途上国における貧困削減と制度・市場・政策
比較経済発展論の試み
Poverty Reduction, Institutions, Markets, and Policies in Developing Countries: Toward a Theory of Comparative Economic Development

PRIMCED Discussion Paper Series, No. 39

Dynamics of Household Assets and Income Shocks in the Long-run Process of Economic Development: The Case of Rural Pakistan

Takashi Kurosaki

March 2013(revised in April 2013)

Research Project **PRIMCED**
Institute of Economic Research
Hitotsubashi University
2-1 Naka, Kunitatchi Tokyo, 186-8601 Japan
http://www.ier.hit-u.ac.jp/primced/e-index.html

Hitotsubashi University

Dynamics of Household Assets and Income Shocks in the Long-run Process of Economic Development: The Case of Rural Pakistan[#]

This version: April 30, 2013
(Previous versions: April 15, 2013; March 17, 2013)

Takashi Kurosaki[*]

Abstract

In this paper, we analyze the dynamics of assets held by low-income households facing various types of income shocks in pre- and post-independence Pakistan. Focusing on the province of Khyber Pakhtunkhwa (formerly known as the North-West Frontier Province, NWFP), we first investigate the long-run data at the district level beginning from 1902. The results show that the population of livestock, the major asset of rural households, experienced a persistent decline after crop shocks due to droughts, but did not respond much to the Great Depression. In the post-independence period, crop agriculture continued to be vulnerable to natural disasters, although less substantially, while the response of livestock to such shocks was indiscernible from district-level data. To examine microeconomic mechanisms underlying such asset dynamics, we analyze a panel dataset collected from approximately 300 households in three villages in the NWFP during the late 1990s. The results show that the dynamics of household landholding and livestock is associated with a single long-run equilibrium. When human capital is included, the dynamics curve changes its shape but is not sufficiently nonlinear to produce statistically significant multiple equilibriums. The size of livestock holding was reduced in all villages hit by macroeconomic stagnation, while land depletion was reported only in a village with inferior access to markets. The patterns of asset dynamics ascertained from historical and contemporary analyses are consistent with limited but improving access to consumption smoothing measures in the study region over the century.

JEL classification codes: O13, O44, N55

Keywords: asset dynamics, natural disaster, buffer stock, poverty trap, Pakistan.

[#]The author would like to thank Natalie Chun, S. Hirashima, Charles Horioka, Masahiro Kawai, Yukinobu Kitamura, Motoi Kusadokoro, Ken Miura, Tetsuji Okazaki, Hiroshi Sato, Masahiro Shoji, Koji Yamazaki, and Yoshifumi Usami for their productive comments on the earlier versions of this paper. The author is also grateful for their useful comments to other participants at the 2012 Asian Historical Economics Conference (Tokyo, September 2012), the Asian Development Review Conference on Development Issues in Asia (Manila, November 2012), and the Kansai Research Group on Development Microeconomcis (Osaka, April 2013). All remaining errors are the author's. This paper has been funded by a JSPS Grant-in-Aid for Scientific Research-S (22223003).

[*]Institute of Economic Research, Hitotsubashi University, 2-1 Naka, Kunitachi, Tokyo 186-8603, Japan. Phone: +81-42-580-8363; Fax: +81-42-580-8333; E-mail: kurosaki@ier.hit-u.ac.jp.

1. Introduction

Natural and manmade disasters, such as floods, droughts, earthquakes, depressions, hyperinflation, epidemics, etc., have affected the local and household economy worldwide and throughout modern history. Households in contemporary, low-income developing countries are particularly vulnerable for several reasons. First, their initial welfare levels are already close to the poverty line. Second, institutional arrangements to cope with disasters are lacking. Third, early warning systems are absent. Similar reasons are applicable to households in developed countries before the countries experienced modern economic growth. This is because of the presence of numerous symptoms associated with absolute poverty in such economies. To compound issues, according to the emergency events database (EM-DAT), there appears to be an increase in the number of natural disasters globally—from fewer than 100 per year in the mid-1970s to approximately 400 per year during the 2000s.[1]

Thus, it is of critical importance to understand how households are affected by such disasters, how they recover from them, and how policies and market environments affect the dynamic process of recovery in the context of long-run economic development. Under incomplete markets, particularly with underdeveloped credit markets and missing insurance markets, poor households need to save as a precaution against downturn risk such as natural and manmade disasters. As a result, the asset choices of poor households may be excessively sensitive to risk avoidance, thereby causing them to miss the opportunity to enhance expected income. In development economics, there are numerous theoretical and empirical studies that focus on households' ability to cope with these shocks (Fafchamps, 2003; Dercon, 2005). Furthermore, if the asset dynamics is highly nonlinear, associated with low and high long-run equilibriums, farmers may reduce consumption substantially after a disaster to preserve the asset and avoid a low equilibrium (Carter and Barrett, 2006). In an extreme case, households may find themselves in a poverty trap in the aftermath of disasters. These theoretical predictions have been investigated quantitatively for several developing countries, but there is no consensus regarding the shape of the asset dynamics curve.[2] Among recent studies, McKay and Perge (2011) tested for evidence of the existence of an asset-based poverty trap mechanism across seven panel datasets in developing countries; however, they did not find evidence for this mechanism.

In contrast, the number of quantitative analyses on asset dynamics applied to historical contexts is small, mostly due to the nonavailability of suitable data. As an exception, the case of

[1]Available on http://www.emdat.be/natural-disasters-trends (accessed on October 20, 2012). It is possible that the reported increase is partially due to an increased tendency to report, not necessarily an increase in the occurrence of disasters.

[2]For example, see Naschold (2005), Adato et al. (2006), Carter et al. (2007), Mogues (2011), McKay and Perge (2011), and Miura et al. (2012).

prewar Japanese farmers has been analyzed in several studies. For example, Kusadokoro et al. (2012) analyzed the asset accumulation behavior of farm households in rural Japan using panel data from 1931 to 1941, the years of reconstruction following the Great Depression. They showed that households accumulated liquid assets such as cash, quasi-money, livestock animals, and in-kind stocks, thereby suggesting the existence of a precautionary saving motive. Analyzing the same period but with a different data source, Fujie and Senda (2011) showed that farm households maintained the amount of arable land, increased the nonfarm labor supply, and decreased the use of fertilizer in response to the depression. They indicated that the aggregate shocks from the Great Depression led to the stagnation of agricultural growth in Japan. Both these studies applied microeconometric approaches similar to those reviewed in the previous paragraph. Since the data requirement is high, application of these approaches to other historical cases is not straightforward.

In this paper, we attempt to fill these gaps in the literature by combining empirical analyses using long-run historical data at the macro or semi-macro levels and contemporary data collected at the household level. This analysis focuses on the province of Khyber Pakhtunkhwa (formerly known as the North-West Frontier Province, the NWFP),[3] Pakistan. Using these different data sources, we address the question of how assets—particularly livestock, which is the core asset in the study area—respond to natural and manmade disasters.

We use long-run historical (semi-) macro data, combined with data from historical reports prepared by the government, to speculate on the microeconomic mechanism underlying the asset dynamics in response to natural and manmade disasters. Then, contemporary household-level data are used to shed light on the speculation from a different angle. The micro panel data used for the contemporary analysis were collected from approximately 300 households in three villages during the late 1990s, the period associated with overall macroeconomic stagnation and not with major natural disasters. Using the household panel data, we examine the shape of the asset dynamics curve using both nonparametric and parametric analyses. We employ the parametric analysis to also examine how each type of assets responded to village-level and idiosyncratic shocks. Thus, the major contribution of this paper is to demonstrate the complementarity of using both historical and contemporary analyses in understanding household vulnerability and resilience in the context of long-run economic development. To the best of our knowledge, there is no attempt in the literature to combine these two types of data in the manner adopted in this study.

The remainder of this paper is organized as follows. In Section 2, we review the microeconomic literature related to this study and outline our empirical methodology. In Section

[3] Khyber Pakhtunkhwa is one of the four provinces that comprise Pakistan. In April 2010, the constitution of Pakistan was amended and the former NWFP was renamed Khyber Pakhtunkhwa. In this paper, we call the province NWFP since most of the data were taken under this name.

3, we describe the rural NWFP economy with a focus on assets and livelihood. Given this background, in Section 4, we provide a descriptive analysis on long-run changes using district-and province-level data on crop production and livestock. In Section 5, we examine the two-period panel data collected during the late 1990s. In Section 6, we provide our interpretation combining the two types of analysis. In Section 7, we present the conclusion.

2. Literature and Analytical Framework

The empirical analysis in this paper is motivated by two strands of development economics literature. The first strand is the consumption smoothing literature focusing on low-income households' ability to cope with exogenous shocks (Fafchamps, 2003; Dercon, 2005). These studies have shown that poor households are likely to suffer not only from low levels of welfare on average but also from fluctuations in their welfare due to their limited coping ability. The inability of households to avoid declines in welfare can be called vulnerability. Currently, there is a substantial amount of literature on the measurement of vulnerability (Ligon and Schechter, 2003; Dercon, 2005; Kurosaki, 2006; Dutta et al., 2010). In developing countries, studies on household vulnerability found that the ability to avoid declines in welfare improves with an increase in the amount of assets, which can be used as a buffer.

The other strand of literature is related to the asset poverty trap hypothesis by Carter and Barrett (2006). In the standard consumer theory of assets as a buffer (Deaton, 1992), the next period's asset is a linear function of the current period's asset multiplied by the factor of one plus real interest rate minus depreciation rate. Under this condition, assets can be used to smooth consumption in response to income shocks. In this framework, a disaster that partially damages assets can be interpreted as an unexpected and transient increase in the depreciation rate. However, in the context of low-income developing countries, the asset dynamics may be nonlinear. Suppose the expected value of an asset in the next period is an S-shaped function of the initial asset with three intersections with a 45-degree line (Figure 1). Then, the long-run dynamics of assets is characterized by the middle and unstable equilibrium (called the Micawber threshold, A^* in Figure 1) and two stable equilibriums. The lower of the two stable equilibriums (A^*_L in Figure 1) corresponds to the poverty trap if the welfare level associated with this level of assets is below or around the poverty line. Given the existence of multiple equilibriums, Carter and Barrett (2006) argue that only those households well above the Micawber threshold can afford to use assets as a buffer to smooth consumption. Further, they argue that those households that are close to the Micawber threshold, when hit by a negative income shock, may rationally attempt to protect their assets to avoid falling into the asset poverty trap instead of selling assets to smooth consumption. Therefore, we may observe asset smoothing behavior, instead of consumption smoothing behavior, in such cases.

<Insert Figure 1 here>

Although empirical support for it is mixed,[4] the concept of the Micawber threshold is an attractive one. Even when the Micawber threshold is not found, the shape of the asset dynamics curve and the location of the equilibrium(s) are informative for understanding household response to shocks. Therefore, in Section 5 of this paper, we estimate asset dynamics curves for several types of assets using both nonparametric and parametric analyses. The parametric analysis also enables us to identify the impact of exogenous shocks on asset changes. Such shocks may include permanent and transient shocks on the one hand and aggregate and idiosyncratic shocks on the other.

This type of analysis is usually conducted using micro panel data of households in developing countries, in isolation from historical (semi-) macro data. The analysis presented in Section 5 of this paper follows this tradition.

However, this paper claims that by combining a microeconometric analysis with a historical one, we can benefit from complementarity. To show this, before the microeconometric analysis, we provide a descriptive analysis on long-run changes using district- and province-level data on livestock assets in Section 4.

If the asset poverty trap hypothesis describes the data better, an exogenous shock that destroys the assets of the majority of households should have a persistent impact. The persistence could possibly lead to an overall decline in the number of the assets in the district in the long run. On the other hand, if asset returns are linear and the assets are used as a buffer, such a shock should have only a temporary impact and the economy should eventually revert to the initial trend. When the exogenous shock destroys the assets of the majority of households, however, the reversion to the initial trend may take time even under the buffer stock hypothesis so that empirically distinguishing the two hypotheses could be difficult.

The theoretical prediction regarding the impact of an exogenous shock that decreases the income of the majority of households but does not directly affect household assets also differs between the two hypotheses. Under the poverty trap hypothesis, the size of assets is not affected much by such a shock while the size of assets reduces according to the buffer stock hypothesis. When the impact of such an exogenous shock on household income is heterogeneous, however, the shock may not affect the aggregate asset level even under the buffer stock hypothesis due to the cancel out. As a result, empirically distinguishing the two hypotheses could be difficult.

Whether a specific type of assets, such as livestock, is used more as a buffer or as productive capital as compared to other types of assets depends on the availability of other consumption smoothing measures and agricultural technology (for example, the substitutability

[4]See studies listed in footnote 2.

of draft animals in farm production). In the next section (Section 3), we describe the means of livelihood in the rural NWFP economy, which focuses on assets and agricultural technology. Combining the information in Section 3 and the theoretical predictions mentioned above, Section 4 provides a descriptive analysis based on historical data on livestock.

Then, in Section 6, we attempt to combine the two types of analysis. First, we interpret the microeconometric results presented in Section 5 from the historical perspective. Then, we re-examine the historical pattern based on the microeconometric findings. Since it is advantageous to have historical semi-macro data that cover the period both before and after the micro panel survey of households, we employ a panel dataset collected a while ago (i.e., during the 1990s). As the panel survey was carefully designed to choose villages that differed in terms of the level of economic development (see Subsection 5.1), the between-village contrast found in the microeconometric analysis can be aligned with long-run changes observed in the historical data.

3. The Study Area

Economic development in South Asia is characterized by moderate success in economic growth and substantial failure in human development such as basic health, education, and gender equality (Drèze and Sen, 1995). This characteristic is most apparent in the NWFP. Furthermore, the scope for economic growth based on crop agriculture is limited since the province is land-scarce and crop production is more risky than in other parts of Pakistan due to low development of irrigation. These additional hardships make the NWFP case study an interesting one to investigate the relationship between asset dynamics and disasters.

3.1. Rural livelihood and the role of livestock

The NWFP as a whole is a rural province. According to the latest population census conducted in 1998, 83% of its population lived in rural areas (Government of Pakistan, 2012). The majority of rural residents were engaged in agriculture, both crop cultivation and animal husbandry. However, since the late 1980s, employment in the nonagricultural sector has been growing. Two types of nonagricultural activities are noteworthy: short-term migration (both domestic and foreign) and rural nonagricultural activities in villages. In both types, semi-skilled work such as transport and construction work dominates in terms of employment creation. The availability of skilled or professional jobs has been limited in the province, although it has been increasing gradually in recent years. Further, the average household size is larger than in other parts of Pakistan, partly reflecting the norm of the Pakhtun—the ethnic majority of people in the NWFP—who highly respect family-based reciprocity and bravery in defending their land, property, family, and women from incursions, etc. (Ahmed, 1980).

The major crops in the NWFP are wheat in the *rabi* (winter) season and maize in the *kharif* (monsoon) season. Both these crops are cultivated as staple food, although large farmers tend to sell the surplus to the market. Sugarcane is the most important cash crop. Further, fodder crops to feed livestock animals also occupy a significant share of cropped land in both *kharif* and *rabi* seasons.

