and returns to scale in migration.

APPENDIX-5

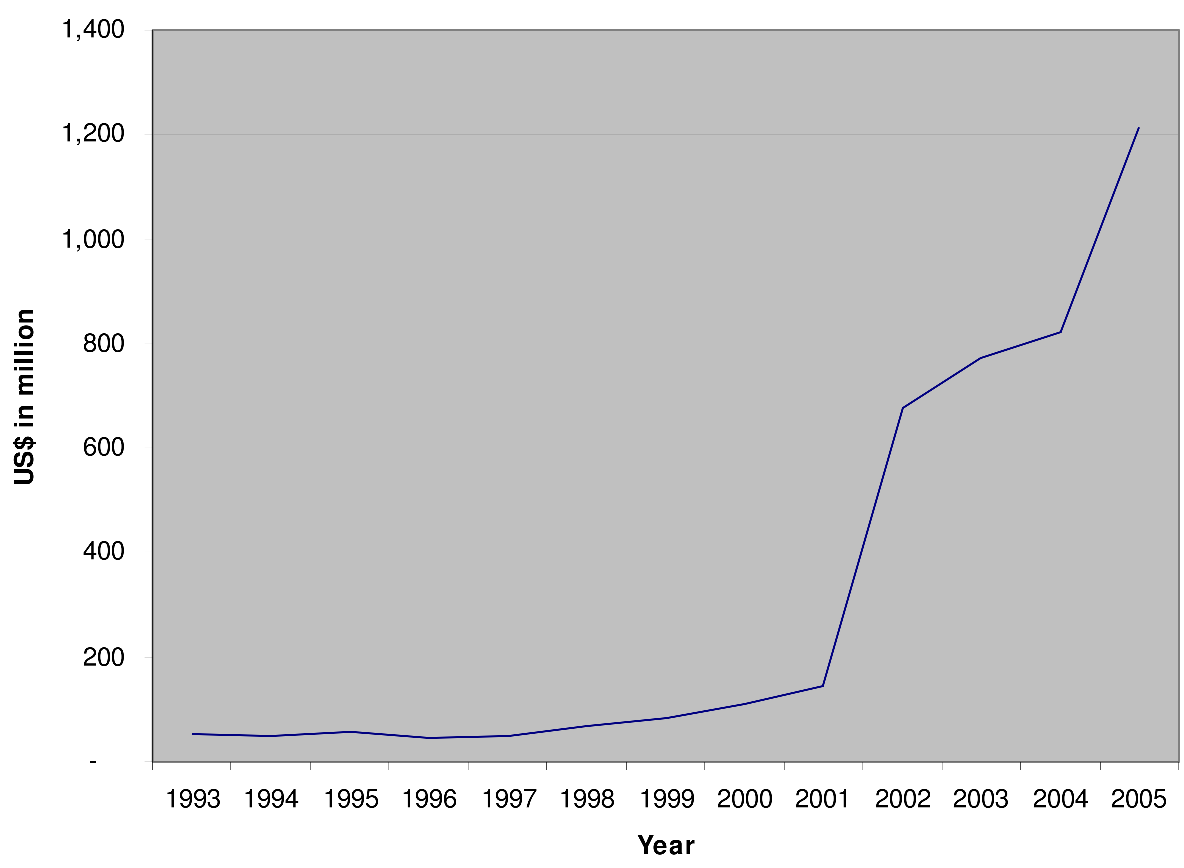

Figure 5.1: Remittance flow in Nepal

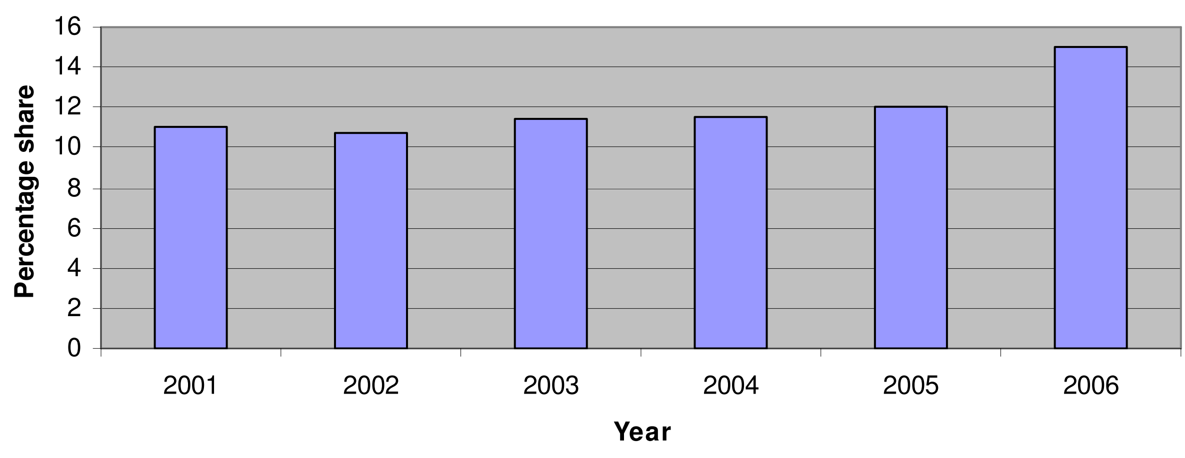

Figure 5.2: Share of remittances in the GDP of Nepal

Table 5.1: Descriptive statistics of remittance receiving households

Variables	NLSS 1995/96		NLSS 2003/04	
	Mean	Std. Dev.	Mean	Std. Dev.
Remittance income[72]	20,801.21	93,425.28	34,798.26	70,567.58
Non labour income	6,375.22	27,346.98	31,032.62	13,1702
Total household(HH) size	6.27	2.99	5.64	3.02
Child<15	2.57	1.85	1.95	1.79
Old pop>65	0.26	0.52	0.30	0.56
Total work hours/HH	433,123.3	10,11436	573,625.9	11,086,047
Total work hours on farm/HH	211,900.7	457,120.3	7,487.54	58,940.5
Total work hours on off-farm/HH	128,498.1	409,962.5	557,881.3	1,080,031
Total work hours on self employment activities/HH	92,724.48	306,663.7	8,257.03	13,341.21
Land in hectares	10.61	16.74	0.71	1.19
Livestock value	12,080.15	13,164.82	35,227.48	33,411.08
Education level of HH head (no. of years)	1.94	3.62	1.82	3.55
No. of migrants from HH	1.24	0.55	1.29	0.60
Female HH head (percent)	28.5		36.02	
No. of HH received remittances	207		322	
