Three essays on productivity in post-Soviet primary agriculture

by

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For the Graduate College

In memory of my father, Arnold Sergeyevich

To my family: Alexander, Anna, and Svetlana

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1. GENERAL INTRODUCTION

Introduction

The dissertation consists of three essays that analyze relative growth of subsidiary farming and a decline in the production of collective farms in post-Soviet Ukraine. The first two essays consider the change in the production shares of the collective and subsidiary sectors as two interrelated phenomena. The analysis is built on the observation that all the employees of the collective farms have access to subsidiary plots. We analyze whether a shift of labor from collective farming towards subsidiary farming may be explained by a rational reaction of households to income uncertainty (the first essay) and to a decline in wages and increased land availability (the second essay). The third essay identifies human capital and farm organization factors that slowed the decline in production at some collective farms compared with others at the early stages of reforms.

As illustrated below, the process of economic reforms in Ukrainian agriculture is far from complete. Land reform has led to transfer of state land to collective and private ownership, but internal farm restructuring has hardly begun. Collective forms of organization continue to dominate agriculture in Ukraine, Russia, Byelorussia, and in some other former Soviet Union countries. Former collective farms control most of the land and remain major employers in rural areas. Yet, subsidiary private agriculture has grown sharply in many post-Soviet countries since the beginning of economic reforms in the early 1990s. It represented nearly a half of gross agricultural output in Russia and Ukraine by 1997, up from approximately a quarter of gross agricultural output in the Soviet Union in 1990 (World Bank, 1994). However, in contrast, the share of gross agricultural land under the subsidiary plots increased from approximately 8 percent to only 12-15 percent during the same period.

Because of the growth in relative importance of output from subsidiary private agriculture, analysis of the changes in economic activity of the collective farms and their employees may help in understanding of the current trends in post-Soviet agricultural production. A better understanding of the economic motives behind the observed phenomena may in turn help in the development of new agricultural policies aimed at speeding up the process of reforms.

The following questions are addressed in the three essays.

1) Can the growth of the subsidiary household plot share in the gross agricultural output be explained, in part, by a rational shift of labor from wage work to subsidiary farming in response to uncertainty in wage income? Similarly, can increased involvement of pensioners in subsidiary farming be a rational reaction to uncertainty in pensions?
2) Can a decline in real wages cause shift of labor from wage work to subsidiary work? Do official statistics support the hypothesized shift of labor from wage work to subsidiary farming?
3) What factors determine the success in collective farm adaptation to the changing economic conditions during the transition from planned economy toward the market oriented one? Why do some collective farms perform better than others do?

The first essay is a theoretical analysis of the effects of uncertainty in income on labor allocation decisions of households that have access to subsidiary plots. An agricultural household model with wage uncertainty is used for the analysis.

The second essay combines the theoretical approach of the agricultural household model with empirical evidence to study redistribution of labor between wage work and subsidiary farming in response to a decline in wages. An increase in the share of the gross agricultural output produced at the subsidiary plots is estimated as a function of changes in labor, land, and other input application using official region-level Ukrainian data.

In the third essay, we estimate a frontier production function, examine the changes in technical efficiency at the earliest stages of economic reforms, and evaluate the relationship between technical efficiency and farm workforce composition using Ukrainian farm-level survey data.

The dissertation is organized as follows. The rest of the Introduction details the current state of economic reforms in the Ukrainian agriculture. Chapters 2 through 4 describe the three studies conducted. Each of the three chapters starts with the research question, followed by the justification of the study, literature review, presentation of models used, and results. The chapters conclude with discussion and interpretation of findings. Lengthy mathematical proofs are collected in the Appendix.

Purpose and scope of economic reforms in agriculture

Creation of a market-oriented privatized agriculture is an important component of overall economic reforms started in Ukraine in the early 1990s. Unlike for western industrialized countries, Ukraine's agricultural sector traditionally accounted for a prominent share of aggregate output and employment. In 1992, primary agriculture contributed 19% to the Ukrainian net material product, and employed about 20% of the labor force (World Bank, 1994). Because of its importance, agriculture has often been considered as an engine that can drive the process of reforms in Ukraine (Csaki and Lerman, 1997).

The ultimate goal of the reforms in agriculture is transformation of the agricultural sector into an efficient and productive system based on private ownership and individual incentives.

In order to achieve this goal, several directions of the reforms have been recommended. Several categorizations of the directions are possible, including the following one by World Bank analysts (World Bank, 1994; Csaki and Lerman, 1997; Sedik, Truebold, and Arnade, 1999):

1) Creation of a new macroeconomic framework for agriculture, including
    a) liberalization of prices and markets for farm products and inputs, and
    b) opening the economy for foreign trade.
2) Land reform, including
    a) privatization of land and
    b) restructuring of traditional socialist farming units into operations consistent with market principles; and
3) Setting up of a competitive market environment, including
    a) privatization and demonopolization of agro-processing, input supply, services, trade, and financial system,
    b) establishment of a legal system capable of enforcing contracts, and
    c) elimination of subsidies for collective production and restrictions on private production.

Only the recommendation on land reform is specific to agriculture. The other two domains of reform relate to the general economy and focus on "upstream " and "downstream" areas of the agricultural sector.

However, all three levels of the reform are inter-related, and progress on one of the issues can not compensate for failure to move forward in the other ones. Yet up to this date, the reforms are far from being complete in any of these directions. Contemporary Ukrainian agriculture is in the stage of transition with elements of both the old command and the new market system at work. The next sections highlight some of the achievements and failures in the reform progress.

Worsening agricultural terms of trade

The overall economic reforms started in Ukraine with limited price liberation and introduction of private property. Prices for purchased inputs grew much faster than farm gate prices for agricultural products that were still controlled by the Government (UIAE, 1996; Pogozheva and Chenard, 1997; Van Atta et al., 1998) (Fig. 1.1). In Ukraine, the price of fuel increased more than 300,000 times, the price of fertilizers and chemicals more than 100,000 times, and machinery prices grew more than 60,000 times between 1991 and 1995. The price of grain, however, rose "only" 22,000 times and the price of sugar beets increased less than 40,000 times over the same period (Csaki and Lerman, 1997).

These changes have resulted in inadequate input applications and contributed to declining output levels (Pogozheva and Chenard, 1997; Sedik, Truebold, and Arnade, 1999) and farm incomes (Kakwani, 1996). Decreased farm income in the presence of high nominal interest rates, in turn, contributed to reduced farm investment. By 1996, Ukrainian