A particular mention must be made of the role of livestock. Most farmers in NWFP are engaged in mixed farming, combining livestock raising and crop cultivation on a single farm. Large livestock animals include cows and female buffaloes for milk. Bullocks were once an important productive asset used for plowing and transportation. However, tractors gradually replaced draft animals, thereby decreasing the role of livestock as draft animals.[5] As shown in the next section, the livestock portfolio in the NWFP has been changing from draft to milk animals. Small livestock animals, such as goats, sheep, and poultry, are common means of saving. This implies several interactions between crop farming and livestock husbandry in the study area (Kurosaki, 1995). The direct interactions can be explained in the following manner: fodder crops and dry fodder (e.g., grain straws) are fed to animals, animal excrements are processed into farmyard manure used in crop cultivation, draft animals are used in plowing and crop transportation, and crop rotations including leguminous fodder crops improve the soil fertility. The indirect interactions between the livestock sector and crop farming through the household economy can be explained in the following manner: milk animals provide milk for consumption and cash from selling surplus milk, family labor is utilized throughout the year for taking care of animals, and livestock as a liquid form of assets can be used as buffer in a bad year. In the following sections, we analyze how these complicated interactions result in a reduced-form relation between asset dynamics and disasters (identifying each of these interactions is beyond the scope of this paper).

The direct interactions mentioned above are relevant only for households that operate farmland for crop cultivation ("farm households" below).[6] However, the abovementioned indirect interactions are important for nonfarm households as well. The income sources of nonfarm households could include livestock activities, nonagricultural activities, net rental receipt, transfers, etc.

This implies that in the study area, agricultural assets (land and livestock) are the key assets that constitute rural livelihood. It also implies that human capital (the size of labor force, education, etc.) and transport/agricultural equipment (such as tractors, vehicles, etc.) are also assuming importance. In Section 5, all these assets will be included in the microeconometric

[5]As the tractor service rental market is well developed, the majority of farmers who use tractors for land preparation do not own a tractor.

[6]Because of a social distinction between land-operating households and others in Pakistan (Hirashima, 2008), we employ the standard categorization in which such households are called "farm households."

analysis. Because of data availability, the historical analysis in Section 4 focuses on livestock animals since they were and are the most important asset that supported/supports the livelihood of both farm and nonfarm households.

3.2. The NWFP during the colonial period and the change after independence

In October 1901, the British government carved out the NWFP out of Punjab as a separate province. The word "Frontier" in the name implied the frontier against Russian influence. As one of the British provinces of the Indian Empire, the NWFP was divided into districts for the purpose of its administration. During the colonial period, there were five districts (Hazara, Peshawar, Kohat, Bannu, and Dera Ismail Khan) until 1937, when a new district of Mardan was carved out of Peshawar District.

Under the British rule in the NWFP, the property right of land was established in which the ownership right was given to cultivators, as was the case in Punjab (Khalid, 1998). The cultivators included village-based landlords who operated a part of their land and rented out the remainder. During the colonial period, social development such as education was highly limited in the province, while infrastructure development such as roads and irrigation canals progressed gradually. The British rule respected the local norm of self-governance in the NWFP, particularly the institution called *jirga*—an assembly of elders taking decisions by consensus (Ahmad, 1980)—as long as such decisions did not violate British rulings. Agricultural innovation such as the introduction of chemical fertilizers and improved methods of cultivation was also facilitated in the province, although at a slower pace than in the post-independence period. For example, systematic agricultural research began in the NWFP in 1908 at a government research institute at Tarnab, Peshawar District. Furthermore, the colonial government introduced a modern credit facility for farmers called *taccavi* loans. However, the credit facility was not utilized by the majority of farmers due to the limited access and high requirement of land collaterals; informal credit prevailed in villages (Malik, 1999).

Pakistan and India obtained independence from the British in August 1947 (the so-called Partition of the Indian Subcontinent). The NWFP belonged to the new state of Pakistan. The basic administrative structure remained intact and the list of six NWFP districts remained the same until 1970; however, since then, the subdivision of districts has continued due to the growth in population. At the end of 2012, there were 25 districts in Khyber Pakhtunkhwa. The household surveys analyzed in Section 5 were conducted in the current district of Peshawar.

After independence, the pace of public investment in infrastructure and agricultural innovation was accelerated. At the time of Partition, the percentage of cultivated area with irrigation was 38% in the NWFP; after 50 years, the corresponding figure was 50%. The Green

Revolution technology of wheat was introduced to the province in the late 1960s. The land property institutions remained more or less the same; laws and regulations related to land reforms were enacted to put ceilings on land holdings, but they did not have much impact in the province as the number of large landlords was small (Khalid, 1998). Further, in the post-independence period, government credit for agricultural production was expanded—for example, the Agricultural Development Bank of Pakistan was established in 1961. Nevertheless, the dependence of rural households on informal credit continued, partly because of the Islamic norm of banning interest payment and partly due to the limited resources in the public sector (Malik, 1999).

4. District- and Province-Level Analysis of Crop Production and Livestock

Given the background in the previous section, this section conducts long-run historical analysis using district-and province-level data on crop production and livestock. Province-level data indicates data aggregated at the NWFP and regarded as the macro level. We regard each district as a semi-macro level. The analysis in this section is descriptive in nature. First, we examine the time series plots for crop production and livestock and extract statements from government reports. Then, we interpret the descriptive results based on theoretical predictions that were summarized in Section 2.

4.1. Data

Considering the changes in district borders described in the previous section, we adopted the following geographical demarcation. For the colonial period, we compiled a balanced panel dataset of five districts (after 1937, data for Peshawar and Mardan were merged to form the initial district of Peshawar). For the post-colonial period, we compiled a balanced panel dataset of six districts (Hazara, Peshawar, Mardan, Kohat, Bannu, and Dera Ismail Khan) that correspond to the district borders at the time of Partition.

Original data sources and the data compilation procedure are the same as those adopted in the author's ongoing attempt for constructing long-term agricultural statistics for South Asia under the Asian Historical Statistics Project at Hitotsubashi University, Tokyo (Kurosaki, 2003; 2011). For the colonial period, various issues of *Season and Crop Reports* published by the NWFP Government were used as the main data source. The first issue was published for the agricultural year 1902/03[7] and the last for the agricultural year of 1944/45.

[7]"1902/03" refers to the period beginning on July 1, 1902, and ending on June 30, 1903. It covers *kharif* crops sown in mid-1902 and harvested in the later months of 1902, *rabi* crops sown in late 1902 and harvested in April-June 1903, and sugarcane harvested in late 1902 to early 1903. In figures with limited space, this period is represented as "1903." In Pakistan, a fiscal year constitutes the same period: from July 1 to June 30 the next year.

Each *Season and Crop Report* presents an overview of the concerned year with regard to rainfall, agriculture, and the rural economy,[8] with statistical tables at the district level. From this source, we compiled district and province-level annual data of areas under crops and output of major crops.[9] The same source reports statistical tables for the district-level agricultural stock (livestock, plows, etc.) based on quinquennial livestock census. Thus, we obtained livestock information for the years 1903, 1904, 1909, 1914, 1920, 1925, 1930, 1935, 1940, and 1945. When compiling the dataset, typographical errors were corrected and definitional changes were adjusted to improve comparability across years.

The data source for the post-colonial period is the official statistics compiled by the Government of Pakistan (*Crops Area Production by Districts* and *Pakistan Livestock Census*—the names differ slightly depending on the publication year). Regarding the district-level crop data, the first year for which data was available was 1947/48. Therefore, a data gap of two years exists between the pre- and post-1947 periods. Since then, annual data on crop production are available at the district level. After Partition, district-level livestock data have been available less frequently than during the colonial period—there are only six observations taken from the Agricultural Census (1960 and 1972) and Livestock Census (1976, 1986, 1996, and 2006).

Three types of crop variables are investigated to infer the shocks that occurred in the crop sector. First, since the area sown with major crops declines if the monsoon rainfall is less than normal, we investigate the total area sown with *kharif* crops (*kharif_a*), the total area sown with *rabi* crops (*rabi_a*), and the total area sown with wheat (*wheat_a*) for the pre-independence period; further, we investigate the area sown with maize (*maize_a*) and *wheat_a* for the post-independence period.[10] Second, as yield per acre is affected by natural disasters such as droughts, floods, and hailstorms, we investigate the per-acre yield of wheat (*wheat_y*) and per-acre yield of maize (*maize_y*). Since per-acre yield information is not available for the early part of the colonial period, this investigation is only for the post-independence period. Third, as a direct measure of crop production shocks, we investigate the total area of failed crops (*fail_a*). Since the information on *fail_a* is not available for the post-independence period, reflecting the negligible areas under this category, this investigation only pertains to the pre-independence period.

We associate changes in these crop variables with changes in the population of livestock animals, which are the major assets of rural households in the NWFP. The livestock

[8]The sections in *Season and Crop Reports* on "agricultural stock," "agricultural deterioration," and "condition of agricultural population" are particularly useful for understanding shocks that occurred during the year. Unfortunately, comparable information is not available for the post-colonial period.
[9]The information on the output of major crops became available from 1906/07 onward.
[10]The reason for the difference is the unreliability of maize data in the pre-independence period and the inconsistency in reporting the total *kharif* area in the post-independence period.

variables analyzed include the number of adult bulls and bullocks (*bull*), adult cows (*cow*), and adult she-buffaloes (*buf_f*).[11]

4.2. Impacts of disasters before independence

Figure 2 plots the time series of crop production and livestock population for the colonial period. Panel A shows the provincial result. First, there was no long-run trend in crop production and livestock population. This is in sharp contrast to the Punjab area of Pakistan before Partition, where there was sustained agricultural growth (Kurosaki, 2003). Since there was population growth in the NWFP during the first half of the century,[12] the relative stagnation of agriculture in this area implied that its dependence on agriculture in Punjab for food increased. Second, crop production fluctuated substantially from year to year. Third, area fluctuations in *kharif* crops and in wheat were not synchronized. In certain years, only one of the two experienced a fall while the other experienced a rise; in other years, both of them moved in the same direction. Fourth, livestock population experienced an increase until 1914, then declined in two subsequent censuses in 1920 and 1925, after which the population remained stable. The figure clearly suggests that the agricultural year 1920/21 was a particularly bad year, followed by a substantial decline in the livestock population. From 1920 to 25, the population of adult bulls and bullocks (*bull*) in the NWFP declined by 5.4%, adult cows (*cow*) by 5.3%, and adult she-buffaloes (*buf_f*) by 9.3%.

<Insert Figure 2 here>

The time series plot for Peshawar District (Figure 2, panel B) is similar to that for the entire province. Of particular importance are the decline in the livestock population from 1920 to 1925 and a substantial crop production shock in 1920/21. The similarity in the time series plot is expected since the colonial district of Peshawar was the most important district in the NWFP in terms of agriculture, accounting for approximately one-third of the cropped areas in the entire province and the extent of spatial specialization was weak due to lack of infrastructure and low level of urbanization. On the other hand, a notable difference in panel B from panel A is the trends after the mid 1920s. With years around 1925 at the bottom, cropped areas and the livestock population in Peshawar District grew gradually since then until the year of independence, while the crop failure rate was on the decline. This could be attributable to agricultural innovation facilitated by systematic agricultural research.

From *Season and Crop Reports*, we extract below several statements regarding

[11]Since a more detailed classification of animals is available after Partition and the distinction among animals according to purpose is important in the study area, we use adult bullocks used as *draft animals*, adult cows *in milk*, and adult she-buffaloes *in milk* after Partition. Therefore, the absolute level of livestock population is not comparable between pre- and post- independence periods.

[12]The population of the NWFP districts grew from 2.04 million in the 1901 Census to 3.25 million in the 1951 Census. The corresponding figure in the 1998 Census was 13.48 million.

agriculture in the NWFP. For example, with regard to the livestock decline in 1920, “The recent cattle census [February 1920] came at rather an unfortunate time following, as it did, a year of war and frontier disturbances, and also a severe season of drought (in the barani [rain-fed] tracts) in 1918. Widespread epidemics of cattle disease followed which the already greatly debilitated stock was unable to withstand” (p.5, the 1919/20 edition, brackets added by the author). Regarding the livestock decline in 1925, “Bulls, cows and cow-buffaloes decreased by 6, 2 and 9 per cent, respectively. The drought of 1920–22 and consequent scarcity of fodder, cattle diseases and plague, which prevailed more or less in all districts during the period under report, were mainly responsible for this” (p.7, the 1924/25 edition). In sharp contrast, we find no such statements for other years.

With regard to the interaction between crop and livestock sectors, notable descriptions in the NWFP *Season and Crop Reports* include the following. “Two poor harvests (except in the Hazara District) combined with a very serious epidemic in the autumn [Spanish flu] have occasioned a passing check to agricultural prosperity” (p.5, the 1918/19 edition). “The abnormally severe drought experienced during the year under report has been a great trial to the agricultural population who have had to dispose of their plough cattle in many tracts in order to raise money to buy food. Seed stocks have mostly been consumed as food... The condition of the agricultural population was generally very unsatisfactory throughout the Province as both the Kharif and Rabi harvests were poor and the supply of water and fodder was insufficient on account of prolonged drought” (pp.5-6, the 1920/21 edition).

There are also statements regarding natural disasters other than droughts, for example, regarding hailstorms and floods. With regard to floods, all the statements found in the reports (p.2, 1903/04; p.2, 1908/09; pp.1-2, 1910/11; p.6, 1921/22) are related to local floods that affected only a particular portion within a district. This is in sharp contrast to the nation-wide floods that hit Pakistan in July–August 2010 (Kurosaki and Khan, 2011). Moreover, we were unable to find a statement in which the livestock population was associated with crop shocks due to hailstorms and floods.

Further, with regard to the Great Depression, the most detailed description is given in the 1930/31 edition: “The fall in prices and the resulting contraction in the credit of the cultivator, the repression in trade and the shortage of money—all aspects of the same phenomenon—have caused the greatest inconvenience to the agricultural community in the Peshawar District where money has to be raised to pay cash rents and Government dues particularly for water-rate. The result is that very large arrears are outstanding in spite of the general remissions and reductions designed to counter the fall in prices” (p.9). Similar but shorter statements were found in the following years’ reports, until 1938/39. However, it is difficult to find the impact of the depression in Figure 2 on crops or livestock. The absence of

the impact on crops could be due to the difficulty in cleanly designating the year(s) of the disaster or due to the indirect nature of the disaster's impact on crop production.

4.3. Crop production and livestock population after independence

Figure 3 plots the time-series of areas and per-acre yield of wheat and maize. It also plots the livestock population found in six agricultural/livestock censuses after independence. Panel A presents the provincial result. First, all four time series for crops show sustained and continuous growth. This is similar to the case of Punjab Province after Partition (Kurosaki, 2003). Second, crop production fluctuated from year to year. However, significant reductions are less frequently observed after Partition than before Partition, except for a sudden drop in per-acre yield of wheat in 2000/01. In 2010/11, when unprecedented floods hit Pakistan (Kurosaki and Khan, 2011), the maize area was not affected since the crop was already sown when floods came, but the maize yield was adversely affected (direct effect of floods); moreover, the wheat area was also adversely affected (due to farmers' preoccupation with reconstruction and floods' destruction of irrigation and other facilities), but wheat yield improved since floods fertilized the soil. Overall, the impact of the 2010 floods does not seem substantial from the macro viewpoint regarding crops. Third, two trends are evident in livestock population: a continuous decrease in the number of bullocks and a continuous increase in the number of cows and she-buffaloes in milk. As data are available only for six years with ten-year intervals on average, it is not possible to examine how the livestock population responded to crop shocks in the short- to medium-run. However, the figure clearly shows that there has been no discernible instance of livestock damage due to crop shocks that has persisted for over a decade.