Total observations	962		962	

[72] All income sources both remittances and non-labour are given in Nepalese currency (i.e. Rupees), where US$1=63.9 Nepalese Rupees.

Table 5.2: Descriptive statistics of non-migrant households

Variables	NLSS 1995/96		NLSS 2003/04	
	Mean	Std. Dev.	Mean	Std. Dev.
Remittance income	-	-	-	-
Non labour income[73]	19,985.03	28,6230.7	84,417.89	483,987.5
Total household(HH) size	5.92	2.63	5.78	2.54
Child<15	2.51	1.76	2.1	1.72
Old pop>65	0.25	0.52	0.30	0.57
Total work hours/HH	420,800.3	941,358.8	754,517.8	152,940
Total work hours on farm/HH	197,745.2	423,899.6	6,046.98	31,428.19
Total work hours on off-farm/HH	12,6573.9	349,393.7	737,526.3	1,518,645
Total work hours on self employment activities/HH	96,481.11	294,612.7	10,944.52	17,504.34
Land in hectares	9.56	19.99	0.73	1.03
Livestock value	10,937.77	12,505.21	31,912.03	34,733.79
Female household head (percent)	8.34	-	10.31	-
Education level of household head (no. of years)	2.80	4.19	3.42	4.49
No. of HHs without any migrant	755		640	
Total observations	962		962	

[73] All income sources both remittances and non-labour are given in Nepalese currency (i.e. Rupees), where US$1=63.9 NRs.)