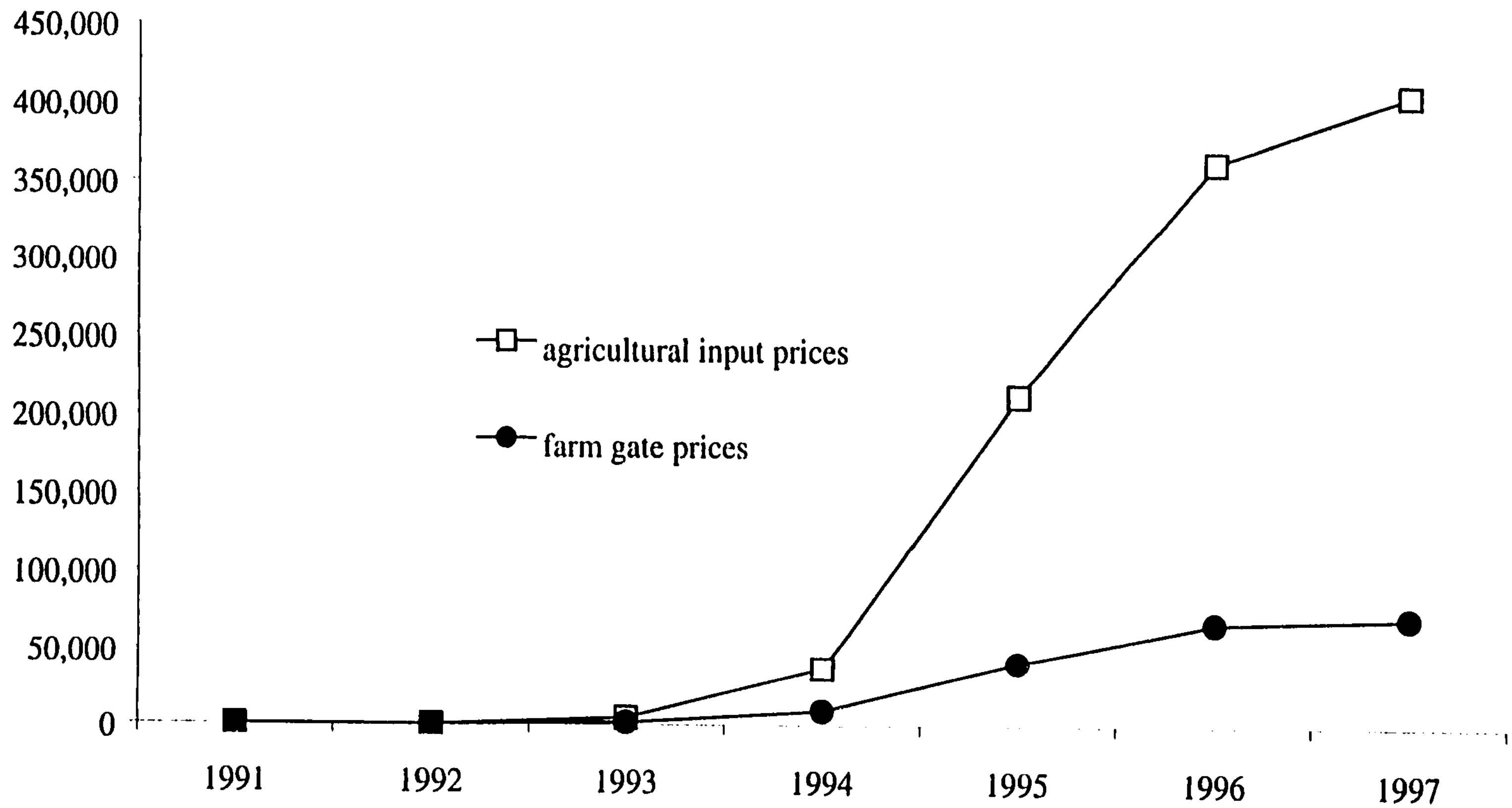

Figure 1.1. Ukraine: Agricultural input and output price indices; 1990=1
Source: OECD, 1998

GDP dropped to 43% of its 1990 level, and gross agricultural product dropped to 59% of the 1990 level (Csaki and Lerman, 1997). Standard measures of agricultural productivity, i.e., output per worker, crop yields, milk per cow, and animal slaughter weights, clearly deteriorated (ibid.). Although areas sown to crops have decreased since 1990 by only 5%, the production of main cash crops, cereals and sugar beets dropped by 30% - 40% between 1990 and 1995.

The Government of Ukraine used short-term adjustment policies to stabilize farm income and food production. Agricultural producers were provided with compensation payments (UIAE, 1996) and farm inputs in exchange for sales of production to the state (Pogozheva and Chenard, 1997; Van Atta et al., 1998). Yet, most of the collective sector farms have been unprofitable since 1996 (SCSU, 1997). Some 92% of Ukrainian farms reported losses in 1998 (RFE/RL, 1999).

Collective enterprises continue to bear little responsibility for the financial results of their operations. Debts continue to be postponed and written off: in 1998, Ukrainian President Kuchma signed a decree postponing payment of huge debts to the state which collective and state agricultural producers incurred since 1992 (EEAF, 1998). In June of 1999, collective farms owed the state around 3 million tons of grain (roughly 10% of the yearly Ukrainian harvest) for inputs provided in 1997-1998; in 1998, the state wrote off debts worth 4 million tons of grain for 1994-1996 (Survey of the Press, 1999).

Decline and uncertainty in incomes

Wages have always been the primary source of income in Ukraine: in 1995, 70% of Ukraine's population lived on an official salary received from state organizations (World

Bank, 1996). Real wages have declined rapidly in all sectors of the economy since the beginning of reforms in the early 1990s (Fig. 1.2). Furthermore, wage arrears and deferments in government-provided social benefits lasting for several months became systematic in Ukraine (Fig. 1.3).

The wage situation in collective agriculture is not different from the rest of the economy. The real average wage accrued in agriculture in 1996 was merely 27% of that in 1991 (SCSU, 1997).

According to a random survey of some 1600 employees of the collective sector in agriculture conducted by the World Bank, some 77% of the respondents experienced payroll arrears in 1995. Among them, one fourth reported 7 to 12 months with irregular salary payments in 1995 (Csaki and Lerman, 1997).

By the end of 1998, virtually all of the 3 million employees of former collective and state farms were affected by wage arrears with an average delay in wage payments of 7.6 months per employee (MAPCU, 1999). Farm-level surveys provide similar data: Perotta (1999b) found that none of the 959 respondents of a survey of Ukrainian farm employees reported timely paid wages. Some 47% of the respondents were not paid more than six months of wages at the end of 1998, and 13% had not been paid cash wages for two years or more. Not surprisingly, the sale of surplus from subsidiary farming was often claimed to be the main or only source of cash for rural residents in this survey.