<Insert Figure 3 here>

The time series plot for Peshawar District (Figure 3, panel B) is rather different from that for the entire province. The major difference is that in Peshawar, sustained growth is observed in the per-acre yield of wheat only. The area under wheat, area under maize, and per-acre yield of maize have been stagnant since the early 1970s. During the post-independence period, there was growth in spatial specialization owing to the development of infrastructure and cities. As a result, agriculture in Peshawar has undergone transformation to include high-value activities such as horticulture, plant nursery, and livestock husbandry. Because of this, the shape of the time series plot in Peshawar District after independence deviates from that at the provincial level. On the other hand, the improvement in per-acre yield of wheat in the late 1970s was substantial (the late arrival of the Green Revolution). From the data depicted in Figure 3, we were not able to find years when most crop-related variables show a substantial fall. Regarding the livestock population, trends similar to the provincial ones are observed in Peshawar District also, with steeper slopes for the decrease in the number of bullocks. Thus, the

diversification toward milk animals in Peshawar District occurred at a faster pace than at the provincial level.

4.4. Interpreting the historical patterns in assets from the viewpoint of microeconomics

The descriptive analysis presented above showed that agriculture in the NWFP, particularly before Partition, was affected by several natural disasters, mostly droughts, which led to a decline in the livestock population that persisted for over five years. On the other hand, such persistent declines in the livestock population were not observed in district-level data after independence. This indicates that during the post-1947 period, persistent declines in the livestock population due to such shocks have been avoided in the NWFP. In this subsection, we provide a speculative interpretation of this contrast based on the theoretical predictions summarized in Section 2.

The pre-independence observations could be consistent with both the asset poverty trap hypothesis and the buffer stock hypothesis. The descriptive analysis showed that in 1920/21, natural disasters damaged the livestock population (which already suffered from small disasters in the preceding years) so intensively that the livestock population level did not recover to the 1920 level even in 1925. The persistence of the damage could be more consistent with predictions under the poverty trap hypothesis than under the buffer stock hypothesis. However, as the droughts killed a number of animals directly, the recovery to the initial trend could have taken a long time even under the buffer stock hypothesis. A statement from the 1920/21 Season and Crops Report quoted above ("agricultural population ... had to dispose of their plough cattle in many tracts in order to raise money to buy food") also supports the view that livestock were used as buffer.

The descriptive analysis also showed that the Great Depression did not affect the trends in the livestock population. This could be interpreted under the poverty trap hypothesis as the absence of direct impact of the shocks on assets; this could be interpreted under the buffer stock hypothesis as that the income shocks were heterogeneous among households so that some farmers sold livestock to cope with the negative shocks while others purchased them, resulting in non-response of the livestock population at the district level.

The post-independence observations seem more consistent with the buffer stock hypothesis than with the poverty trap hypothesis. The descriptive analysis showed the absence of persistent declines in the livestock population despite several instances of crop shocks that should have reduced the livestock population directly in the short run. If assets returns are almost linear and the assets are used as a buffer, such a shock would have only a temporary impact and the economy would revert quickly to the initial trend. This theoretical prediction is consistent with Figure 3, as it does not show any disturbance in the trends in the livestock

population. However, this observation could also be consistent with the poverty trap hypothesis with non-linear asset returns, if farmers had sufficiently diversified portfolios so that several instances of crop shocks shown in Figure 3 did not actually reduce the livestock population substantially. Unfortunately, the unavailability of more frequent and/or more disaggregated data on the livestock population does not allow us to explore this possibility further.

The historical description of the study areas in Section 3 could provide another support to the interpretation that the post-independence livestock dynamics was more consistent with the buffer stock hypothesis. As shown in Section 3, the post-independence period was characterized by better infrastructure, more availability of formal credit in villages, and agricultural technology where draft animals were substitutable with tractor services. Our speculation is that the combination of the changing agricultural technology and better opportunities for villagers to spread risk across and within villages was responsible for the contrast between pre- and post- independence periods.

5. Household-Level Asset Dynamics in the Period 1996–99

Although suggestive, the empirical results given in the previous section were at the aggregate level, not indicative of the asset dynamics at the household level. The speculations discussed above need to be supplemented by micro-level evidence. Therefore, in this section, we examine the dynamics using a detailed panel dataset of households collected from three villages in Peshawar District during the late 1990s.

5.1. Data

The panel dataset was compiled from the baseline survey conducted in the fiscal year 1996/97 and the resurvey conducted three years later (Kurosaki, 2006; Kurosaki and Khan, 2006).[13] The baseline survey covered 355 households, randomly chosen from three villages in Peshawar District. Sample villages were chosen purposefully so that they would be similar in terms of size, historical background, and tenancy structure, but different in irrigation level and access to the main market (Peshawar, the provincial capital of NWFP). The intention for this method of choosing villages was to infer long-run development implications by comparing the three villages. Using a detailed questionnaire, information was collected on household roster, agricultural production (corresponding to the agricultural year of 1995/96), employment, assets, etc. We call this the 1996 survey. The resurvey conducted three years after collected crop information for the agricultural year 1998/99. We call this the 1999 survey. Out of 355 households surveyed in 1996, 304 households were resurveyed successfully. Among those

[13]In existing papers using the same dataset, including Kurosaki (2006) and Kurosaki and Khan (2006), the dynamics of assets has not yet been analyzed.

resurveyed, three were divided into multiple households and two had incomplete information on consumption. Therefore, a balanced panel dataset of 299 households with two periods was utilized for the analysis.[14] After the 1999 survey, the author re-visited the villages several times, observing changes in a casual manner.

Table 1 summarizes the characteristics of sample villages and households. Village A is rain-fed and is located at a considerable distance from the main roads, serving as an example of the least developed villages. Village C is fully irrigated and is located close to a national highway, serving as an example of the most developed villages. Village B is in between Villages A and C. The average household sizes are larger in Village A than in Villages B and C, thereby reflecting the stronger prevalence of an extended family system in the village. Average landholding sizes in acres are also larger in Village A than in Villages B and C. Since the productivity of purely rain-fed land is substantially lower than that of irrigated land, effective landholding sizes are comparable among the three villages, as shown in the statistics for per-capita values of land assets in Table 1. Household income and consumption were calculated by including the imputed values of non-marketed transactions. Average income and consumption per capita are lowest in Village A and highest in Village C, which is in line with our survey objective of selecting villages with different levels of economic development. In terms of education, Village C had higher achievement levels than the other two villages. As shown in Kurosaki and Hussain (1999), in 1996, nonagricultural income constituted a larger share in the total household income than agricultural income regardless of the land operation status of households in all three villages. In all three villages, nonagricultural, unskilled wage work accounted for approximately one-third of household income. Among other nonagricultural sources, migration income was important in Village A, while self-employed business was important in Village C. Self-employment income from livestock activities accounted for approximately 10% of the household income, including nonfarm households.

<Insert Table 1 here>

As shown in Table 1, the average household income per capita declined substantially from 1996 to 1999. This was mostly due to the macroeconomic stagnation of Pakistan's economy associated with political turmoil, which affected the NWFP's economy most severely

[14]To infer the potential bias in the context of this paper, we first regressed the attrition dummy on village dummies and household initial characteristics (Appendix Table 1). The probit result shows that attrition occurred more among households living in Village A than in Villages B and C and among households whose heads were more educated. Other household attributes were not statistically significant. As the probit result shows that attrition was not completely random on observables, we conducted a test developed by Becketti et al. (1988). The welfare ratio in the first survey was regressed on the baseline characteristics of households, an attrition dummy, and the attrition dummy interacted with the other explanatory variables (Appendix Table 2). None of the coefficients corresponding to an additional slope for the attrition households was significant and the joint significance test did not reject the null hypothesis at the 20% level. Therefore, there is unlikely to be a significant attrition bias in our estimates.

among the four provinces. As shown in Figure 3 in the previous section, there was no province-wide agricultural shock that affected both the *rabi* and *kharif* crops during 1996–99. Therefore, the analysis in this section is intended to capture the asset dynamics in years with a manmade disaster but without major natural disasters. On the other hand, Table 1 shows that the average household consumption in 1999 remained similar to the level in 1996. As will be shown below, sample households sold the assets, mostly livestock, to supplement the reduced income.

In addition to the macroeconomic shock, household-level consumption was also subject to idiosyncratic shocks, thereby resulting in substantial fluctuation. Kurosaki (2006) presented a transition matrix of consumption poverty with five categories of poverty status in each year and indicated a highly frequent perturbation of the poverty status at the micro level. This variation is utilized in this section to assess the asset dynamics.

A note needs to be provided to justify the use of a dataset that is somewhat dated. As discussed in Section 2, the advantage of having historical semi-macro data that cover the period both before and after the micro panel survey of households is the main reason for using this micro dataset. In retrospect, because of the village selection strategy, the economic conditions in Village A during the panel survey appear to correspond to the semi-macro picture during the 1960s–70s in panel B of Figure 3, those in Village B to the semi-macro picture during the 1980s–90s, and those in Village C to the semi-macro picture during the 2000s. Based on this observation, we combine the microeconometric analysis in this section and historical analysis in the previous section in Section 6. Furthermore, because of the low economic growth rates and the slow pace of social transformation in Pakistan's economy in recent decades, the basic economic behavior of households during the second half of the 1990s is of relevance to development issues in Pakistan currently. For example, the importance of livestock in the assets portfolio of households was confirmed in the author's recent resurvey of the study region (Kurosaki and Khan, 2011). For these reasons, we regard the analysis of this panel dataset as highly relevant for the purpose of this paper.

5.2. Empirical strategy

Motivated by the asset poverty trap hypothesis given by Carter and Barrett (2006), we follow the empirical strategy of McKay and Perge (2011). First, we estimate the shape of the asset dynamics curve, in which $Y_{i,1999}$—the asset level of household i in 1999—is regressed on $Y_{i,1996}$, the corresponding value in 1996:

$$Y_{i,1999} = f(Y_{i,1996}) + u_i, \qquad (1)$$

Where $f(.)$ is the unknown function and u_i is a zero-mean error term. To let the data determine

the shape of the function, we employ a nonparametric approach to estimate the function. If the expected value of the asset in 1999 is an S-shaped function of the initial asset with three intersections with the 45-degree line, as shown in Figure 1, the long-run dynamics of assets is characterized by the middle and unstable equilibrium (the Micawber threshold) and two stable equilibriums. The lower of the two stable equilibriums may correspond to the poverty trap.

Then, we estimate a parametric model that controls for various shocks and initial conditions as the asset dynamics curve is likely to be affected by these factors. As semi-parametric analyses are computationally expensive in general and not feasible in this case due to the small sample size, we adopt a completely parametric model in which function $f(.)$ in equation (1) is proxied by a polynomial function. Thus, we estimate the model:

$$Y_{i,1999} - Y_{i,1996} = a_1 Y_{i,1996} + a_2 Y_{i,1996}^2 + a_3 Y_{i,1996}^3 + a_4 Y_{i,1996}^4 + a_5 Y_{i,1996}^5 + X_i b_1 + D_v d_v + Z_i \gamma + u_i, \quad (2)$$

where X_i is a vector of household-level variables that might affect the asset dynamics, D_v is a vector of village dummies, Z_i is a vector of variables that characterizes shocks experienced by each household, and (a_1, a_2, a_3, a_4, a_5, b_1, d_v, and γ) are the parameters to be estimated. Note that the effect of household-level time-invariant factors on the asset level is controlled cleanly as we employ the first difference as the dependent variable. The empirical specifications for X_i, D_v, and Z_i will be discussed in the next subsection on the estimation results.

Using specification (2), we first examine the shape of the polynomial function—defined as the fitted values of $(1+a_1)Y_{i,1996} + a_2 Y_{i,1996}^2 + a_3 Y_{i,1996}^3 + a_4 Y_{i,1996}^4 + a_5 Y_{i,1996}^5$—as an asset dynamics curve conditional on X_i, D_v, and Z_i. We compare its shape with its unconditional counterpart estimated from equation (1). A similar parametric approach is adopted in the literature as well, for example, by Naschold (2005) and McKay and Perge (2011), although they use a fourth-order polynomial. If the null hypothesis of $a_2 = a_3 = a_4 = a_5 = 0$ is not rejected, the linear specification is supported.

Then, we examine the coefficient vectors of d_v and γ. By comparing d_v across different types of assets, we can characterize how each asset responds to village-level aggregate shocks. By comparing γ for different types of shocks and different types of assets, we can infer which asset is more responsive to a particular type of idiosyncratic shock. Although any empirical measure of household-level shocks may contain aggregate components, the inclusion of village fixed effects absorbs the effects of the aggregate components so that we can interpret coefficient γ as showing the asset response to idiosyncratic components of an observed measure of household-level shocks. Thus, Equation (2) is a parameterized version of equation (1) to focus

on the asset response to shocks.[15] See Mogues (2011) and Kusadokoro et al. (2012) for other empirical attempts in which both (1) and (2) are estimated with focus on the asset response to shocks.

With regard to the type of assets, we first estimate these equations for livestock and land assets separately. Then, we analyze a composite asset (called the "livelihood asset" below), which aggregates the vector of various types of human capital, social capital, and physical assets that contribute to the well-being of the household. Following the empirical methodology by Adato et al. (2006), we estimate the livelihood asset in the following five steps. First, for each household in each year, per-capita consumption expenditure is calculated, including the imputed values of in-kind transactions. Second, the per-capita expenditure is divided by the poverty line in each year that corresponds to the official poverty line. This measure is called the welfare ratio and reported in Table 1. Third, the welfare ratio is regressed linearly on various types of assets. The vector of assets includes village fixed effects, demographic variables (household size, female ratio, dependency ratio, female head dummy, and the age of household head), the literacy rate of working-age adults, monetary assets, machinery and equipment (agricultural, nonagricultural, and consumption durables), value of owned land and livestock animals, and income sources (access to nonfarm income and remittance receipts). The fitted value of this regression is our estimate for the livelihood asset. The coefficients on assets used in the aggregation give "the marginal contribution to livelihood of the *j* different assets" (Adato et al., 2006, p.233).

5.3. Shape of the asset dynamics curves

Figure 4 shows the estimation results using the LOWESS (locally weighted scatter plot smoothing) methodology. The red curve represents the LOWESS fit while the green one represents the 45-degree line. The shape and corresponding equilibrium values remained qualitatively the same when the fractional polynomial fit was used instead or $f(.)$ in equation (1) was replaced by a polynomial function up to the fifth degree, as in equation (2).

First, panels A and B show that the dynamics curves for livestock and farmland have a single long-run equilibrium. As the curve intersects the 45-degree line from above, the single equilibrium is stable. The exact level of land or livestock equilibrium is close to the household average. Since the majority of the households are poor,[16] this appears to indicate that the long-run equilibrium is associated with poverty.