Table 5.3: The effects of migration using ZIP model

Explanatory variables	Coefficients	Std. Err.
Family size	0.07***	0.018
Percentage of migration of the district	0.04***	0.013
Per capita household income without remittances	0.001***	0.002
Dependent ratio	0.10	0.068
Age of household head	.001***	0.003
Education level of household head	-0.02***	0.012
Sex of household head (dummy)	0.42***	0.129
Rural or urban (dummy)	0.74***	0.190
Constant	-2.548***	0.303
LR Chi2 test statistics	90.17***	
Vuong test (ZIP vs. PRM)	3.70***	
AIC (for ZIP)	2716.093	
BIC (for ZIP)	2793.963	
AIC (for PRM)	2775.27	
BIC (for PRM)	2825.33	
AIC (for NBRM)	2765.45	
BIC (for NBRM)	2815.51	
Likelihood Ratio (LR) test of $\alpha = 0$ NBM against PRM	0.00 (P_{value}=1.00)	
Likelihood Ratio (LR) test versus pooled: chi2bar (01)	0.00 (P_{value}=1.00)	
Number of observations	1924	

*** significant at 1percent level.

Table 5.4: Regression results of household labour hours using random effects instrumental variable

Explanatory variables	Household work hours				
	Total	Farm	Off-farm	Self-employment activities	Hired labour
Remittance income	-8.24*	-2.45*	-5.40	-0.39	0.003*
	(4.68)	(1.36)	(3.79)	(0.76)	(0.001)
Land per hectare	6439.82	7251.19***	-4575.32	3749.20***	14.74***
	(4684.55)	(1361.37)	(3795.68)	(763.83)	(1.78)
Non labour income	1.24	0.31	0.93	0.001	-0.0003
	(1.02)	(0.29)	(0.83)	(0.16)	(0.0003)
Livestock value	5.95***	-0.89	7.25***	-0.42**	0.004***
	(1.96)	(0.57)	(1.59)	(0.32)	(0.0007)
Family size (including migrants)	150603.9***	25552.44***	103358.7***	19666.8***	25.93**
	(26661.86)	(7748.17)	(21602.9)	(4347.33)	(10.15)
Children <6 yrs	-29749.53	-9926.87	-4801.36	-14956.35	-64.93*
	(66079.05)	(19203.15)	(53540.89)	(10774.49)	(25.17)
Senior citizen>65yrs	-331068.4***	-70899.13**	-248716.1***	-11462.96	9.71
	(102045.5)	(29655.31)	(82682.87)	(16638.98)	(38.87)
Dependent ratio	-255225.5***	-43653.41*	-197410.3***	-14174.79	12.96
	(86336.64)	(25.90.18)	(69954.7)	(14077.58)	(32.88)
Female household head (dummy)	230077.7	41014.15	189266.5	-84.03	118.93*
	(179662.7)	(52211.54)	(145572.6)	(29294.81)	(68.44)
Off-farm wage rate	1530.79	-184.79	1873.88**	-121.88	-0.39
	(1075.79)	(312.63)	(871.67)	(175.41)	(0.41)
Constant	-121010.2	32281.68	-115334.7	-37900.46	-56.69
	(167283.7)	(48614.1)	(135542.5)	(27276.36)	(63.72)
Wald χ^2 (10)	240.05***	88.55***	102.58***	76.06***	144.33***
R^2 (overall)	0.10	0.07	0.08	0.11	0.14
No. of observations	529	529	529	529	529

Standard errors in parentheses. ***, **, * 1 percent, 5 percent and 10 percent significance level respectively.

Table 5.5: Instrumental variable Tobit estimation of total household work hours by gender

Explanatory variables	Men	Women	Pooled(both)
Per capita remittance income	-0.002**	-0.001**	-0.002***
	(0.007)	(0.0006)	(0.0006)
Per capita non labour income (excluding remittance income)	0.003**	0.0005*	0.0005***
	(0.001)	(0.0003)	(0.0002)
Age of individual	0.46***	-0.10	-0.20***
	(0.09)	(0.093)	(0.07)
Education level of the individual	2.29***	0.28	1.38***
	(0.44)	(0.42)	(0.33)
Ethnicity of Individual	0.13	0.02	0.05
	(0.10)	(0.11)	(0.09)
Number of children <6 years in household	-0.21	0.01	1.72
	(1.13)	(1.16)	(1.12)
Number of old person > 65 years in household	-3.42	-4.40*	-4.48**
	(3.05)	(2.53)	(1.12)
Household size	-0.63	-2.04	-2.06***
	(0.80)	(0.65)	(0.49)
Rural or urban	3.80	19.38***	13.88***
	(6.04)	(6.05)	(4.83)
Female head household	-1.63	15.26***	15.31***
	(7.08)	(5.69)	(4.58)
Constant	10.01	33.51***	22.40***
	(7.16)	(6.58)	(5.48)
Wald $\chi^2(10)$	83.36 ($P_{<0.000}$)	46.97 ($P_{<0.000}$)	49.83($P_{<0.000}$)
Wald test for exogeneity $(/\alpha = 0): \chi^2(1)$	5.18 ($P_{<0.022}$)	3.36($P_{<0.066}$)	10.99($P_{<0.000}$)
No. of individuals(16-65 years)	644	890	1534