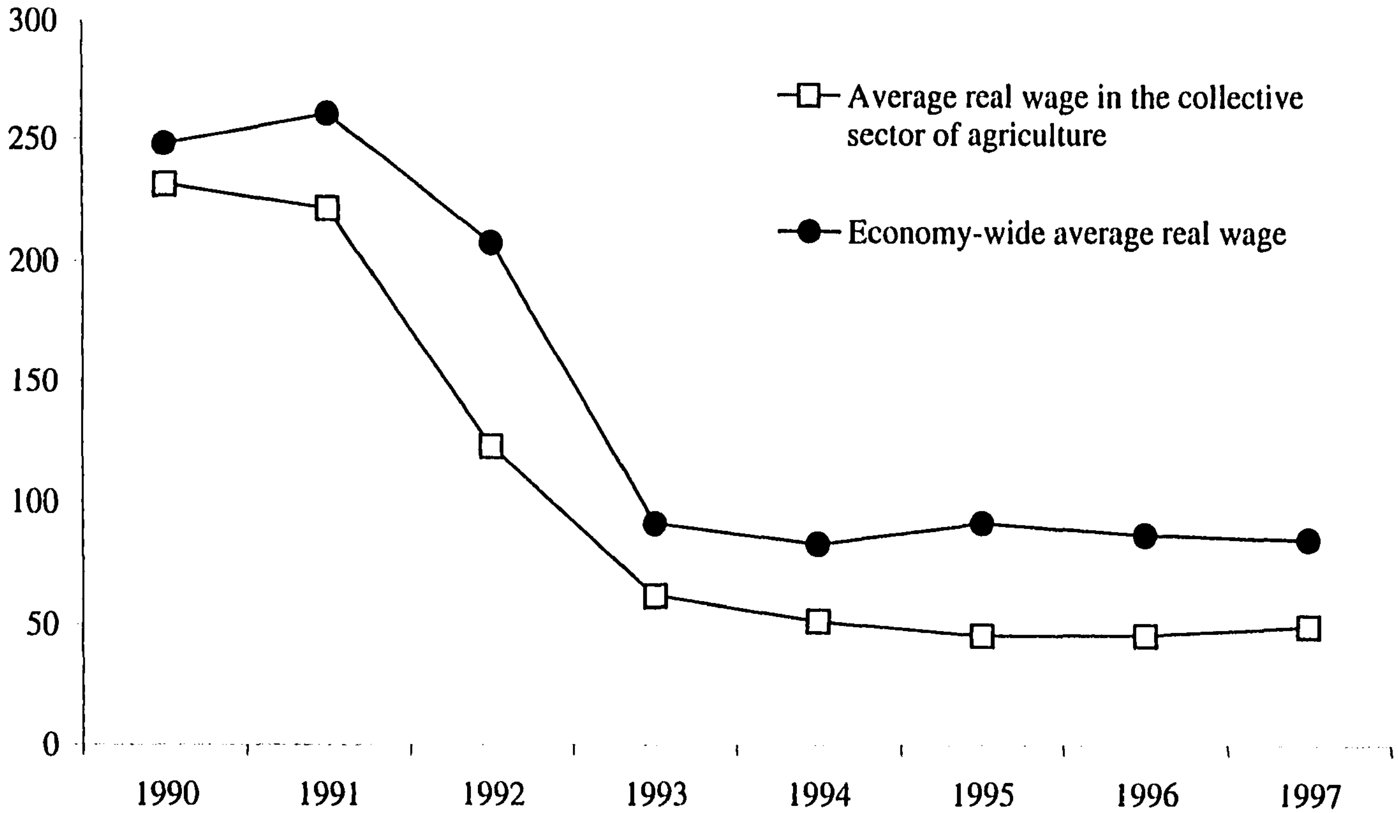

Figure 1.2. Ukraine: real wages per month; 1990 Krb.
Sources: MSU, 1992, 1996; World Bank, 1996; SCSU, 1997; Ukrainian Economic Trends, 1998; MAPCU, 1999.

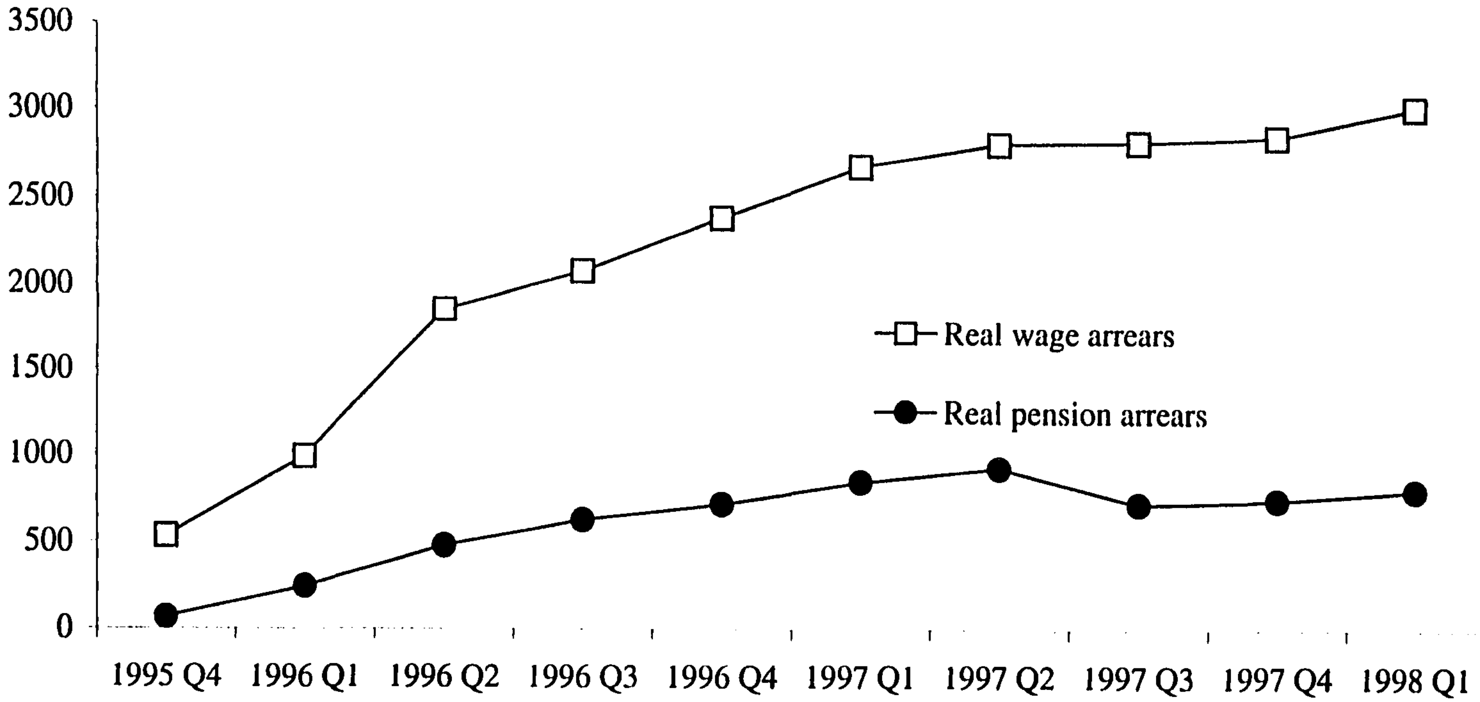

Figure 1.3. Ukraine: Wage and pension arrears; mln. 1990 Krb.
Source: Ukrainian Economics Trends, 1998

Institutional structure of primary agriculture

Inherited institutional structure

The collective farming system was an integral part of Ukraine's centrally planned national economy. It consisted mainly of two centrally controlled types of large-scale farms: collective and state. Output and all assets of the collective farms were owned jointly by their members, whereas those of the state farms were owned by the state. The differences, however, were practically eliminated after World War II with the adoption of guaranteed wages for the collective farm members and provision of credit, much of which was later written off. In 1992, there were 9,080 collective and 2,643 state farms in Ukraine. On average, they employed 355 and 439 workers, and had 2,731 and 3,254 hectares of farmland, respectively (World Bank, 1994). The well being of the farms depended not on financial results of production, but on how well the centrally planned production targets were met.

The private sector consisted of so-called subsidiary household plots (SHP) of the state and collective farm members and gardens and vegetable plots allocated to urban citizens. In the second half of the 1980s an estimated 2.8 million families used 2.7 million hectares (6.2% of the total Ukrainian arable land) to produce 30% of livestock and 20% of the gross agricultural production in Ukraine (World Bank, 1994). However, the relatively high productivity of private agriculture is likely to be overestimated, as the household plots' production was intensively supported by the large scale state and collective farms through provision of critical inputs (fertilizer, seeds, farm machinery and transport, feed, pastures, etc.), often free of charge. Large industrial enterprises often subsidized their workers' gardens and vegetables plots production through provision of transportation and purchase of some production inputs at subsidized prices. The creation of independent family farms did not start until 1990.