[15] Although equation (2) allows us to examine the different responses of assets to aggregate vs. idiosyncratic shocks, we cannot examine their different responses to transient vs. permanent shocks due to a data limitation—the two-period panel data is too short for the latter analysis.

[16] For example, when the official poverty line was applied to the dataset, the poverty headcount ratio among the sample households was 67% and the poverty gap ratio was 20%.

The shape of the asset dynamics curve changes slightly when various types of assets are aggregated into a scalar of the livelihood asset following the methodology given by Adato et al. (2006).[17] Panel C of Figure 4 shows the results when the LOWESS method is applied to the livelihood asset. The figure depicts an S-curve with two stable equilibriums. The lower of the two corresponds to the poverty trap defined by Carter and Barrett (2006), since it is at the level around the poverty line and the other (the highest intersection) could correspond to a middle-class income level, far beyond the poverty line.

<Insert Figure 4 here>

However, at the same time, observations are scattered over the fitted curve with a large variance,[18] thereby indicating that the actual asset dynamics are subject to substantial stochastic shocks. A large unexplained variance is evident from panels A and B as well.

To explain some of this unexplained variance, it would be useful to control for shocks and initial conditions. For this reason, we estimate the parametric model of equation (2). As controls for the household characteristics (X_i in equation (2)), three demographic variables are included: the initial number of household members, the change in the number of household members, and the literacy rate of working-age adults in the baseline survey. These variables, together with a polynomial function of the lagged asset variables, control for households' activities and available consumption smoothing measures. Another reason for including the two variables regarding household size is that asset variables are defined in a manner that they are affected by demographic changes by construction. As proxy variables for household-level shocks (Z_i in equation (2)), the dataset includes fourteen dummy variables collected in the 1999 survey with respect to shocks that hit the household during the three years. From these fourteen variables, we created three indicator variables that take a positive value if the household was hit by shocks that decreased its income and welfare. The three variables are shocks in farming, off-farm wage work, and others.[19] The definition and summary statistics of these household-level shock variables are provided in the footnotes to Table 2. The regression results are reported in Table 2. In all three cases, the null hypothesis of linearity is rejected at the 5%

[17]See Appendix Table 3 for the regression results used to construct the livelihood asset. In estimation, the larger sample including attrition or split households was used to fully utilize the cross-section information. The qualitative results remained the same when the subsample of 299 households was used instead.

[18]Although not shown in the figure, the 95% confidence interval zone estimated by bootstrapped standard errors contains the 45-degree line for almost the entire distribution of the livelihood asset in 1996. Therefore, the three equilibrium points are not statistically significant. In this sense, Figure 4 confirms what is indicated in existing literature that multiple equilibriums are not found in Pakistan (Naschold, 2005).

[19]The major portion of the variation in these three variables is idiosyncratic. The ANOVA decomposition suggests that the between-village components explain only 0.60% of the total variation for "Agricultural shock," 0.68% for "Off-farm work shock," and 1.05% for "Other shock." Our observations in the field also support this view. For example, farmers were subject to highly idiosyncratic agricultural shocks, such as plot-specific wild animal/pest attacks, farmer-specific unfavorable selling prices, etc.

level. All three coefficients on the linear lagged asset variable are between -1 and 0, thereby suggesting local convergence evaluated at the mean.[20] As the null hypothesis that slopes of explanatory variables are the same across villages was not rejected except for the intercept, we report the results based on equation (2) assuming village-specific intercepts.

<Insert Table 2 here>

Based on the results in Table 2, we plot the estimated asset dynamic curves in Figure 5. The red curve represents the fitted value of $(1+a_1)Y_{i,1996} + a_2Y_{i,1996}^2 + a_3Y_{i,1996}^3 + a_4Y_{i,1996}^4 + a_5Y_{i,1996}^5$, while the scatter plot is replaced by the observed value minus the fitted value of $X_ib_1 + D_vd_v + Z_i\gamma$. Because of the contribution of these controls, observations net of the controls are scattered over the fitted curve with a smaller variance than that depicted in Figure 4. However, what is striking is the similarity of the asset dynamics curves. Panels A and B of Figure 5 show that the dynamics curves for livestock and farmland are associated with a single long-run equilibrium. The precise level of land or livestock equilibriums is close to the level shown in Figure 4. The shape of the asset dynamics curve for the livelihood asset appears to be an S-curve as well (Figure 5, panel C). However, the fitted curve and the 45-degree lines are very similar in the wide range of the asset level that corresponds to the welfare level that ranges between 1 to 1.75 poverty line units.

<Insert Figure 5 here>

Thus, Figures 4 and 5 suggest that the dynamics of household landholding and livestock is associated with a single long-run equilibrium. When human capital is added, the dynamics curve changes its shape but is not sufficiently nonlinear to produce statistically significant multiple equilibriums. Therefore, the tentative conclusion is that the poverty trap hypothesis *a la* Carter and Barrett (2006) does not explain the behavior of household assets in the NWFP during the late 1990s.

5.4. Response of assets to village- and household-level shocks

Here, we discuss coefficients related to the shocks presented in Table 2. First, the coefficients on village dummies (d_v in equation (2)) show an interesting contrast across the three types of assets. All three of the village fixed effects are negative and statistically significant when the dependent variable is the change in livestock assets. This indicates that sample households sold livestock to supplement the reduced income when the three villages were hit by macroeconomic stagnation.

On the other hand, there was a significant reduction in farmland in Village A only. In the farmland asset regression, the null hypothesis of homogenous village fixed effects is rejected

[20]We conducted the convergence test at different quartiles of the lagged asset distribution as well. The results were also consistent with local convergence at these evaluation points. See Appendix Table 4.

at the 1% level. Our interpretation is that this reflects the cost of inferior access to markets in Village A. Because of isolation, farm households in Village A had to sell or mortgage part of their farmland to cope with aggregate negative shocks. In contrast, farm households in Villages B and C did not need to use their land since they had access to other smoothing measures as well. Another interesting inter-village difference is that the livelihood asset increased slightly in Village C, while it remained at the same level in the other two villages. During the three years spanning the two surveys, the author observed in the field that there was a rapid diversification of the economy in Village C, with a growth in new activities such as the plant nursery business and commuting to the city of Peshawar. In such circumstances, the livelihood asset in this village increased because the livelihood asset is a positive function of human capital (see Appendix Table 3) and the human capital level increased in this village during the three years when the survey was conducted.[21] However, these are speculations without solid evidence, as village fixed effects can capture any unobservable factors.

Further, we expected the coefficients on household-level negative shocks (γ in equation (2)) to be negative; our estimations revealed that eight out of nine coefficients were negative (Table 2). However, only one of them (the impact of "other shock" on the change in farmland) is statistically significant. The significant coefficient suggests that there was a depletion in farmland when the household was hit by a shock that was not related to agriculture or off-farm wage work. The overall insignificance of these idiosyncratic shocks suggests that, on average, such shocks did not directly reduce assets and households did not need to reduce their assets after these shocks.

Thus, the estimation results reported in Table 2 regarding coefficients on shock variables are consistent with the behavior in which households use assets as a buffer. These results were robustly supported through other specifications (see Appendix Tables 5-9). For example, when the list of household initial characteristics in X_i of equation (2) was expanded, the additional variables had insignificant coefficients and other coefficients remained highly similar to those in Table 2. This is probably because the lagged asset value on the right-hand side of equation (2) already controls for most of the impact of such variables on the asset dynamics. We also attempted several alterations for the definition of household-level shocks and different weights used in regression. Regardless of the alterations, the estimation results are qualitatively the same as those reported in Table 2.

[21]This interpretation is consistent with the finding by Kurosaki and Khan (2006) using the same panel dataset, that education investment had high economic returns if associated with non-agricultural employment. With new opportunities for poverty reduction through human capital investment, the livelihood asset can be increased during the adverse macroeconomic conditions. Those households who moved out of poverty through human capital accumulation may be settled in the higher equilibrium in the S-shape curve in panel C of Figure 4.

6. Combining Microeconometric and Historical Analyses

6.1. Interpreting the microeconometric results from the historical perspective

The microeconometric results discussed in the previous section could be interpreted in several ways if the analysis were conducted in isolation. As we have historical semi-macro data encompassing the period both before and after when the panel data were collected, the information derived from these data can be utilized to narrow down the interpretation.

First, with regard to the shape of the asset dynamics curve, the microeconometric results for land and livestock suggested the absence of multiple equilibriums. This is further supported by the historical finding of the absence of persistent declines in livestock population after independence. When human capital was included, the results were ambiguous due to statistical insignificance of multiple equilibriums. Therefore, without other indirect evidence, we conclude that no evidence is found for multiple equilibriums. If historical data were available on the average level and distribution of education at the district level, it would be possible to provide further support or refutation to this tentative conclusion. As speculated in the previous subsection, our field impression is that it is possible that multiple equilibriums existed in recent years when human capital became the key component of the livelihood asset. This possibility could be investigated in further research with other datasets.

Second, regarding the response of household assets to shocks, the results of the microeconometric analysis revealed that livestock declined rapidly in all villages when these villages were hit by macroeconomic shocks. Since there was no natural disaster that caused the death of livestock during 1996–99, the negative coefficients cannot be interpreted as done for 1920/21 when livestock animals died due to droughts. Therefore, this is evidence for livestock used as a buffer against negative aggregate shocks during the 1990s. Examining the historical trends (Figures 2 and 3) reveals that the change in the livestock portfolio over the century is worth attention in this regard. Since draft animals were an indispensable part of crop production in the old days, it was difficult for farmers to reduce the stock even in difficult years. In contrast, the number of milk animals can be reduced more easily and the increasing share of such animals in the livestock portfolio of households has facilitated the effectiveness of livestock as a buffer. Thus, the microeconometric results in Table 2 can be better understood with the help of long-term historical evidence.

Furthermore, the microeconometric results regarding household idiosyncratic shocks showed that assets declined on average, but the decline was not statistically significant. Among the shocks, the adverse impact of “other shocks” such as unexpected deaths and funerals and discontinuation of remittances from family members living outside the village was statistically significant in the land regression. The results could be interpreted as showing heterogeneity among villagers and among the type of shocks in terms of the extent of insurance against

idiosyncratic shocks. This interpretation is indirectly supported by the historical analysis if we analogize the cross-sectional difference with changes over time. The historical analysis showed that the livestock population at the district level became less responsive to crop shocks in more recent years with the development of infrastructure, agricultural technology, and intertemporal resource allocation opportunities.

6.2. Re-interpreting the historical patterns

In Section 4, we speculated that (i) the pre-independence livestock dynamics was consistent with both the asset poverty trap hypothesis and the buffer stock hypothesis, while the post-independence livestock dynamics was more consistent with the buffer stock hypothesis; (ii) the contrast could be attributable to different levels of infrastructure, formal credit facilities, and agricultural technology.

The microeconometric findings in Section 5 are broadly supportive of these speculations. They reveal that the asset behavior during the late 1990s was consistent with the role of assets as a buffer. The between-village contrast also supported the contention that as the economy develops, the function of assets in smoothing consumption against shocks is strengthened. As the buffer stock hypothesis was supported even for the least developed village in the microeconometric analysis, it appears more likely that the asset dynamics during the pre-independence period was also more consistent with the buffer stock hypothesis than with the poverty trap hypothesis.

As a final remark on combining the two types of analysis, let us consider a prediction regarding the district livestock population, which is theoretically derived from the conclusion that the asset dynamics of livestock follows the buffer stock hypothesis. As discussed in Section 2, the theoretical prediction is that the decline in the livestock population witnessed at the micro level during the 1996–99 period should be temporary. Panel B of Figure 3 indeed supports this: the change in the livestock population from 1996 to 2006 is connected with the change from 1986 to 1996.[22] We do not find a significant discontinuity in the growth rates.

However, it must be noted that to infer the district-level dynamics from the micro-level analysis, we need to specify how initial assets are distributed across households and villages over the entire district and how livestock markets behave in response to district-level changes. The previous prediction is based on a simple assumption that the initial livestock distribution is the multiple of three villages that we analyzed and there is no market equilibrium effect in the livestock markets. Further research is necessary to replace this assumption by a

[22]The following are the annual growth rates of the livestock population in Panel B of Figure 3 (the first number shows the growth from 1986 to 1996 and the second from 1996 to 2006). Bullocks as draft animals: -6.4% and -2.0%, adult cows in milk: +1.2% and +2.7%); and adult she-buffaloes in milk: +7.5% and +4.3%.

numerical model based on hard data and an appropriate microeconomic model.

7. Conclusion

In this paper, we analyzed asset dynamics held by low-income households in the NWFP area in Pakistan over a period from 1902 to 2011. First, we investigated the long-run data at the district- and province-level. The results showed that the population of livestock—the major asset of rural households—declined with crop shocks due to droughts, but did not respond much to the Great Depression. The decline in livestock due to droughts was persistent. In the post-independence period, crop agriculture continued to be vulnerable to natural disasters, although less substantially, while the response of livestock to such shocks was indiscernible in district-level data. Then, we analyzed a panel dataset collected from approximately 300 households in three villages in the NWFP during the late 1990s. The results showed that the dynamics of household landholding and livestock was associated with a single equilibrium. When human capital was included, the dynamics curve changed its shape but was not sufficiently nonlinear to produce statistically significant multiple equilibriums. On the other hand, the response of household assets to village- and household-level shocks showed several interesting patterns―livestock assets were depleted widely when the village economy was affected by macroeconomic stagnation; land assets were depleted only in a village with inferior access to markets; idiosyncratic agricultural and off-farm work shocks did not affect the household-level asset dynamics substantially.

To understand these patterns revealed from historical and contemporary analyses, we suggested the possibility that the contrast could be attributable to the different levels of infrastructure, formal credit facilities, and agricultural technology. In retrospect to the long-run historical data, the household panel data during the 1990s appear to show that there was an improvement in the access to consumption smoothing measures such as asset sales markets, credit institutions, and reciprocity-based transfers. However, the improvement was not homogenous, leaving pockets of villages and households with inferior access. In this regard, the role of livestock as liquid assets was found to be important in smoothing consumption while the role of less liquid assets, particularly land, was more limited. The reduction in the number of draft animals in the livestock portfolio in the long-term, replaced by milk animals, facilitated the effectiveness of livestock as a buffer against negative shocks. On the other hand, in the NWFP, throughout the period since the early twentieth century, financial markets existed in cities and villagers had a network of credit transactions. However, the actual use of modern financial markets and formal credit institutions did not prevail widely in the early stage of development. The highly unequal distribution of land in Pakistan could have accentuated the disparity, as land is often used as collateral in formal credit transactions.

These interpretations imply that improving the intertemporal smoothing ability of households through the development of assets and credit markets is key to mitigating the adverse effects of natural disasters. It is also expected that investment in infrastructure such as transport and communication could contribute to higher resilience against natural disasters as it would facilitate the movement of labor and improve the level of efficiency of risk sharing and credit transactions.