***, **, * 1 percent, 5 percent and 10 percent significance level respectively.

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Introduction

Nepal, predominantly an agrarian country, has been operating under resource-constrained environments and with formidable mandates of reducing poverty and hunger, and has given high priority on agricultural-led growth. Despite a visible change in the political scenario over recent years, overall economic growth has not yet shown any significant change. Hence the country still needs a high rate of economic growth both in the agricultural and non-agricultural sectors. Policy markers and economists see the causes of economic stagnation in Nepal during the last decade as resulting from the decade long conflict between government and the rebellion group, combined with regional disparities in access to resources, pervasive poverty, and food insecurity. This vulnerability has affected many aspects of the economy, specifically unemployment due to limited opportunities that increase the intensity of migration from rural to urban areas and abroad, low productivity, due to reduction in investment on farm and off-farm sectors, price rises resulting from devaluation of the domestic currency, and a high trade deficit.

This dissertation is motivated by the need to understand how price volatility and remittance income affect household income and labour allocation decisions and the factors affecting the adoption of new farm technologies. The microeconomic foundation thesis is formed by the theory of household choice in the presence of incomplete and imperfect markets

After an introduction and literature review, which forms chapter 2, the dissertation consists of three substantive essays. The first chapter outlines the motivation and objectives of the dissertation, and describes the data sources employed. The second chapter reviews the literature, giving an overview of the role of factor markets in rural economies and the application of theoretical framework in rural policies, combined with brief outlook of existing literature, economic theories, and analytical approaches applied in resource poor economies. Chapter 3 examines the factors affecting the adoption decisions of new farm technologies, improved seeds and inorganic fertilizers in particular. The underlying assumption is that farmers take adoption decisions of improved seeds and inorganic fertilizers jointly. Chapter 4 investigates agricultural commodity price volatility and its impact on household income variability. The motivation for this part is to understand the Nepalese household responses in the context of the economic liberalization programs adopted consequent upon the country becoming a member of WTO. Finally, Chapter 5 examines the labour allocation of remittance-receiving households and factors motivating migration decisions. The flow of remittances during the last decade has increased rapidly and the impact of remittance income is obviously a matter of interest on labour allocation decisions of remittance-receiving households.

Sections 6.2-6.4 summarize the major findings of the three substantive essays which form Chapter 3, 4 and 5 of the thesis.

6.2 Summary and conclusions of Chapter 3

The first substantive part of the dissertation analyses the determinants of household's adoption decisions of new farm technologies, improved seeds and inorganic fertilizers in particular, using two year panel data from the Nepal Living Standard Surveys. This study assumes simultaneity decisions in adoption of both improved seeds and inorganic fertilizers in contrast to the conventional method that often deals technology (e.g., improved seeds, inorganic fertilizers and farm mechanization) adoption as independent decision to each other.

The assumption of joint decisions in new farm technology is plausible, particularly in developing countries where farmers are often constrained by labour and capital combined with poor infrastructure that affects timely distribution of improved seeds and chemical fertilizers. Decisions to adopt new technology may therefore depend on these constraints such as timely available of seeds and inorganic fertilizers, probability of obtaining credit, labour availability, and information about new technology rather than farmers' choice of any one technology. This study thus attempts to fill gaps in the literature, in particular in relation to Nepal.

This paper applies both reduced form probit models for period 1(1996) and LPM and GMM probit with moment restrictions for the second period in lieu of the bivariate probit to solve the identification problem. The paper also examines the adoption decisions of both technologies using both random effects and simple Tobit models from household level data in which the proportion of land using improved seeds and inorganic fertilizers is the dependent variable in the exercise. These models control plot characteristics, human capital, and market participation in order to explore the factors influencing adoption of improved seeds and inorganic fertilizers.