Land reform

Csaki and Lerman (1997) and Lerman, Brooks, and Csaki (1994) provide useful information on Ukraine's land reform.

Before the reforms started, agricultural land was 100 percent state owned, and the Soviet system recognized user rights to the state-owned land only. Legislation adopted in 1990-92 recognized three forms of land ownership: state, collective, and private. Exclusively state ownership remained for a reasonably restricted list of lands, while all other lands became transferable to collective and private ownership. Collective ownership is a transitional form from state to private ownership. The land under gardens and vegetable plots of urban citizens and under SHP became private ownership directly. The transfer of land from the state to collective and private ownership is free except for private farmers, who must pay the state for any land in excess of the average land share as calculated on a per-capita basis for each district.

Under the new laws, all citizens of Ukraine are entitled to own land. However, the current Land Code establishes *severe restrictions* on transactions, use, and the size of the privately owned land. The restrictions include a six-year moratorium on selling of privately owned land (still in place as of July 1999), prohibition of leasing out the land for more than 5 years in duration, and mandatory continuous use of land for farming. Legitimate non-farming uses include construction of "dachas" (second homes in rural areas), and garage or storage spaces. If any of these conditions is violated, the private land is taken away by local authorities.

The size of the privately owned land unit is restricted to not exceed 50 ha in a private farm, 0.6 ha in a SHP, and 0.25 ha for residential construction in rural areas. Urban residents are allowed to own up to 0.12 ha under a garden plot, up to 0.01 ha under a garage plot, and no more than 0.1 ha for a "dacha" (Lerman, Brooks, and Csaki, 1994).

The pool of land available for distribution into private ownership was set up through creation of a state land reserve and special reserve.

Collective and state farms had to extract up to 10% of their land for the state reserve. The reserve is a source of land for new users, who are not members or employees of existing farm enterprises ("outsiders"). Reserve land that has not been actually allocated to individuals remains in temporary use by the collective or state farm. However, as of 1996, individuals had received only 50% of the total reserve of 6.2 million hectares.

"Insiders", i.e. members or employees of existing farm enterprises received land for SHP augmentation from a special reserve created by extracting an additional 15% of the remaining land in collective and state farms.

The land remaining after the extraction transfers to collective ownership. Most of the collectively owned land is to be distributed among the members of the collective, including social sphere workers and pensioners residing in the village. The collective land is divided through calculation of *land shares* in the form of individual certificates of entitlement.

The land share represents the right of an individual to private ownership of a plot of land *without* physical demarcation of that plot in the field or even on a map. The land shares are more tradable than actual land plots, at least on paper. However, according to a World Bank survey, the determination of land shares practically began in 1995, and only half of former state and collective farms had calculated land shares as of February 1996 (Csaki and Lerman, 1997).

The 1990-92 legislation states that every individual is free to leave the collective with a physical plot of land, and the private ownership then will be certified by an official title. Yet as of 1997, most of the land in Ukraine is in collective, and not private, ownership: privately owned land accounted for 15%, and collectively owned for 65% of the total country's land (Csaki and Lerman, 1997).

The first laws of land reform provided a legal basis for the expansion of private sector in Ukrainian agriculture. Private farms could now be created with land coming from the land shares and SHP of former collective farm members and state farm workers, and the land from the state reserve. In addition, land could be purchased from the state and leased from both state and non-state entities. However, lack of a functioning land market has hampered the development of a rural finance market, which, in turn, has limited further development of private agriculture.

Contemporary institutional structure

By 1997, because of the reforms, the number of SHP increased to 12 million, and nearly 35,000 private family farms emerged. However, today, the share of individual use of land in the Ukrainian agriculture is still very small, as the newly created private farms together with the SHP account for only 15% of agricultural land (Csaki and Lerman, 1997) (Fig. 1.4). Some 65% of the land is in collective use, and 17% of the land is in state farms.

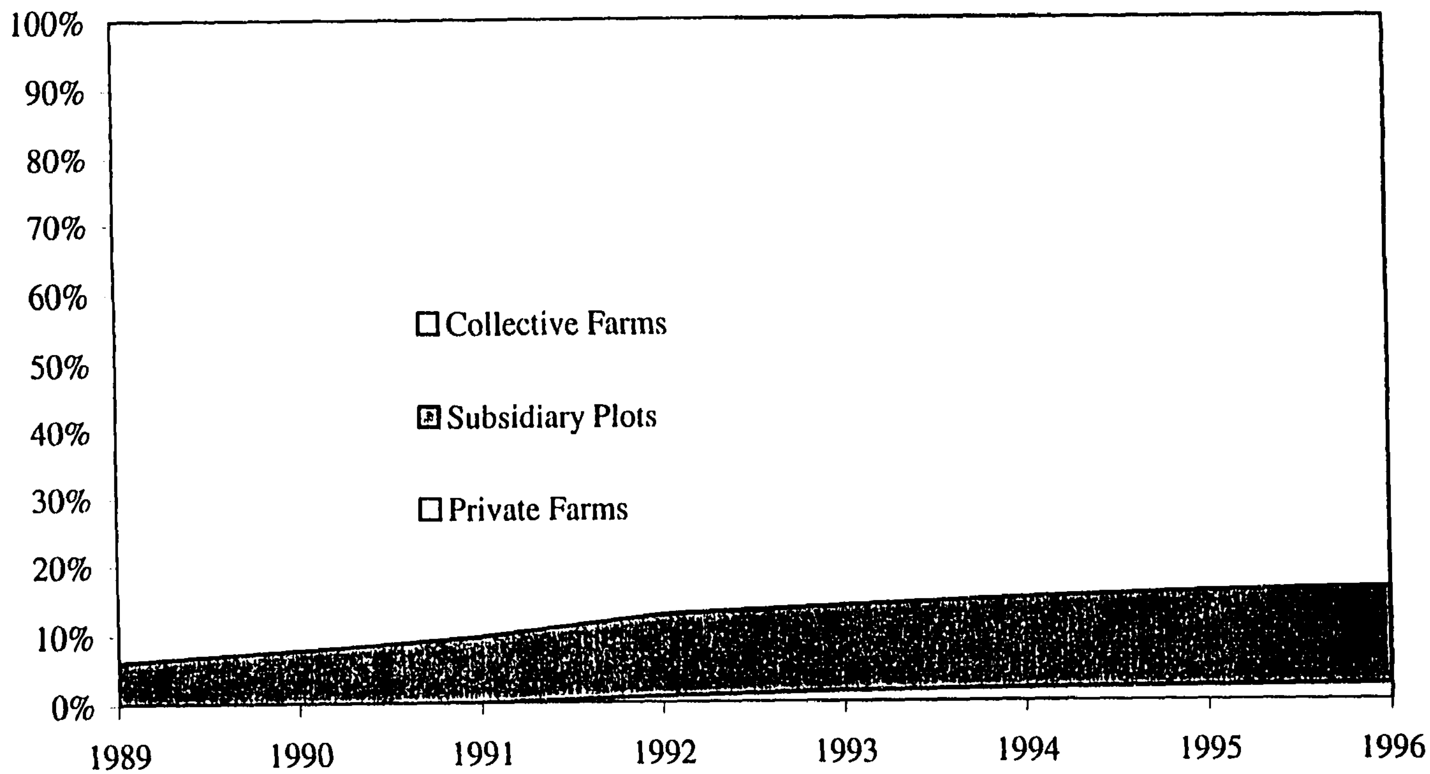

Figure 1.4. Ukraine: Agricultural land by users; percent of total
Source: SCSU, 1997

The transfer of state land to collective ownership was the first step in the reorganization of former state and collective farms. The other steps are computation of land and asset shares, distribution of physical assets according to the shares, and, ultimately, internal reorganization of farms into enterprises based on private ownership and individual incentives. By 1997, some 80% of the collective and state farms reorganized into collective agricultural enterprises, farmers' unions, associations, cooperatives, partnerships, joint-stock societies, and state farms. Despite this diversity, the reorganization of the collective farming system in Ukraine (and in Russia) has been purely formal so far, as most of these farms reorganized into the new legal form of collective farm enterprise without any internal reorganization. Hereafter, we will refer to all the collective sector farms as to collectivist farms.