It must be noted that these interpretations and policy implications are merely speculations. A limitation of this paper is that the attempt to demonstrate the complementarity of combining historical and contemporary analyses is not complete. Because of data limitations, we were unable to investigate the asset dynamics during the pre-independence period in a microeconometric way. This is left for further research. Nevertheless, we believe that as a policy-oriented research, this paper shows the potential benefit of empirical analyses that combine both contemporary and historical information. Economic development is, by definition, a long-term process. A microeconometric test of a particular structure of incomplete markets needs to be aligned with the historical context.

References

Adato, Michelle, Michael R. Carter, and Julian May (2006), "Exploring Poverty Traps and Social Exclusion in South Africa Using Qualitative and Quantitative Data," *Journal of Development Studies*, 42(2): 226–247.

Ahmed, Akbar S. (1980), *Pukhtun Economy and Society: Traditional Structure and Economic Development in a Tribal Society*, London: Routledge & Kegan Paul.

Becketti, Sean, William Gould, Lee Lillard, and Finis Welch (1988), "The Panel Study of Income Dynamics after Fourteen Years: An Evaluation," *Journal of Labor Economics*, 6(4): 472–492.

Carter, Michael R. and Christopher Barrett (2006), "The Economics of Poverty Traps and Persistent Poverty: An Asset-Based Approach," *Journal of Development Studies*, 42(2): 178–199

Carter, Michael R., Peter D. Little, Tewodaj Mogues, and Workneh Negatu (2007), "Poverty Traps and Natural Disasters in Ethiopia and Honduras," *World Development*, 35(5): 835–856.

Deaton, Angus (1992), *Understanding Consumption*, Oxford: Clarendon Press.

Dercon, Stefan (ed.) (2005), *Insurance Against Poverty*, Oxford: Oxford University Press.

Drèze, Jean and Amartya K. Sen (1995), *India: Economic Development and Social Opportunity*, Delhi: Oxford University Press.

Dutta, Indranil, James Foster, and Ajit Mishra (2010), "On Measuring Vulnerability to Poverty," IED Discussion Paper No.194, Institute for Economic Development, Boston University, April 2010.

Fafchamps, Marcel (2003), *Rural Poverty, Risk and Development*, Cheltenham, UK: Edward Elger.

Fujie, Takeshi and Tetsushi Senda (2011), "How Do Farm Households Cope with Aggregate Shocks? Evidence from the Great Depression in Prewar Japan," *Journal of Rural Economics*, 83(1): 15–27 (in Japanese).

Government of Pakistan (2012), *Pakistan Economic Survey 2011-12*, Islamabad: Economic Adviser's Wing, Government of Pakistan.

Hirashima, S. (2008), "The Land Market in Development: A Case Study of Punjab in Pakistan and India," *Economic and Political Weekly*, October 18: 41–47.

Khalid, A.K. (1998), *The Agrarian History of Pakistan*, Lahore: Allied Press Ltd.

Kurosaki, Takashi (1995), "Risk and Insurance in a Household Economy: Role of Livestock in Mixed Farming in Pakistan," *Developing Economies*, 33(4): 464–485.

----- (2003), "Specialization and Diversification in Agricultural Transformation: The Case of West Punjab, 1903-1992," *American Journal of Agricultural Economics*, 85(2): 372–386.

----- (2006), "Consumption Vulnerability to Risk in Rural Pakistan," *Journal of Development Studies*, 42(1): 70–89.

----- (2011), "Compilation of Agricultural Production Data in Areas Currently in India, Pakistan, and Bangladesh from 1901/02 to 2001/02," G-COE Discussion Paper, No.169/ PRIMCED Discussion Paper, No.6, February 2011, Hitotsubashi University.

Kurosaki, Takashi and Anwar Hussain (1999), "Poverty, Risk, and Human Capital in the Rural

North-West Frontier Province, Pakistan," IER Discussion Paper Series B No. 24, March 1999, Hitotsubashi University.

Kurosaki, Takashi and Humayun Khan (2006), "Human Capital, Productivity, and Stratification in Rural Pakistan," *Review of Development Economics*, 10(1): 116–134.

----- (2011), "Floods, Relief Aid, and Household Resilience in Rural Pakistan: Findings from a Pilot Survey in Khyber Pakhtunkhwa," *The Review of Agrarian Studies*, 1(2): 79–107.

Kusadokoro, Motoi, Takeshi Maru, and Masanori Takashima (2012), "Asset Accumulation Behavior of Rural Households in the Reconstruction Period following the Showa Depression: A Panel Data Analysis Using the Third Period MAF Survey of Farm Household Economy," Paper Presented at the Asian Historical Economic Conference, September 13–15, 2012, Hitotsubashi University (available at http://ahec2012.org/papers/).

Ligon, Ethan and Laura Schechter (2003), "Measuring Vulnerability," *Economic Journal*, 113: C95-C102.

Malik, Sohail (1999), *Poverty and Rural Credit: The Case of Pakistan*, Islamabad: Pakistan Institute of Development Economics.

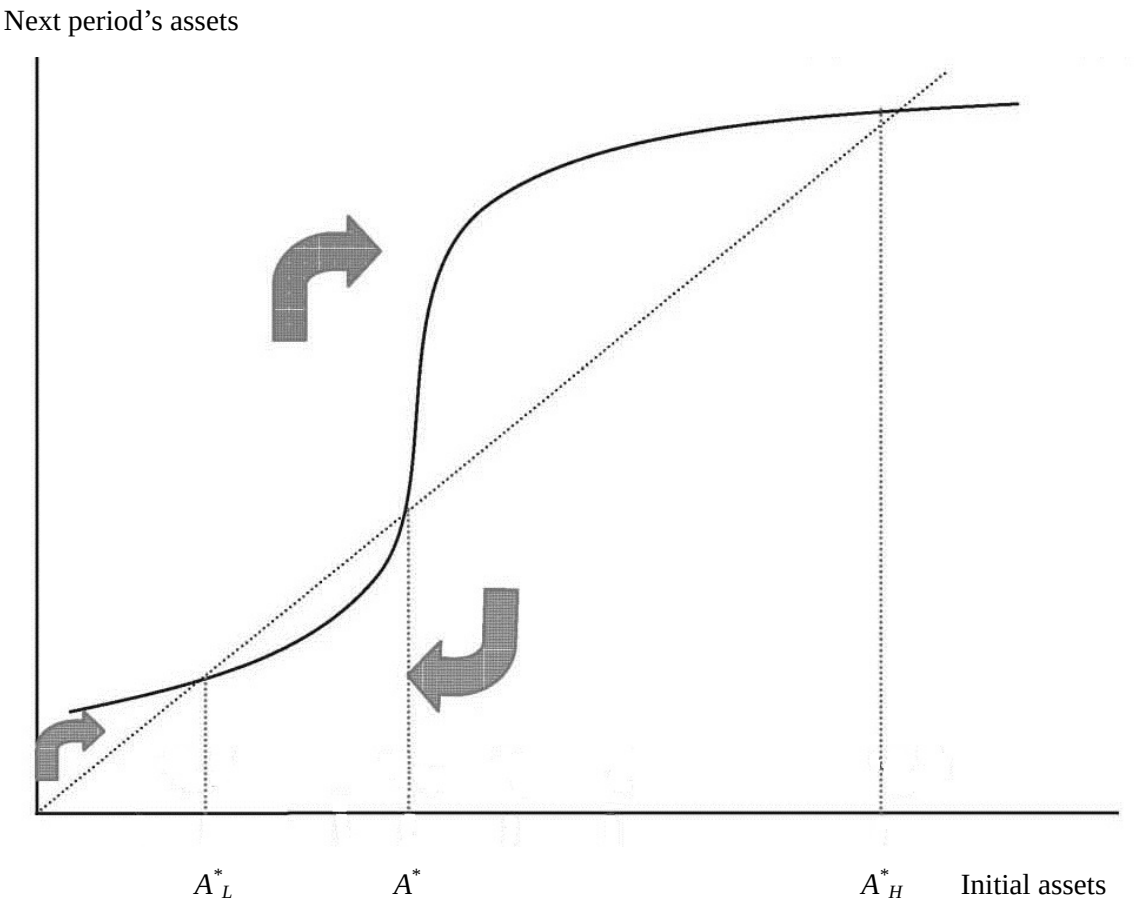
Mckay, Andrew, and Emilie Perge (2011), "How Strong is the Evidence for the Existence of Poverty Traps? A Multi-country Assessment," Working Paper 180, Chronic Poverty Research Centre.

Miura, Ken, Hiromitsu Kanno, and Takeshi Sakurai (2012), "Rainfall Shock and Livestock Transactions in Rural Zambia: An Empirical Examination Using High Frequency Panel Data," Paper Presented at the Asian Historical Economic Conference, September 13–15, 2012, Hitotsubashi University (available at http://ahec2012.org/papers/).

Mogues, Tewodaj (2011), "Shocks and Asset Dynamics in Ethiopia," *Economic Development and Cultural Change*, 60(1): 91–120.

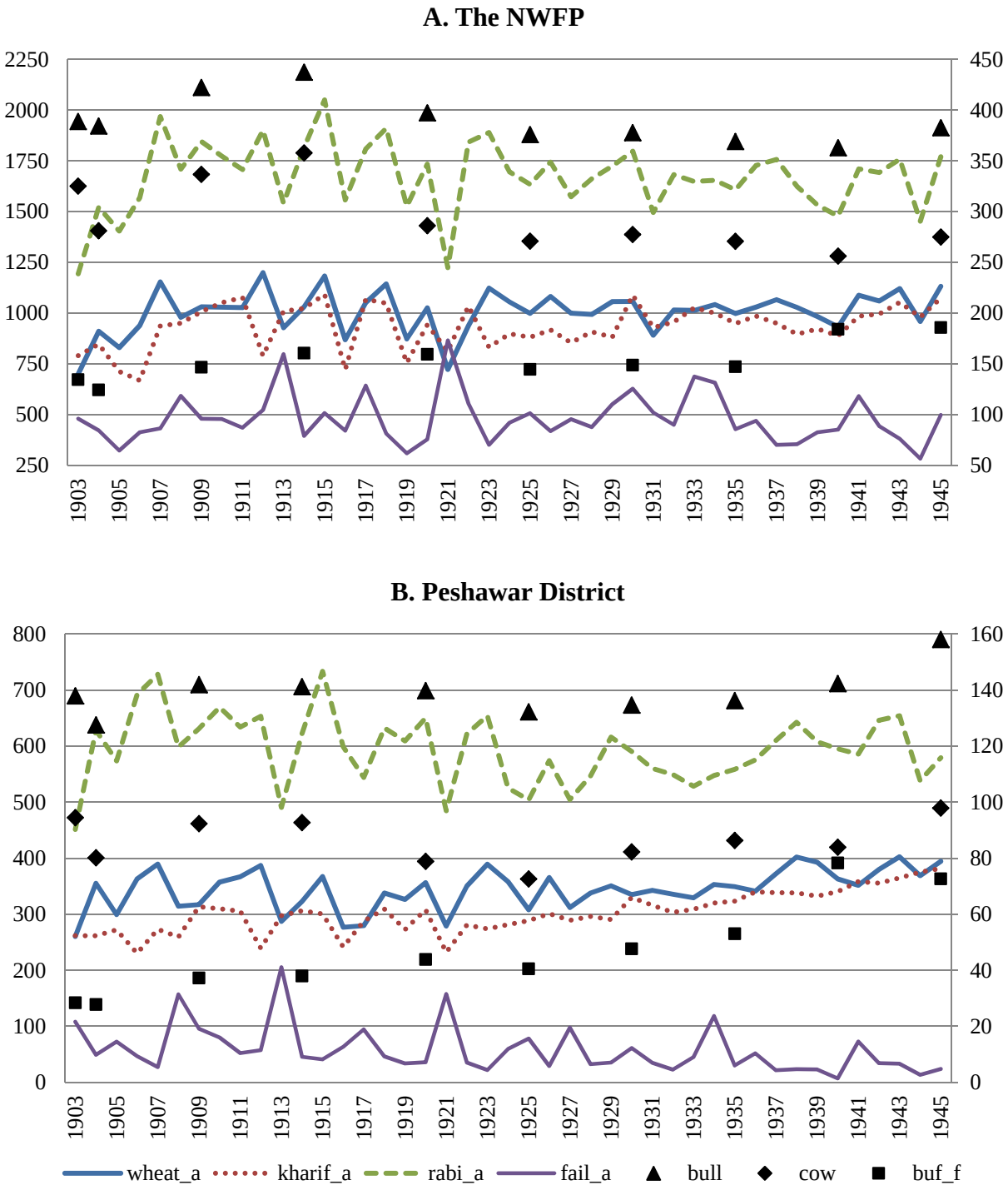
Naschold, Felix (2005), "Identifying Asset Poverty Thresholds: New Methods with an Application to Pakistan and Ethiopia," Working Paper, Cornell University.

Figure 1.The Asset Dynamics Curve



Source: Adapted from Figure 4 of Carter and Barrett (2006).

Figure 2. Crop Production and Livestock in the NWFP before Partition (1903–1945)

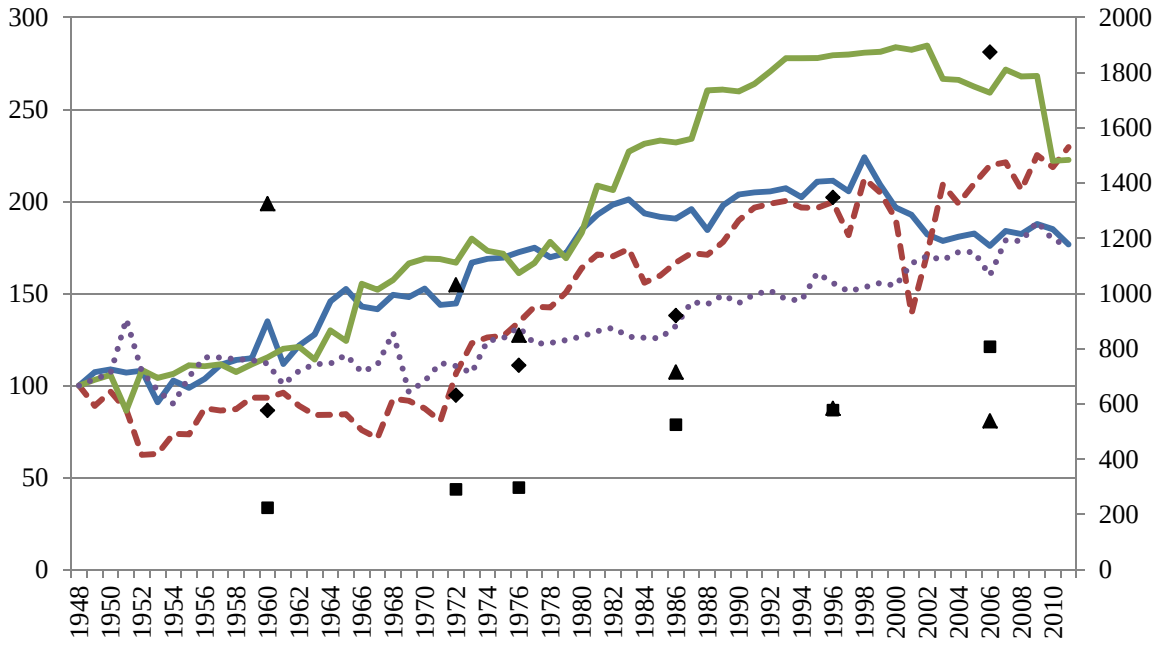


Note: (1) Crop variables (*wheat_a*, *kharif_a*, *rabi_a*, and *fail_a*) are plotted on the left axis (unit: 1,000 acres). (2) Livestock numbers (*bull*, *cow*, and *buf_f*) are plotted on the right axis (unit: 1,000 heads). (3) Peshawar District corresponds to the district borders until 1937. It comprises the current districts of Peshawar, Charsadda, Nowshera, Mardan, and Swabi.