The results weekly support the assumption of joint decisions for both technologies. Adoption of improved seeds is more likely to be influenced by the adoption of inorganic fertilizers but apparently not vice versa. Adoption decisions are significantly influenced by the factor markets for credit and for labour, agricultural extension services, and household labour endowment. Moreover, adoption rates are likely to be high with the household proximity to road transport and access to markets. Household head's education and age also show positive impact on adoption decisions with some exceptions. The results from random effects and simple Tobit models are mostly in line with the results from reduced form and structural models with few exceptions. Conclusively, well-developed infrastructure along with smooth functioning of factor markets can significantly lead to adoption of new technologies.

These results have important policy implications. For instance, adoption of improved seeds is more likely to be associated with inorganic fertilizers, so that policy needs to address this issue while introducing new varieties of seeds. However, the reverse effect is not established, implying that adoption of inorganic fertilizers is not necessarily associated with improved seeds. In other words, this study only weakly supports the assumption of simultaneity decisions in adoption of both technologies and suggests instead a possible recursive structure. Moreover, well-developed infrastructure facilities with better road transport are prerequisites for the transformation of subsistence agriculture into commercialized in Nepal.

This analysis provides insights which will be useful in future studies in farm technology adoption in which adoption of single technology may not be a valid assumption particularly in the developing world due to pervasive market imperfections, leading farmers with many constrains such as labour and capital, access to markets, and information about new technologies. Economists need to address these issues while analyzing farmers' behaviour on technology adoption.

Though this study analyzes adoption of both technologies as joint decisions, further studies seems to be focused on the intensity of technology adoption over a period of time combined with the role of social learning in agricultural innovation and diffusions.

Plot level data for specific crops which additionally consider the role of gender may also provide better insights in technology adoption decisions in the developing world.

6.3 Summary and conclusions of Chapter 4

The second paper of the dissertation investigates how agricultural commodity price volatility influences the income variability of agricultural-dependent households in Nepal. This analysis is important in the context when the country has already implemented market economic policies and has become an LDC member of the World Trade Organization. In order to capture this idea, this paper applies a more recent analytical framework that allows to use both price and yield variations to calculate the household income variance, combined with the price transmission coefficients using VAR or autoregression models depending on whether the particular commodity tradable with the Indian markets, combined with statistical properties of the time series data. Cross-section data from the NLSS for the calculation of the share of agricultural income in the total household income and time series data of both prices and yields for transmission coefficients and variances were used to analysis in this paper. A number of scenarios such as full, actual and no exposures with Indian markets were assumed in order to explore the extend of impact on different ecological belts as well as administrative zones among the different levels of agricultural income share households in Nepal.

The results show a higher extent of variability of household income for household with a higher share of income from agricultural products (more than 65 percent), followed by 30 to 65 percent share of agricultural products in the total household income. However, there is no significant difference in CVs between poor and non-poor households. The result also shows increased income variability of agricultural households in almost regions and ecological belts, relatively higher due to domestic shocks. Geographical heterogeneity seems to be major factor affecting the domestic market integration with international prices. The results from the Granger causality test show higher integration of border markets between Nepal and India, in which most of Nepalese commodity prices follow Indian prices with an exception of a small number of commodities in few border markets.

The findings from this paper have significant policy implications. The results show that geographical heterogeneity, even in a country as small as Nepal, is a major problem for market integration. Nepal needs to emphasize domestic market integration through the investment on road transport, irrigation and infrastructure development that can reduce the geographical heterogeneity and the extent of price and production variability within the country in addition to integration with regional and world markets. The integration of domestic markets through investment in infrastructure would further enhance farmer's access to resources and lead to higher integration with regional and world markets. Market integration is therefore necessary to make food more easily available and to keep prices stable, because in well-integrated markets, price changes of comparable goods in one location are consistently related to price changes in other locations.

The methodology used in this study is relatively new approach to analyze the price volatility and its impact on agricultural household income instability, world in general and Nepal in particular. The study on the impact of Indian price volatility on Nepalese household income instability has a great importance for Nepal rather than the world markets due to largest trade partner and also the major transit providing country. The analysis of price transmission across adjacent cities of both countries (Nepal and India) is also a significant contribution in the literature that can provide market integration at different level among adjacent cities of both countries in comparison to single Indian market centre and the world markets. Moreover, the study on Indian and world price transmission in Nepal is itself great significant for newly WTO member state such as Nepal in order to analyze the impact of agricultural trade liberalization,

Further studies may be interesting to analyse income instability for cash and high value crops depending households (e.g. tea, tobacco, sugar, other vegetables). Price volatility of cash and high value crops may give better insights of price transmission and its impact on income stability due to more commercial crops in comparison to subsistence staple crops.