In addition to the land shares, division of farm assets by asset shares was determined at 74% of collectivist farms (Csaki and Lerman, 1997) by 1996. Where the land and assets shares were computed, most of the sharing process beneficiaries "invested" their shares into the collectivist farm thus becoming shareholders of a new corporate entity. However, the new farm organizational forms *have not* induced reallocation of resources, such as land, assets, and labor to market-oriented sub-units. Sedik, Foster, and Liefert (1996) report that in 1993 no changes occurred in large farm management practice. According to a World Bank survey, in 1996, 86% former state and collective farms preserved central management responsible for overall production planning. In addition, more than 80% of farm managers continued to endorse a lifetime employment policy for farm members. New units of the reorganized farms were allocated mostly the land and assets they had held under the old balance sheets (Csaki and Lerman, 1997).

Social responsibilities of collectivist farms

During the Soviet times, the state and collective farms not only produced agricultural output, but also provided most of the social and municipal services for the communities where they were located (World Bank, 1994; Sedik, Foster, and Liefert, 1996; Csaki and Lerman, 1997). Social assets, like central heating and water supply, local roads and lighting, child care and recreational facilities, public catering were actually built, operated, and financed by farm enterprises from their operating profits. While schools and medical services were state provided, the farms participated actively in their repair and provided their staff with housing and SHPs. The collectivist farms rendered social services and benefits, like products at subsidized prices and production support for their household plots, both for the farm employees and for other rural workers. As part of the reorganization process, the farms were expected to transfer their traditional responsibilities for social assets and provision of rural social services to local municipal councils.

However, according to World Bank surveys conducted in 1993/94 and 1995/96, the farms remain the primary providers of these services (Csaki and Lerman, 1997). Lerman, Brooks, and Csaki (1994) suggest that potential loss of farm-provided social benefits was considered as one of the main reasons for the decision of farm employees to remain on the collectivist farm. Local authorities could not afford to have these services on their accounts, whereas for the farm enterprises the cost of maintaining social infrastructure was relatively low. According to the 1993/94 survey, social infrastructure expenditures constituted 8.5% of total farm expenditures on average, and about 3% of the total farm labor force were social workers (Lerman, Brooks, and Csaki, 1994). The last number remained the same in 1996 (Csaki and Lerman, 1997).

Farm non-agricultural productive activities

Besides social services provision the collectivist farms often did their own building construction, machinery maintenance, and processing, and, in this way, have participated in the food industry vertical integration process (ILO, 1995). According to the 1993/94 World Bank survey, 12% of farm labor had non-agricultural occupations in 1993, such as processing, construction, and repairs (Lerman, Brooks, and Csaki, 1994). A survey conducted by the Ukrainian Institute of Agrarian Economics did not differentiate between social services and other non-agricultural occupations but provides similar total numbers. Some 14% of workers did not work directly in agricultural activities and 11% of farm total costs were not associated with agricultural activities on average in 1989-1992 years.

The involvement of collectivist farms in social services provision and non-agricultural activities made them, in practice, the exclusive employers in rural areas. The slow progress in restructuring of collectivist farms means then that there are still very limited employment opportunities in rural areas outside of the collective sector.

Role of subsidiary household plots (SHP)

The private sector of Ukrainian agriculture consists of the SHP of collectivist farm employees, gardens and vegetable plots of urban citizens, and officially registered private family farms.

Difference between SHP and officially registered private farms

The difference between the officially registered private family farms and the rest of the private sector is that the latter are worked part-time by people otherwise employed somewhere else or by those previously employed and now retired. The officially registered private farmers, in contrast, run their farms full-time. As Lerman, Brooks, and Csaki (1994, p.10) put it, "Private farmers produce for markets and consume a residual, unlike household subsidiary producers, who produce for their own use and market a residual."

Specialization and size reflect the difference. The average private farm was 23.6 hectares in 1997 (SCSU, 1997), while the average SHP was 0.5 hectares (Csaki and Lerman, 1997). Being smaller, the SHPs produce predominantly fruits, vegetables, and livestock products; much of the production is for subsistence (Valdes et al., 1997). The large private farms specialize in grains, sugar beets, and sunflower production (Csaki and Lerman, 1997).

Another dimension differentiating the two types of farms is that unlike the officially registered private farm production, the SHP production is tax-free.

Share of SHP in gross agricultural product

In 1980, in the USSR, the share of non-social economy in grain was estimated to be 1%, and that for sunflower seeds 2%, meat 31%, milk 30%, eggs 32%, wool 21%, vegetables 33%, and potatoes 64% (Omirova, 1983). In 1991, private household plot production occupied 10% of the Ukrainian agricultural land, and contributed 26% of total crop production and 34% to total livestock production. By 1996, the shares grew to 14, 49, and 56%, respectively (Fig. 1.5). The household plots accounted for 95 % of the country's potato production, 82 % of total vegetable production, and 74 % of Ukrainian fruit crop in 1996 (SCSU, 1997).

Extent of citizens' involvement into household production

The degree of citizen's involvement in household plot production is large for such an industrialized country as Ukraine; according to International Labor Office calculations