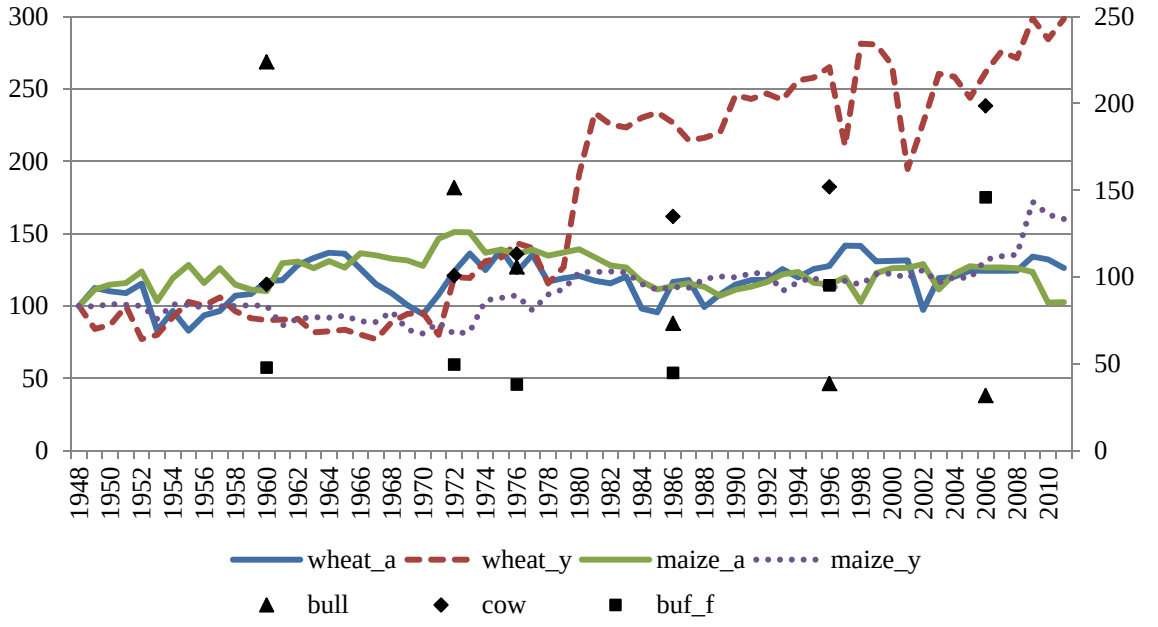
Source: Created by the author using the dataset described in the text (the same for the following figures).

Figure 3. Crop Production in the NWFP after Partition (1948–2011)

A. The NWFP



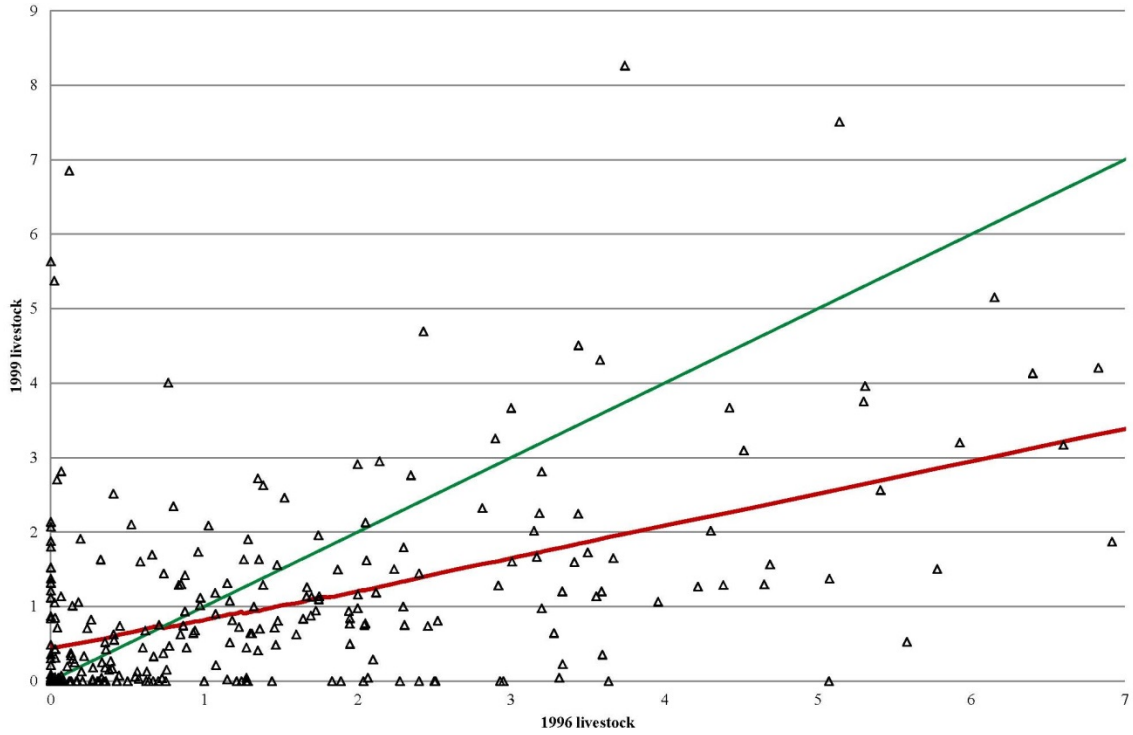
B. Peshawar District



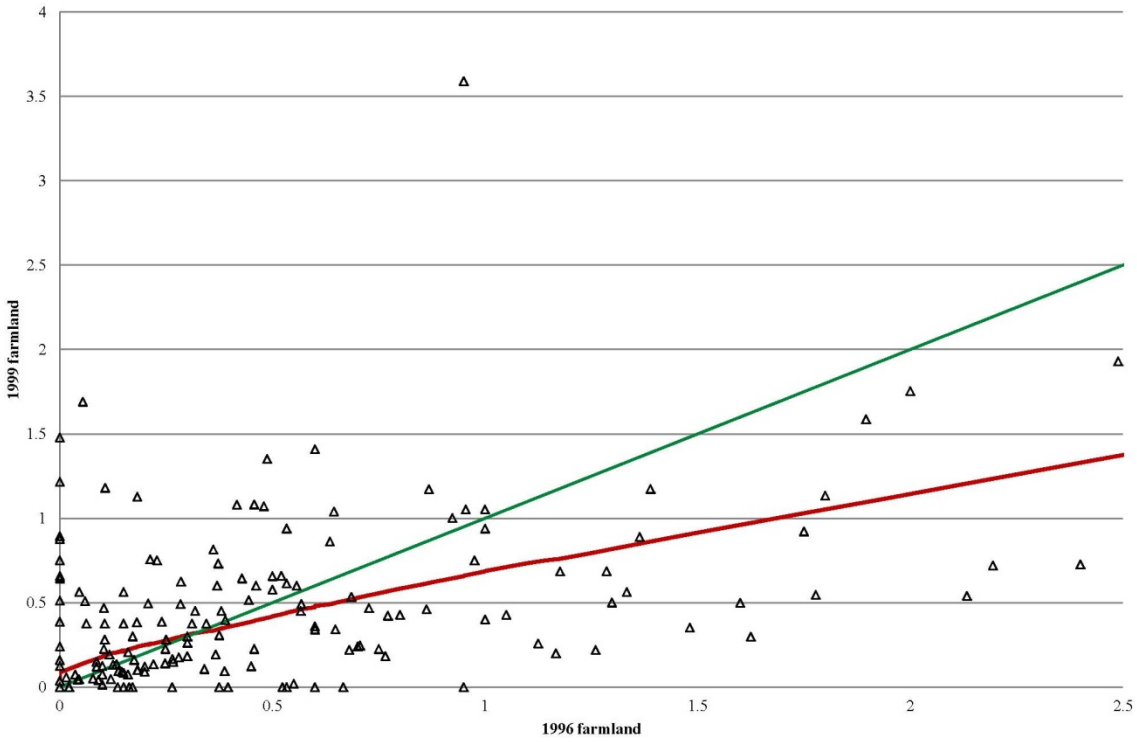
Note: (1) Crop variables (*wheat_a*, *wheat_y*, *maize_a*, and *maize_y*) are plotted on the left axis (unit: index with 1948 = 100. The absolute level in 1948 for the four variables are 410 (1000 ha), 695 (kg/ha), 190 (1000 ha), 995 (kg/ha) for the NWFP and 68 (1000 ha), 828 (kg/ha), 36 (1000 ha), 1550 (kg/ha) for Peshawar. (2) Livestock numbers (*bull*, *cow*, and *buf_f*) are plotted on the right axis (unit: 1,000 heads). (3) Peshawar District corresponds to the district borders in 1948. It comprises the current districts of Peshawar, Charsadda, and Nowshera.

Figure 4.Nonparametrically Estimated Asset Dynamics Curves, Pakistan (NWFP), 1996–1999

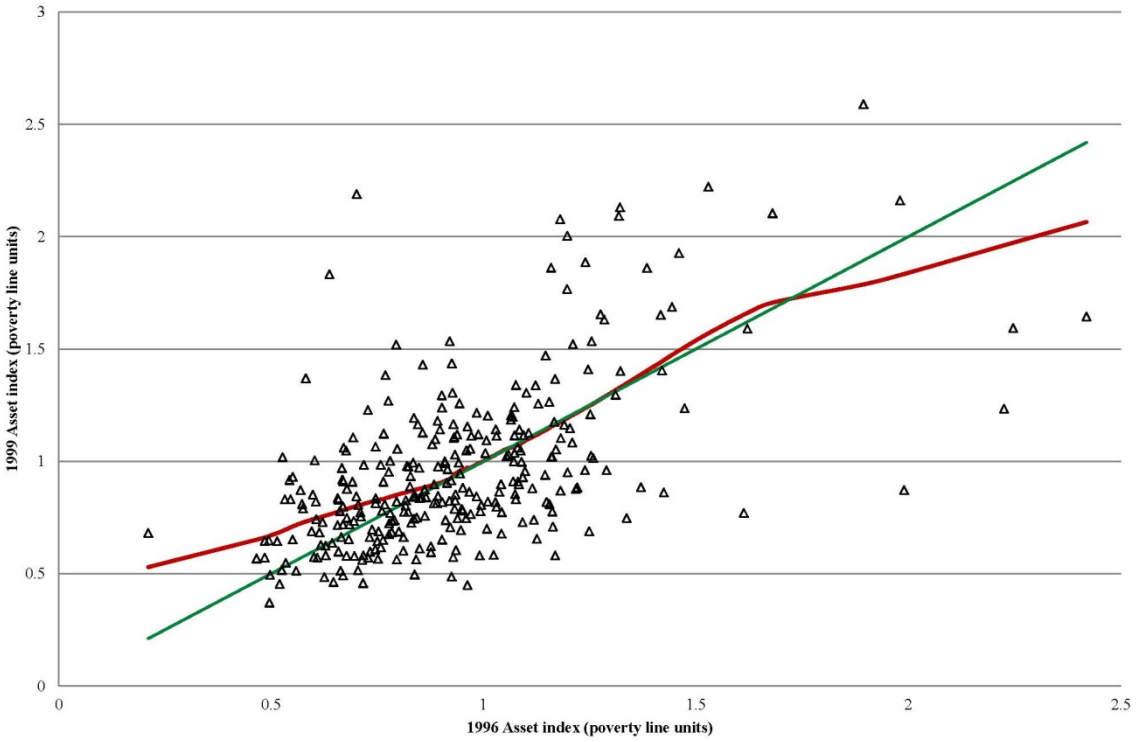
A. Livestock per capita (unit: Rs. 1,000 at 1996 prices)



B. Owned farmland per capita (unit: Rs. 100,000 at 1996 prices)



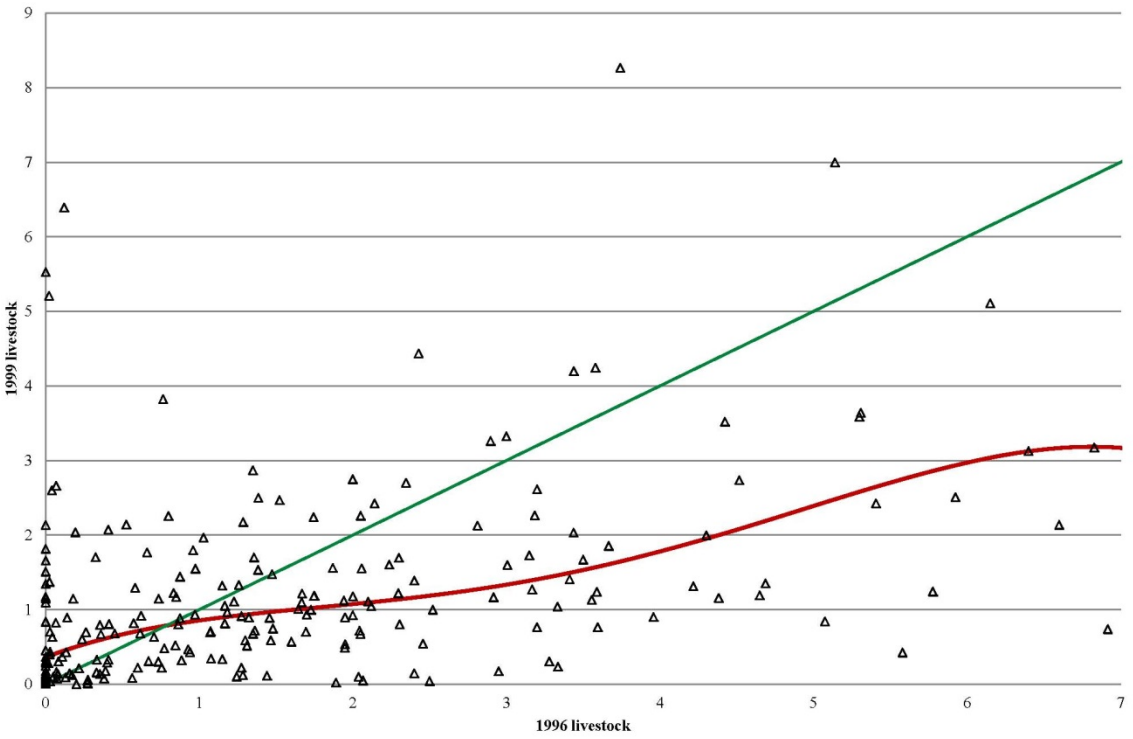
C. The livelihood asset (unit: the poverty line)