6.4 Summary and conclusions of Chapter 5

The flow of migration from rural to urban areas and abroad has increased over the past two decades as families seek improved living standards in the face of limited access to local employment opportunities. This phenomenon has been observed both in Nepal and throughout the developing world. In Nepal, migration has been further stimulated by political instability and conflict. Remittances earned by migrant workers have also significantly increased and become a major source of foreign exchange earnings in Nepal. The impact of remittance income on household welfare is a matter of interest for economists and policy makers.

This paper examines the labour allocation decisions of remittance-receiving households in different sectors such on-farm, off-farm, self-employment activities and hired labour by drawing the insights from the New Economics of Labour Migration (NELM). The theoretical approach of NELM assumes that migration decisions are made by larger units of related people – typically families or households-in which people act collectively not only to maximize expected income, but also to minimize risks and to loosen constraints associated with a variety of market failures in contrast to the neoclassical approach that assumes migration decisions as an individual phenomenon which is a response to the urban-rural differential in wages (or future earnings). The NELM also postulates that migration normally occurs due to incomplete or missing markets in the given area, in which labour allocation decision of remittance-receiving households (i.e. non migrant members) depends on the constraint (e.g. labour or liquidity) faced by the particular household. For example, liquidity constraint household may invest more on farm such as hiring labour hours. In the case of labour constraint, non migrant members may reallocate their labour hours back to on-farm to compensate their labour loss due to migration.

This paper first applies the zero inflated Poisson (ZIP) model to analyse the migration decisions and then used random effects instrumental variables regressions for estimating the impact of remittance income on household labour allocation in different sectors and instrumental variables Tobit models to estimate labour allocation decisions of remittance-receiving households separately for working age men and women and pooled of both men and women.

The results show that rural people with larger family size and higher per capita income without remittances are likely to emigrate. Remittances decrease work hours in a number sectors, but increases work hours of hired labour in remittance-receiving households. Remittance income seems as substitution of non-labour income for remittance-receiving households. No significant effects on off-farm and self-employment activities were observed in the sample households. In contrast, non labour income appears to increase work hours of household members. Moreover, demographic characteristics seem to be influential in the allocation of household work hours, implying that higher family size leads to higher work hours, and a larger number of children (<6 years) leads to a reduction of work hours of females and but not for males. Educated people are also more likely to increase their work hours when a family member migrates. The results from the Tobit models for men and women aged between 16-65 years in remittance-receiving households show that remittances increase the hours of leisure of individual members. However, individuals having higher non-labour income are more likely to increase their hours of work.

The study is helpful to understand the behaviour of remittance-receiving households on labour allocation decisions under the assumption of incomplete or missing markets. The analysis provides the insights how remittance-receiving households allocate labour hours in different sectors such as on-farm, off-farm, self employment activities, and hired labour under the presence of liquidity and labour constraints. The evidence provided can be useful for policy makers, in particular intra-household substitution and labour allocation decisions in different sectors. Labour allocation decisions may go through the income effects and the use of remittance income. The results from labour allocation decisions of remittance-receiving households can give insights on the functioning of labour markets in relation to changes in household income and wage rates as well as the preference of household members in the labour markets in different sectors such as on-farm, off-farm and self-employment.

The study on the impact of remittance income on household labour allocation is relatively new area of research in comparison to the migration. This paper intends to contribute in the literature of migration and labour allocation decisions by giving a detailed theoretical framework based on the agricultural household model under the assumption of both perfect markets and incomplete or missing markets. The paper also attempts to address a number of issues pertaining to the problem of endogeneity between labour hours, remittance and migration, sample selection bias, and omitted variables and applies a number of econometric models such as random effects instrumental variables regressions and instrumental variables Tobit models to control household level unobserved effects.

The study, though, provides the insights of labour allocation of remittance-receiving households; further research needs to focus on the impact of remittance income on different income level of households in different regions. The study on the return to scale in migration could be interesting by obtaining the detailed information about migrant characteristics.

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