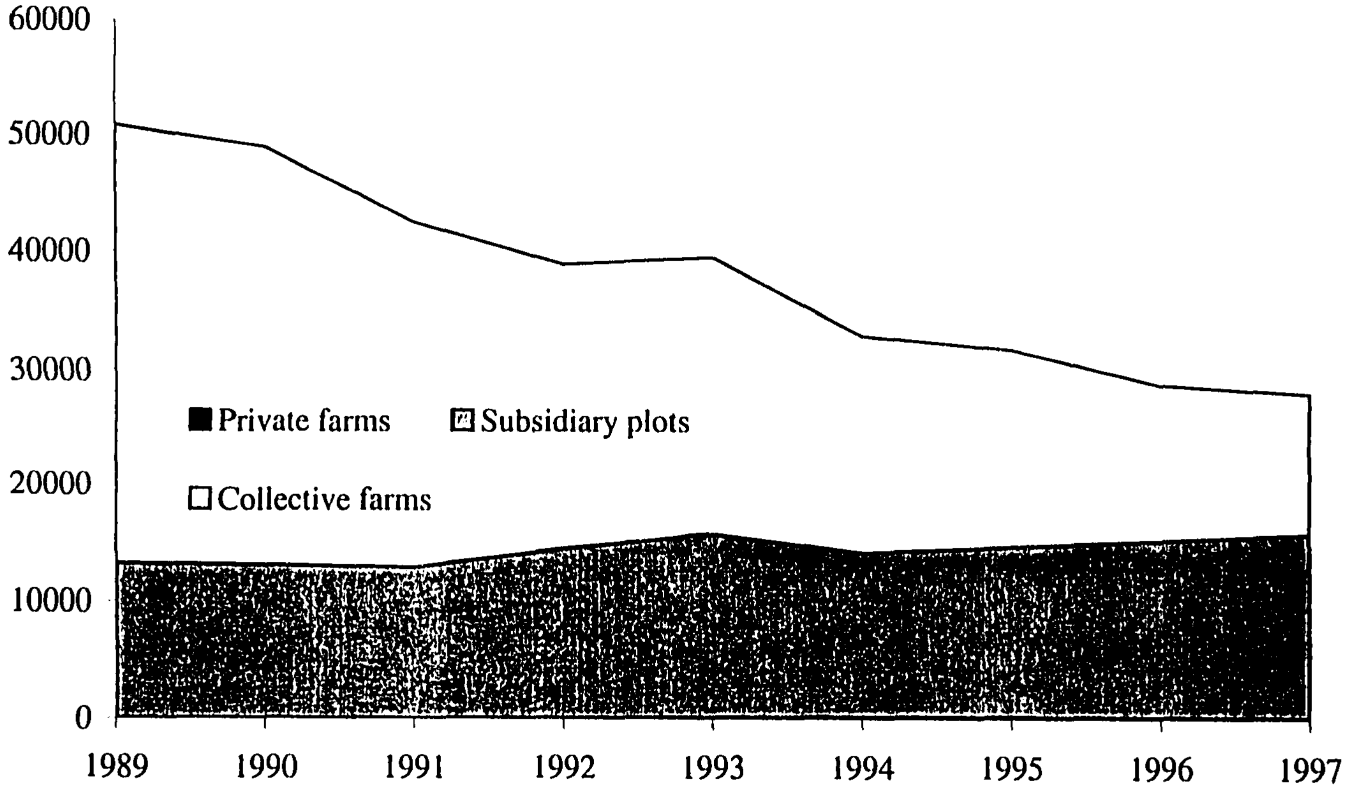

Figure 1.5. Ukraine: agricultural production; million 1983 Krb.
Source: Adapted from Csaki and Lerman, 1997

(ILO, 1995), urban residents possessed some 6.8 million private plots in 1993. That means that every second urban family was growing fruits, vegetables, and potatoes on the plots averaging 600 square meters. According to the official Ukrainian statistics, some 11 million people owned and worked subsidiary plots in 1996 (SCSU, 1997), i.e. approximately every fifth Ukrainian citizen is involved in subsidiary agricultural production. These numbers reflect the under-development of both labor and food markets as labor has no better opportunities than to work land to secure subsistent levels of food consumption.

Household plots as a source of income

Household plot production is an important source of income for people of Ukraine (Brainerd, 1995; Johnson, Kauffman, and Ustemko, 1996). Family Budget Surveys (FBS) reveal that the household plots provide a sizable share of collectivist farm employee income. The FBS were conducted in USSR annually and their aggregated results became first available to the public in the late 1980s. Both members of collective farms and state farm employees were represented in the surveys though in different sub-surveys. The state farm employees were combined with state employees in other sectors, while the collective farm member households were represented in a separate sub-survey.[1]

According to the FBS, state sector employees derived from 2.3% to 2.5% of their income from subsidiary plot production (MSUSSR, 1991). Because of the inclusion of rural

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[1]FBS design had several shortcomings (Atkinson and Micklewright, 1992). Exclusion of families of those employed in cooperative or private sectors and those not employed, over-representation of families with more than one member working in the state sector, and bias of the sample toward families of elder persons with longer working history are the most known ones. Pensioners are believed to be under-represented as some are included in state employee or collective farm member samples according to their previous employment (ibid.). Notwithstanding these shortcomings, the FBS are a valuable source of information on the importance of private household plots in total income of collectivist farm workers and the farm retirees.

state enterprise employees into one category with the urban ones, these numbers obviously underestimate this share for state farm employees while overstating the share for the urban workers.

An estimated 25.3% of collective farm member family income was derived from SHP in 1980 in USSR (Omirova, 1983). For Ukraine, the share was above the USSR average. The FBS show that 28 to 30 percent of the collective farm worker families' income came from subsidiary plot production in the period 1980-1990 (MSUSSR, 1991). These numbers might be under-estimated as well, as the SHP production that was consumed was valued at state prices as opposed to the marketed SHP production valued at the actual sale prices. While some share of the private household production was sold through the collectivist farm at state prices, another part was sold at the collective farm market at considerably higher prices.

According to surveys conducted by the World Bank, the sales from household plots provided 20% of total cash income of average collectivist farm worker families in 1996 (Csaki and Lerman, 1997). The authors observe also that household plot production is the only supplementary source of income for rural employees working full time on collectivist farms, as there are no other jobs in villages.

Cultivation of personal plots of land became the only job for a majority of workers who were fired and retired, especially in rural areas (Lazarenko and Zvihlianych, 1996). According to the authors, the number of individuals cultivating individual plots for income has increased by 500,000 annually since 1990. According to the FBS, the SHP income constituted 12 to 18 percent of state enterprise pensioner income, and 42 to 52 percent of the income of those who previously worked at collective farms in 1980s (MSUSSR, 1991).

Household plots as a source of food

The cash income share does not capture the much larger importance of the plots for the population. The state supported the SHP because they provided scarce food, especially in rural areas, to protect the population from food shortages. For some products, the majority of the food staples used by peasant families came from SHP in the 1970s (Shmelev, 1979).

Based on data from the World Bank surveys (1993/94 and 1995/96), about 90% of rural families identify the household plot as a channel of food supply. Most crops produced are consumed, while 80% of beef, 40% of pork, and 20% of milk produced are sold (Csaki and Lerman, 1997).

The private subsidiary production plays a similarly important role in Russian agriculture. The share of these forms of production in Russia's gross agricultural is similar to that of Ukraine: 44% of gross agricultural product, 90% of potato, 73% of vegetable, and 77% of total fruit and berry production in 1995. Some 44 million households out of total 50 million Russian households are involved in this production; 38 million families own SHPs (rural households) or gardens and vegetable plots (urban citizens) (Shmelev, 1996).

In sum, the sector of private household plots plays a prominent role in providing both income and supply of agricultural products in Ukraine during the transition period when both labor and agricultural production markets are under-developed.

2. EFFECT OF INCOME UNCERTAINTY ON SHP LABOR SUPPLY

Private subsistence agriculture always coexisted with collectivized agriculture in the former Soviet Union. Both rural and urban households worked relatively small plots of land for supplementary food and income. Although the land remained state property, the rights to work plots were inheritable and plot output belonged to producers. The producer households mostly consumed the production with any surplus sold either at farmers' markets or through state channels.

The studies presented in this and the next chapters of the dissertation seek to show both theoretically and empirically that the growth of subsidiary subsistence farming is consistent with other phenomena of transitional economies. The current chapter investigates the effect of uncertain real wages and pensions on labor supply decisions of the households that have access to subsidiary plots. The next chapter returns to the certainty case to study the effect of the decline in wages and increased availability of land for the private use on the labor supply decisions.