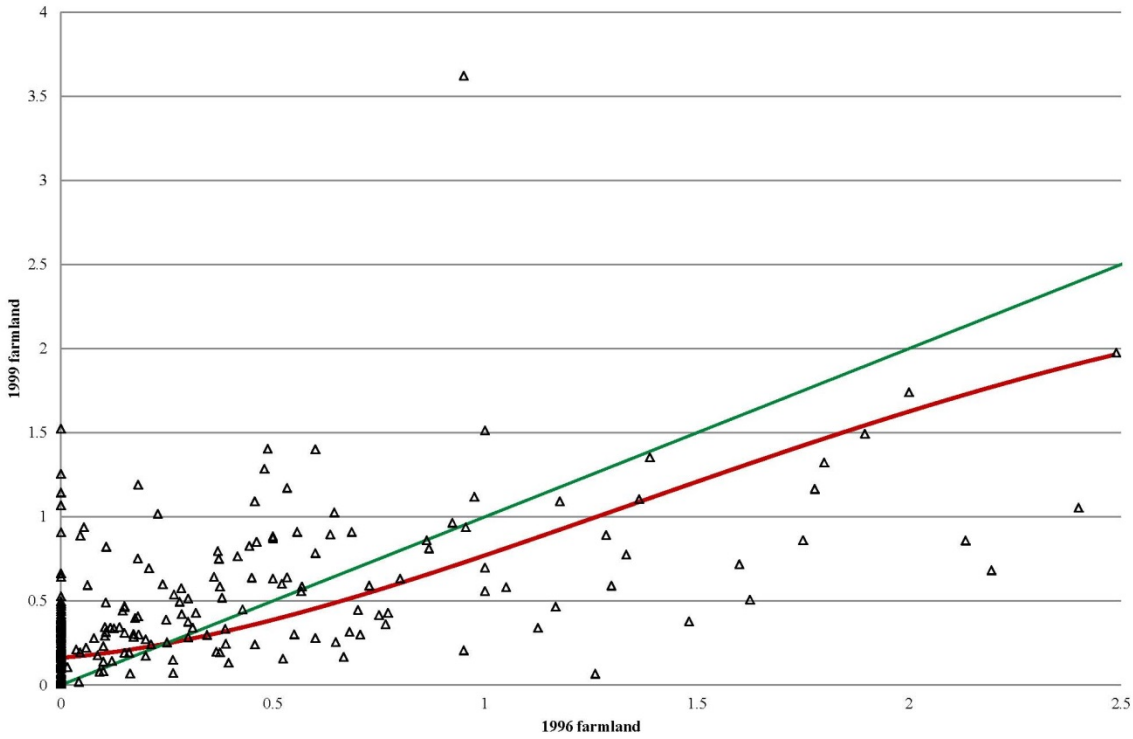
Notes: Nonparametrically estimated by LOWESS with a bandwidth of 0.8. The scatter plots on the vertical axis are raw observations without any control.

Figure 5.Parametrically Estimated Asset Dynamics Curves, Pakistan (the NWFP), 1996–1999

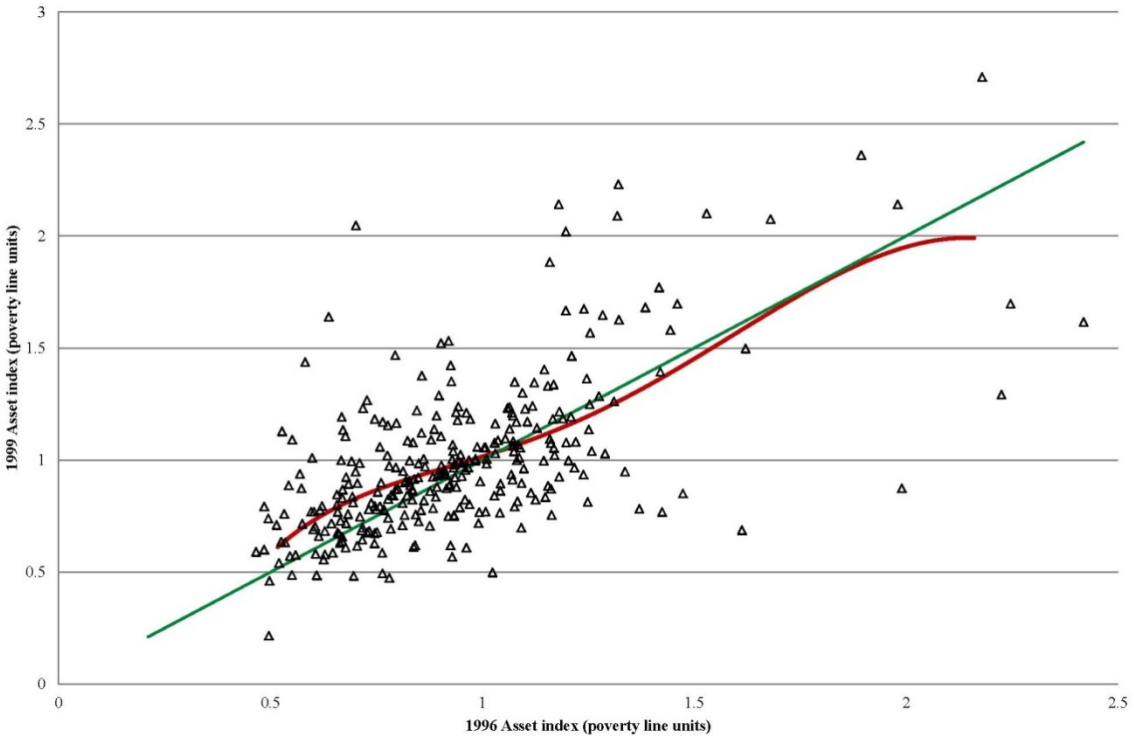
A. Livestock per capita (unit: Rs. 1,000 at 1996 prices)



B. Owned farmland per capita (unit: Rs. 100,000 at 1996 prices)



C. The livelihood asset (unit: the poverty line)



Notes: Parametrically estimated by OLS. The scatter plots on the vertical axis are raw observations net of asset changes predicted by other controls included in Table 2.

Table 1. Characteristics of the Sample Households in the 1996–99 Panel Survey, the NWFP, Pakistan

Variable	Village A	Village B	Village C
1. Village characteristics			
Agriculture	Rain-fed	Rain/irrig.	Irrigated
Distance to main roads (km)	10	4	1
Population (1998 Census)	2,858	3,831	7,575
Adult literacy rates in % (1998 Census)	25.8	19.9	37.5
2. Characteristics of households in the panel			
Number of households	83	111	105
Average of initial characteristics in the 1996 survey[1]			
Household size	10.75	8.41	8.95
Literacy rate of working-age adults (%)	16.8	17.6	31.3
Average farmland owned (acres)	5.51	1.28	1.43
Per-capita value[2] of farmland asset (Rs. 100,000[3])			
in the 1996 survey	0.475	0.804	0.376
in the 1999 survey	0.306	0.417	0.394
Per-capita value[2] of livestock asset (Rs. 1,000[3])			
in the 1996 survey	1.525	1.181	1.884
in the 1999 survey	1.087	0.727	1.042
Per-capita income[2] (poverty line units[4])			
in the 1996 survey	1.074	1.278	1.861
in the 1999 survey	0.856	0.953	1.225
Per-capita consumption[2] (poverty line units[4])			
in the 1996 survey	0.743	0.868	1.110
in the 1999 survey	0.773	0.828	1.148

Notes:
(1) “Average of initial characteristics” represents the average over all sample households.
(2) “Per-capita value” represents the average based on individuals. It is calculated with the number of household members as weights.
(3) “Rs.” indicates Pakistani Rupees in 1996 prices, adjusted for inflation.
(4) The same poverty line (but different for 1996 and 1999 adjusted for inflation) was used for both income and consumption and for all villages to convert per-capita income (consumption) into poverty line units.
Source: Prepared by the author using the 1996–99 panel data described in the text (same for the following tables).

Table 2. Response of Assets to Village- and Household-level Shocks

	Dependent variable: Change in assets from 1996 to 1999		
	D_livestock	*D_farmland*	*D_livelihood asset*
Initial level of each asset			
Linear	-0.801***	-0.340***	-0.421**
	[0.210]	[0.085]	[0.186]
Squared	-0.023	0.300	0.233
	[0.085]	[0.203]	[0.637]
Cubic	0.049	-0.155**	1.179
	[0.053]	[0.072]	[0.749]
Fourth degree	-0.007	0.021**	-1.325
	[0.006]	[0.009]	[1.062]
Fifth degree	0.000	-0.001**	0.269
	[0.000]	[0.000]	[0.803]
Demographic controls			
Initial hh size	-0.019	0.012	0.007
	[0.015]	[0.008]	[0.007]
D_hh size	-0.031*	-0.021*	-0.023***
	[0.017]	[0.012]	[0.005]
Literacy rate of working-age adults	-0.329	0.429***	0.106
	[0.360]	[0.131]	[0.136]
Response to village-level shock (coefficient on the fixed effect)			
Village A	-0.656***	-0.272***	0.020
	[0.137]	[0.088]	[0.050]
Village B	-0.699***	-0.109	-0.009
	[0.178]	[0.083]	[0.054]
Village C	-0.446***	-0.097	0.100***
	[0.164]	[0.078]	[0.029]
Response to household-level shock			
Agricultural shock	-0.003	-0.021	-0.033
	[0.122]	[0.080]	[0.032]
Off-farm work shock	-0.072	0.065	-0.055
	[0.233]	[0.088]	[0.046]
Other shocks	-0.200	-0.138**	-0.047
	[0.151]	[0.061]	[0.040]
R-squared	0.784	0.389	0.314
F-stat. for zero coef. on non-linear terms	7.50***	2.97**	3.73***
F-stat. for homogenous village f.e.	0.87	3.35**	1.85
F-stat. for zero coef. on hh-level shocks	0.65	2.06	1.48

Notes to Table 2:
(1) Huber-White robust standard errors are given in square brackets.
(2) ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.
(3) WLS regression with village fixed effects (no intercept) is employed, where weights are the number of household members inflated by village-specific inflation factors.
(4) To make the coefficients on village fixed effects readily interpretable, the initial asset, hh size, and literacy rates are replaced by their deviations from the mean. See Table 1 and Appendix Table 3 for the summary statistics of these variables.
(5) The following are the definitions and statistics of household-level shocks:

"Agricultural shock" = Index of agricultural shocks that the household experienced between 1996 and 1999. If the household experienced both crop failure and output prices lower than the market rate, +2; if it experienced either, +1; if it experienced neither, 0; if it experienced either of bumper crop harvest or output prices higher than the market rate, -1; if it experienced both, -2. The mean is -0.074 and the standard deviation is 0.721.

"Off-farm work shock" = Index of shocks to the off-farm work conditions of the household between 1996 and 1999. If the household experienced both the loss of employment and a decrease in wage rates, +2; if it experienced either, +1; if it experienced neither, 0; if it experienced either of the gain in employment or the increase in wage rates, -1; if it experienced both, -2. The mean is 0.036 and the standard deviation is 0.532.

"Other shock" = Index of other shocks that the household experienced between 1996 and 1999, such as unexpected deaths and funerals and discontinuation of remittances from family members living outside the village. If it is a negative shock, +1; if there was no such shock, 0; if it is a positive shock, -1. The mean is 0.098 and the standard deviation is 0.565.

Appendix Table 1. Correlates of Attrition (Probit Regression Result)

	Dependent variable: *retention* (dummy variable for being included in the panel data analysis)		
	Coef.	[S.E.]	dP/dX
Village-specific intercept			
Village A	0.749***	[0.260]	0.156
Village B	1.945***	[0.307]	0.406
Village C	1.404**	[0.262]	0.293
Household's initial characteristics			
Household size	-0.075	[0.142]	-0.016
Ratio of dependent members	0.047	[0.084]	0.010
Age of household head	-0.014	[0.102]	-0.003
Dummy for nonfarm fulltime employees	-0.045	[0.189]	-0.009
Dummy for regular remittance receipt	-0.387	[0.337]	-0.081
Land ownership dummy	-0.114	[0.205]	-0.024
Land asset value	0.319	[0.506]	0.066
Livestock value	0.197	[0.207]	0.041
Net monetary asset	-0.022	[0.125]	-0.005
Other asset value	0.388	[0.389]	0.081
Education of household head	-0.201**	[0.091]	-0.042
Log likelihood			-133.4
Fraction of correct prediction			0.848
LR test (chi2) for zero slopes of all explanatory variables			42.70***
LR test (chi2) for zero slopes of household's initial characteristics			12.26

Notes: (1) Standard errors [S.E.] were robust standard errors computed from analytical second derivatives. Continuous variables in "Household's initial characteristics" are normalized by their means and standard errors. (2) Statistically significant at the 1% (***), 5% (**), and 10% (*) level. (3) The number of observations is 355.

Appendix Table 2. Welfare Level and the Attrition Status

	Dependent variable: Welfare ratio			
	Base slope		Additional slope for the attritor households	
Village-specific intercept				
Village A	1.040***	[0.142]	-0.214	[0.239]
Village B	1.140***	[0.138]	-0.309	[0.306]
Village C	1.248***	[0.147]	-0.436*	[0.237]
Household wealth characteristics				
Household size	-0.012*	[0.007]	-0.006	[0.010]
Ratio of females	-0.042	[0.165]	0.190	[0.372]
Ratio of dependent members	-0.532***	[0.154]	0.370	[0.301]
Dummy for a female-headed household	-0.275**	[0.132]	(dropped)	
Age of the household head	-0.001	[0.002]	0.004	[0.003]
Literacy rate of working-age adults	0.311***	[0.119]	0.024	[0.193]
Per-capita value of assets other than those below	0.014**	[0.007]	0.027	[0.027]
Per-capita outstanding credit	0.017***	[0.003]	0.030	[0.019]
Per-capita value of farmland	0.081***	[0.020]	-0.100	[0.080]
Per-capita value of livestock	0.041***	[0.013]	-0.031*	[0.018]
Dummy for non-agricultural employment, permanent	0.010	[0.054]	-0.120	[0.098]
Dummy for regular remittance receipt	0.183*	[0.110]	-0.255	[0.185]
R-squared			0.896	
F-stat. for zero coef. on all base slopes and the same coeff of village-spec. intercept			12.55***	
F-stat. for zero coef. on all additional slopes interacted with the attrition dummy			1.24	

Notes: See Appendix Table 3 for summary statistics of the explanatory variables. The additional slope for the attritor households w.r.t. female headed household was dropped as no such household dropped out of the sample.

Appendix Table 3. Estimation of the Livelihood Asset through Regression Analysis

	Dependent variable: Welfare ratio			
	1996		1999	
	Summary statistics	Regression results	Summary statistics	Regression results
Village-specific intercept				
Village A	0.201	1.003***	0.206	0.937***
	(0.402)	[0.115]	(0.405)	[0.131]
Village B	0.270	1.104***	0.251	0.948***
	(0.444)	[0.117]	(0.434)	[0.120]
Village C	0.529	1.197***	0.544	1.123***
	(0.500)	[0.123]	(0.499)	[0.121]
Household wealth characteristics				
Number of household members	11.843	-0.012**	12.222	-0.006
	(6.854)	[0.006]	(7.606)	[0.005]
Ratio of females in the household	0.484	-0.017	0.483	0.070
	(0.129)	[0.143]	(0.126)	[0.182]
Ratio of dependent members in the household	0.488	-0.481***	0.492	-0.644***
	(0.184)	[0.136]	(0.189)	[0.133]
Dummy for a female-headed household	0.005	-0.261**	0.014	0.007
	(0.072)	[0.121]	(0.118)	[0.128]
Age of the household head	52.259	-0.001	54.735	0.001
	(16.411)	[0.001]	(15.809)	[0.001]
Literacy rate of working-age adults	0.278	0.349***	0.323	0.176*
	(0.257)	[0.101]	(0.258)	[0.092]
Per-capita value of household assets such as agricultural machinery, transport equipment, durable goods, etc. (Rs. 1,000 in 1996 prices)	2.494	0.015**	0.597	0.219***
	(6.259)	[0.007]	(0.963)	[0.043]
Per-capita outstanding credit including informal lending to others (Rs. 1,000 in 1996 prices)	0.967	0.017***	0.719	0.013
	(5.778)	[0.003]	(3.605)	[0.013]
Per-capita value of farmland owned by the household (Rs. 100,000 in 1996 prices)	0.488	0.081***	0.366	0.120***
	(1.500)	[0.020]	(0.919)	[0.024]
Per-capita value of livestock owned by the household (Rs. 100,000 in 1996 prices)	1.531	0.039***	0.934	0.060*
	(2.656)	[0.011]	(1.297)	[0.034]
Dummy for a household with workers employed in nonagricultural employment on a permanent basis	0.551	-0.013	0.583	-0.089**
	(0.498)	[0.047]	(0.494)	[0.043]
Dummy for a household that regularly receives remittances from family members living separately	0.086	0.164*	0.184	0.127*
	(0.281)	[0.097]	(0.388)	[0.075]
Mean of the dep.var / R-squared	0.957	0.893	0.994	0.902
(Std.Dev.) of the dep.var / F-stat. for zero slopes	(0.473)	14.28***	(0.512)	15.71***
Number of observations	354	354	351	351

Notes: (1) In the summary statistics column, weighted means are reported with standard deviations shown in parentheses. (2) Huber-White robust standard errors are shown in brackets. (3) WLS regression with village fixed effects (no intercept) is employed. (4) Weights are the same as those described in Table 2. (5) Statistically significant at the 1% (***), 5% (**), and 10% (*) level. (6) In the 1996 regression, the number of observations is 344 as one observation was excluded due to the non-availability of consumption data. In the 1999 regression, the number of observation is 351 as we included split and replacement households.

Appendix Table 4. Test for Convergence

	Dependent variable: Change in assets from 1996 to 1999		
	D_livestock	*D_farmland*	*D_livelihood asset*
Evaluated at the 25% percentile			
Point estimate of the slope on the lagged asset	-0.265	-0.788	-0.289
F-statistics for the null that the slope is zero	0.23	6.67	1.20
p-value	0.6329	0.0103	0.2749
F-statistics for the null that the slope is -2	10.10	15.80	42.32
p-value	0.0016	0.0001	0.0000
Evaluated at the median			
Point estimate of the slope on the lagged asset	-0.661	-0.737	-0.434
F-statistics for the null that the slope is zero	32.45	7.05	6.64
p-value	0.0000	0.0084	0.0105
F-statistics for the null that the slope is -2	132.87	20.72	86.70
p-value	0.0000	0.0000	0.0000
Evaluated at the 75% percentile			
Point estimate of the slope on the lagged asset	-0.792	-0.383	-0.293
F-statistics for the null that the slope is zero	10.52	15.43	1.15
p-value	0.0013	0.0001	0.2847
F-statistics for the null that the slope is -2	24.45	275.09	39.05
p-value	0.0000	0.0000	0.0000

Notes: Point estimates and test statistics are based on specifications reported in Table 2. If the null hypothesis is rejected in favor of the point estimate between -2 and 0, local convergence evaluated at each percentile is suggested.

Appendix Table 5. Robustness Check 1 (Addition of More Controls)

	Dependent variable: Change in assets from 1996 to 1999		
	D_livestock	*D_farmland*	*D_livelihood asset*
Initial level of each asset			
Linear	-0.797***	-0.324***	-0.260
	[0.214]	[0.087]	[0.436]
Squared	-0.013	0.338	0.964
	[0.085]	[0.211]	[0.722]
Cubic	0.046	-0.169**	0.937
	[0.054]	[0.076]	[0.727]
4th degree	-0.007	0.023**	-2.606**
	[0.006]	[0.009]	[1.253]
5th degree	0.000	-0.001**	1.057
	[0.000]	[0.000]	[0.907]
Demographic controls			
Initial hh size	-0.020	0.015	0.013
	[0.017]	[0.011]	[0.008]
D_hh size	-0.028	-0.022	-0.025***
	[0.018]	[0.013]	[0.005]
Literacy rate of working-age adults	-0.275	0.442***	0.067
	[0.364]	[0.134]	[0.192]
Other initial household assets			
Ratio of females in the household	0.763	0.149	-0.023
	[0.576]	[0.176]	[0.136]
Ratio of dependent members in the household	-0.133	-0.257	-0.113
	[0.601]	[0.210]	[0.228]
Age of the household head	0.005	-0.001	-0.002
	[0.005]	[0.003]	[0.002]
Per-capita value of other hh assets	-0.004	-0.003	-0.012
	[0.012]	[0.007]	[0.010]
Per-capita outstanding credit	-0.002	-0.006	-0.008
	[0.020]	[0.006]	[0.008]
Response to village-level shock (coefficient on the fixed effect)			
Village A	-0.665***	-0.297***	-0.029
	[0.146]	[0.095]	[0.055]
Village B	-0.714***	-0.113	-0.052
	[0.185]	[0.082]	[0.046]
Village C	-0.461***	-0.099	0.076**
	[0.167]	[0.078]	[0.032]
Response to household-level shock			
Agricultural shock	-0.017	-0.023	-0.027
	[0.121]	[0.080]	[0.028]
Off farm work shock	-0.039	0.058	-0.063
	[0.250]	[0.083]	[0.046]
Other shock	-0.204	-0.134**	-0.045
	[0.155]	[0.062]	[0.038]
R-squared	0.786	0.396	0.360
F-stat. for zero coef. on non-linear terms	6.96***	3.11**	5.98***
F-stat. for homogenous village f.e.	0.76	3.67**	3.58**
F-stat. for zero coef. on hh-level shocks	0.71	1.84	1.64

Notes: See Table 2. Summary statistics of the additional variables under "Other initial household assets" are provided in Appendix Table 3. From the list of potential controls in Appendix Table 3, continuous variables were added to the regression because the addition of dummy variables resulted in a high level of multicollinearity in our dataset.

Reference Table 6. Robustness Check 2 (Unweighted Regression Results)

	Dependent variable: Change in assets from 1996 to 1999		
	D_livestock	*D_farmland*	*D_livelihood asset*
Initial level of each asset			
Linear	-0.762***	-0.414***	-0.376**
	[0.179]	[0.081]	[0.149]
Squared	-0.033	0.134	0.898*
	[0.074]	[0.219]	[0.477]
Cubic	0.050	-0.062	0.781
	[0.046]	[0.095]	[0.592]
Fourth degree	-0.007	0.007	-2.230***
	[0.005]	[0.013]	[0.842]
Fifth degree	0.000	0.000	0.838
	[0.000]	[0.001]	[0.623]
Demographic controls			
Initial hh size	-0.016	0.010	0.000
	[0.018]	[0.009]	[0.005]
D_hh size	-0.033*	-0.025**	-0.026***
	[0.017]	[0.011]	[0.004]
Literacy rate of working-age adults	-0.215	0.328***	0.059
	[0.340]	[0.106]	[0.091]
Response to village-level shock (coefficient on the fixed effect)			
Village A	-0.594***	-0.169**	-0.006
	[0.117]	[0.072]	[0.043]
Village B	-0.679***	-0.081	-0.066
	[0.160]	[0.081]	[0.042]
Village C	-0.387**	-0.051	0.090***
	[0.157]	[0.068]	[0.030]
Response to household-level shock			
Agricultural shock	0.043	-0.062	0.001
	[0.136]	[0.087]	[0.028]
Off farm work shock	-0.021	0.057	-0.048
	[0.200]	[0.074]	[0.038]
Other shock	-0.206*	-0.086*	-0.073**
	[0.120]	[0.049]	[0.031]
R-squared	0.631	0.503	0.283
F-stat. for zero coef. on non-linear terms	12.11***	1.07	4.80***
F-stat. for homogenous village f.e.	1.08	2.21	5.63***
F-stat. for zero coef. on hh-level shocks	1.09	1.05	2.51*

Notes: Esimated by OLS. See Table 2 for other notes.

Appendix Table 7. Robustness Check 3 (Disaggregated Household-level Shocks)

	Dependent variable: Change in assets from 1996 to 1999		
	D_livestock	*D_farmland*	*D_livelihood asset*
Initial level of each asset			
Linear	-0.749***	-0.432***	-0.370**
	[0.179]	[0.077]	[0.151]
Squared	-0.039	0.169	0.919*
	[0.075]	[0.217]	[0.480]
Cubic	0.050	-0.077	0.754
	[0.046]	[0.094]	[0.601]
Fourth degree	-0.007	0.009	-2.289***
	[0.005]	[0.013]	[0.862]
Fifth degree	0.000	0.000	0.884
	[0.000]	[0.001]	[0.644]
Demographic controls			
Initial hh size	-0.012	0.012	0.001
	[0.017]	[0.010]	[0.005]
D_hh size	-0.030*	-0.024**	-0.026***
	[0.017]	[0.011]	[0.004]
Literacy rate of working-age adults	-0.272	0.288***	0.051
	[0.347]	[0.098]	[0.094]
Response to village-level shock (coefficient on the fixed effect)			
Village A	-0.598***	-0.187***	-0.007
	[0.117]	[0.071]	[0.043]
Village B	-0.635***	-0.093	-0.066
	[0.160]	[0.076]	[0.042]
Village C	-0.357**	-0.064	0.089***
	[0.162]	[0.066]	[0.031]
Response to household-level shock			
Agricultural shock, crop failure	0.036	0.084	0.031
	[0.300]	[0.108]	[0.047]
Agricultural shock, price fall	0.038	-0.232*	-0.035
	[0.260]	[0.125]	[0.046]
Off farm work shock, loss of employm	-0.396	-0.091	-0.068
	[0.331]	[0.059]	[0.058]
Off farm work shock, wage fall	0.277	0.156	-0.037
	[0.216]	[0.137]	[0.043]
Other shock	-0.224*	-0.093*	-0.073**
	[0.122]	[0.051]	[0.032]
R-squared	0.636	0.511	0.286
F-stat. for zero coef. on non-linear terms	12.71***	1.20	4.93***
F-stat. for homogenous village f.e.	1.10	2.32	5.49***
F-stat. for zero coef. on hh-level shocks	1.26	1.35	1.56

Notes: "Agricultural shock" and "Off farm work shock" in Table 2 are disaggregated into 2 variables each. Now the all of the five shock variables are indicators variable taking the values of -1, 0, and 1. See Table 2 for other notes.

Appendix Table 8. Robustness Check 4 (Aggregated Household-level Shocks)

	Dependent variable: Change in assets from 1996 to 1999		
	D_livestock	*D_farmland*	*D_livelihood asset*
Initial level of each asset			
Linear	-0.744***	-0.419***	-0.361**
	[0.180]	[0.082]	[0.151]
Squared	-0.027	0.142	0.886*
	[0.074]	[0.232]	[0.482]
Cubic	0.045	-0.065	0.751
	[0.046]	[0.099]	[0.592]
Fourth degree	-0.007	0.007	-2.249**
	[0.005]	[0.014]	[0.868]
Fifth degree	0.000	0.000	0.861
	[0.000]	[0.001]	[0.630]
Demographic controls			
Initial hh size	-0.018	0.009	0.000
	[0.018]	[0.009]	[0.005]
D_hh size	-0.035**	-0.027**	-0.026***
	[0.017]	[0.012]	[0.005]
Literacy rate of working-age adults	-0.200	0.346***	0.060
	[0.343]	[0.111]	[0.092]
Response to village-level shock (coefficient on the fixed effect)			
Village A	-0.604***	-0.166**	-0.006
	[0.118]	[0.072]	[0.042]
Village B	-0.711***	-0.086	-0.071*
	[0.155]	[0.079]	[0.041]
Village C	-0.416***	-0.058	0.085***
	[0.160]	[0.069]	[0.030]
Response to household-level shock			
Sum of the three types of shocks	-0.048	-0.035	-0.035**
	[0.085]	[0.029]	[0.017]
R-squared	0.629	0.499	0.276
F-stat. for zero coef. on non-linear terms	12.31***	1.12	4.43***
F-stat. for homogenous village f.e.	1.12	1.98	5.48***

Notes: "Agricultural shock", "Off farm work shock", and "Other shock" in Table 2 are added to construct one householdlevel shock variable. It is an indicator variable taking the values of -3, -2, -1, 0, 1, 2, and 3. See Table 2 for other notes.

Appendix Table 9. Robustness Check 5 (Change in Household Size Excluded)

	Dependent variable: Change in assets from 1996 to 1999		
	D_livestock	*D_farmland*	*D_livelihood asset*
Initial level of each asset			
Linear	-0.846***	-0.398***	-0.542***
	[0.210]	[0.090]	[0.199]
Squared	-0.012	0.369*	-0.005
	[0.086]	[0.223]	[0.645]
Cubic	0.052	-0.176**	1.067
	[0.054]	[0.078]	[0.820]
Fourth degree	-0.008	0.024***	0.161
	[0.006]	[0.009]	[1.075]
Fifth degree	0.000	-0.001**	-0.594
	[0.000]	[0.000]	[0.859]
Demographic controls			
Initial hh size	-0.005	0.020**	0.012*
	[0.014]	[0.010]	[0.006]
Literacy rate of working-age adults	-0.390	0.390***	0.126
	[0.369]	[0.133]	[0.151]
Response to village-level shock (coefficient on the fixed effect)			
Village A	-0.665***	-0.283***	-0.012
	[0.133]	[0.086]	[0.053]
Village B	-0.680***	-0.110	0.013
	[0.183]	[0.084]	[0.058]
Village C	-0.461***	-0.114	0.121***
	[0.165]	[0.083]	[0.031]
Response to household-level shock			
Agricultural shock	0.003	-0.012	-0.029
	[0.125]	[0.080]	[0.034]
Off farm work shock	-0.028	0.095	-0.021
	[0.243]	[0.095]	[0.047]
Other shock	-0.279**	-0.189**	-0.106**
	[0.139]	[0.080]	[0.045]
R-squared	0.781	0.371	0.226
F-stat. for zero coef. on non-linear terms	6.78***	2.83*	0.78
F-stat. for homogenous village f.e.	0.67	3.95**	2.98*
F-stat. for zero coef. on hh-level shocks	1.64	2.17*	2.34*

Notes: "D_hh size" in Table 2 is excluded from the regression as the variable is more endogenous than others. See Table 2 for other notes.