Intuitively, when an individual has two sources of income, wage work and subsidiary farming, uncertainty in the wage should force risk averse agents to increase their effort in the relatively safe income-generating activity, subsidiary household production. Therefore, at least a part of the growth in subsidiary agriculture productivity may be explained by the decreasing probability of timely payment of wages that causes increased supply of labor to the subsidiary farming. The current chapter includes discussion of the theoretical foundations for this conjecture and a related research question that has received little attention in the literature: the effect of wage uncertainty on agricultural labor supply.

An agricultural household model (AHM) is used to analyze the effects of several transition economy phenomena on the allocation of labor in agricultural production, specifically the share of SHP labor in total labor supply. The dual nature of the AHM, when production decisions are combined with consumption decisions, imposes certain methodological difficulty under the assumption of uncertainty.

In the case of certainty, under reasonable assumptions, AHM displays a property of recursiveness. Recursiveness refers to the fact that the decisions made by an agricultural household could be modeled as being made in two steps (Strauss, 1986). First, the household makes a decision on production as a purely competitive firm. Next, consumption decisions are made given the income from the first step. In contrast, when wage is random, the recursiveness is no longer preserved, and this makes the analysis of the uncertainty case more challenging.

As a price of labor inputs going into subsidiary plot production, wage affects the SHP production decision. For a purely competitive firm, the randomness of a price of an input *lowers* the amount of an input used in production if a producer is risk averse (Turnovsky, 1969). However, since the household is also the supplier of the labor input, the wage affects its income as well. In general, income uncertainty under very reasonable assumptions has been shown to *increase* labor force participation (Block and Heineke, 1973). Thus, even without taking into account the consumption part of the decisions, when considered separately, two opposite effects make the overall uncertainty effect of wages on SHP labor hours ambiguous.

As a price of leisure, wage affects the leisure-consumption decision. As a price of household time endowment, wage affects the full income of the household. In the case of a generic labor supply model, when no farming opportunity is assumed, wage uncertainty has been shown to have two effects on labor supply (e.g. Block and Heineke, 1973; Kim, 1994; Horowitz, 1994). The uncertain price of time endowment produces an 'uncertainty income effect' (Block and Heineke, 1973, p.383) that forces a risk averse individual to increase his/her productive efforts, i.e. labor supply, in response to uncertain income. However, since the agent can reduce uncertainty by substituting away from the activity, an 'uncertainty substitution effect' (ibid.) suggests lowering involvement in the activity affected by uncertainty, i.e. wage work. The two opposite effects make the overall effect of uncertainty in wages on the labor supply ambiguous.

Although a generic labor supply model predicts an ambiguous effect of wage uncertainty on labor supply, considering the labor supply decision as a part of larger model may help obtain definite results. As an example, Ormiston and Schlee (1994) showed that if workers are risk averse, then aggregate hours of work are lowered in a long-run competitive equilibrium in the labor market. In our case, the existence of two aspects of the labor supply, SHP work and wage work, makes signing the effects of uncertainty for wage earning households possible.

The chapter is organized as follows. First, a review of previous research is presented, followed by a presentation and discussion of the model used. Changes affecting households with wage earners are considered: a decline in real wages, an increase of SHP area, uncertainty in real wages, and a decline in the probability of receiving wages. Next, an AHM model with absent labor markets provides the basis for analyzing changes affecting pensioners: a decline in real pensions, an increase in land plots, uncertainty in pensions, and an increase in uncertainty of pension income. The increase in uncertainty is modeled as a mean-preserving spread in the distribution of pensions. The chapter concludes with a discussion of the obtained results.

Previous research

To model the effects of income changes and income uncertainty on SHP labor supply, the framework of the neo-classical agricultural household model (AHM) is the most natural choice. The model, as presented, for example, in Singh, Squire, and Strauss (1986), has been used extensively to study economic behavior of peasant households, where the peasant households are defined as those facing both consumption and agricultural production decisions. The basic model assumes a utility maximizing, price-taking agent that makes consumption choices simultaneously with the time allocation choice between farm work, off-farm employment, and leisure.

The AHM has become a widely used tool to study collective farm worker behavior. Similar to the neoclassical AHM, a collective farm member allocates his/her time between three alternatives: collective farm work, subsidiary household plot work, and leisure. The institution of collective farming imposes two constraints in a generic AHM. Firstly, households can sell labor to the collectivist farm, but can not hire any labor for the SHP. Secondly, households must sell some of their labor to the collectivist farm in order to have the right to work the subsidiary plot. With these constraints, an AHM applied to collective farming in the (post-) Soviet economy stands in between the basic AHM and the AHM with completely absent labor markets discussed by Strauss (1986).

The collective farmer model has been applied in two settings: as a producer cooperative model (Bradley, 1971, 1973; Cameron, 1973a,b; Ireland and Law, 1980; and

Bonin, 1977) and as a wage based model (Chandler, 1984). The difference between the two versions is in modeling the collectivist farm income. In the producer cooperative model, a system of shared residual wages is assumed, by which the income of a collective member from collective production is determined residually as the collective accounting profit per member. This system has been changing since the mid-1960s toward one of guaranteed wages, and was completely abolished in the late 1970s. State farm workers always received fixed wages (World Bank, 1994). The wage version of the collective farm applications of the AHM models the member's income from collective production more realistically by assuming that the remuneration is a fixed wage times hours of work.

The models of collectivist farm household labor supply have been applied predominantly in deterministic settings (Bradley, 1971; Cameron, 1973a; Ireland and Law, 1980; Chandler, 1984). The model predicts that *ceteris paribus*, an increase in subsidiary plot size causes a decline in both total labor supply and wage labor supply, and an increase in the SHP hours (Chandler, 1984). A decrease in wage increases subsidiary plot labor supply (ibid.). Consequently, increased land availability for subsidiary plots and declining real wages are consistent with the recent relative growth of subsidiary farming in post-Soviet countries.

Wage uncertainty in the collective farm model was first considered by Bradley (1971). The author points out that because of differences in tastes, the effort put into collective farm work would be unequal among collective farm members. With the residual wages model, each worker is uncertain about the quantity of labor supplied to collective production by other households. This leads to uncertainty in wage income. Bradley concludes intuitively that workers would respond to the wage uncertainty by redirecting labor activities from the collective farm work toward private plot production and leisure, but no theoretical model is advanced to study this response.

Bradley (1973) formalizes his 1971 idea about uncertainty. Marginal income from wage work is assumed to be known up to an additive random variable, and similarly, marginal income from private production is assumed to have another component defined as additive error. The author argues, that in addition to uncertainty in government price and procurement policies and natural conditions, which is a part of both random measures, the random component in the collective farm remuneration is affected by the number of households in the collective. He concludes that the uncertainty of the marginal yield to labor must be greater in the collective sector. Again, the intuitive conjecture that this must lead to a greater supply of labor to private production is not supported theoretically.

Cameron (1973b) questions Bradley's assumption that marginal income at the collective farm is greater than that at the private plot by pointing to relatively certain state procurement price for collective farm output, as opposed to the more or less freely determined prices for produce at farmers' markets (the price at which the subsidiary household plot output is sold). In addition, the collectivist farm could diversify its activities to reduce variability of its revenues. Finally, with large soviet collective farms, the effect of variability of collective income due to variability of individual preferences would be small. It should be noted, that this entire debate about relative variability of collective versus private subsidiary production took place more than twenty years ago in the period of political stability in the Soviet Union. The contemporary situation is obviously quite different.

Bonin (1977) picks up the debate between Bradley and Cameron by explicitly modeling uncertainty in a collective farm model. The author considers production uncertainty on the collective plot, which, from the perspective of an individual choice problem results in an uncertain wage in the collective sector (off-farm wage in AHM setting). As a separate question, the author considers the effect of uncertainty in the price of private plot output. Under the assumptions of decreasing absolute risk aversion and fixed leisure, Bonin shows that individuals reallocate work between plots toward less risky remuneration. When leisure is allowed to vary, Bonin considers only the case of both uncertainties present (from the collective sector and private plot production) and concludes that the effect of the uncertainties on the labor decision can not be signed. While this result is true for the private plot price uncertainty case, as it was later shown in detail by Finkelshtain and Chalfant (1991), the conclusion does not hold in the case of uncertainty from wages alone.

Outside of the collectivist farm setting, the AHM has been applied to analyze a variety of uncertainties. Among others, Fafchamps (1992), Finkelshtain and Chalfant (1991), Kurosaki (1995), Mishra and Goodwin (1997) investigated the effects of farm output price uncertainty. Yield risks were incorporated into models used by Roe and Graham-Tomasi (1986), and that investigated by Fabella (1988). However, wage uncertainty has not been studied probably because, non-agricultural income has always been treated as being less volatile than the agricultural one in market economies.

Time allocation decisions of pensioners that have access to SHP (i.e., of those without market wage opportunities) can be considered within the framework of the AHM with absent labor markets. The model, traceable to the works of Chaianov (see, e.g., Strauss, 1986), is laid out analytically by Nakajima (1969). The model restricts the generic AHM model by assuming that the household does not sell any labor, and the only time choice is between leisure and farm work. Nakajima proved that a decrease in unearned income increases farm work hours, a result that in our context means that a decline in real pensions increases hours of subsidiary farming by pensioners. Nakajima showed that an increase in farm size has an ambiguous effect on farm work hours because of opposite income and substitution effects. To date, no known studies have considered the AHM with absent labor markets under the assumption of uncertainty.

Theoretical model of wage earning household

In the following sections, first, we lay out and discuss the wage earning household model in the certainty case. Next, we extend the model to the wage uncertainty setting and compare SHP labor hours in the uncertainty case to that when the wage is set identically to its mean. Finally, we assume a discrete distribution of wage and investigate changes in labor allocation when the probability of receiving wages declines.

Model set up

An individual (household) maximizes utility subject to constraints. The individual derives utility from consumption of *leisure* and *food*. The food can either be produced on the subsidiary household plot (SHP) or bought in the market at a certain price. Household income comes from wage work and sales of the SHP production. The individual has a choice between off-SHP work for a wage, SHP work, and leisure.

The household is assumed to maximize utility U subject to a total time constraint, $l + h^c + h^p = T$, to a budget constraint $x = Wh^c + f(h^p, m)$, to the constraint of no labor from outside of the household, $h^p < T$, and to the mandatory collective farm work constraint $h^c > 0$. Here x denotes food consumption; l is leisure consumption in hours; $U(x,l)$ is the agent's utility function; $f(h^p,m)$ is the SHP production function; W is the hourly wage rate measured in units of food per hour; m is the size of the subsidiary plot land; h^c is the time spent working for the wage in hours; h^p is the time spent working in the SHP in hours; and T denotes total hours available to the agent. Conventionally, we use the notation g_i for a partial derivative of the function g with respect to the *i-th* argument, and the notation g_{ij}, and a second partial derivative of g with respect to the *i-th* and *j-th* arguments respectively, $i, j = 1,2$; $g = U, f$.

With the expressions for x and l derived from the constraints, the agent's problem becomes:

$$\max_{T>h^p\geq 0,\, T\geq h^c>0,\, T-h^p-h^c\geq 0} \quad U\left(Wh^c + f(h^p,m)\,,\, T-h^p-h^c\right). \tag{2.1}$$

We will call a solution (h^p, h^c) to (2.1) an interior solution if the optimizing values of h^c and h^p are both positive.

Interior solutions

Throughout our analysis, we consider interior solutions only. That means that neither the option of quitting the wage job, nor the option of quitting the SHP farming is considered. While these seem to be strong assumptions, they are supported to some extent by the results of earlier surveys. The results reported by ILO (1995), Csaki and Lerman (1997), and Perotta (1998) show that quitting SHP farming is not an option for most households. However, the question of quitting wage work to concentrate on farming alone is a subtler one.

The model we consider is applied to both city dwellers and rural residents possessing subsidiary household plots. Several studies found that both the unfavorable social image of farm work and the perceived transitory nature of uncertainties with wages preclude many city workers from quitting wage jobs to start farming. In addition, relatively little agricultural experience might also contribute to an unwillingness to become a private farmer.

As for rural residents, quitting wage work while keeping the SHP was legally impossible to do up to the early 1990s. Nowadays, with adoption of new land laws, quitting wage work means breaking the ties with a collectivist farm that provides their wages and the requirement to become a new legal entity, a private farmer. It is a common knowledge (see, for example, Maggs (1971), Rumer (1981), Perotta (1999b), Bonanno et al. (1993)) that in addition to the wages, the collectivist farms supplied their workers with payments in kind and subsidized inputs to their subsidiary plot production. In addition, collectivist farms remain major providers of social services in rural areas, like childcare, utilities, and the like. The preferred access to the most of the farm provided social services is lost once an employee leaves the collectivist farm (Csaki and Lerman (1997); Perotta (1999a)).

In this study, we treat these fringe benefits as a part of the hourly wage and implicitly assume that after taking into account these benefits, the expected wage is higher than the marginal product of labor in the SHP production. Leaving the collectivist farm is difficult because of poorly specified leaving procedures, under-developed farming infrastructure, high production risks due to under-developed input markets, and insufficient business experience for the most of the collectivist farm workers (Csaki and Lerman (1997); Perotta (1999a)). For these reasons, we focus only on *redistribution of effort* between wage job and subsidiary farming due to wage rate changes. Modeling quitting the collectivist farm to establish a private farm is beyond the scope of our study.

Aggregation of consumption commodities

We model preferences in just two arguments, food and leisure. In this way, the first argument of the utility function is equated to the total income of the household. Several assumptions are implicit in this setting. First, we assume that other commodities (not explicitly modeled) can be easily exchanged for the food with no or low costs of exchange. This is reasonable for the economies in transition: the SHP output can be exchanged for goods and services and sold at the farmers' markets relatively easily (e.g., Perotta, 1999a).

Another implicit assumption is that commodities other than labor could be aggregated in the analysis. That is, utility maximization in the aggregated model (2.1) yields the same results on labor allocation as an analysis of a model where more than one consumption commodity is modeled. Epstein (1975) points out that the aggregated analysis might be potentially misleading in an uncertainty setting. Rather than imposing assumptions on preferences, we justify the aggregated analysis by limited ability to substitute food for other commodities due to low level of income in question.

According to the Composite commodity theorem, as presented, for example, in Deaton and Muellbauer (1983), if a group of prices moves in parallel, then the corresponding commodity can be treated as a single good. That means, that the preferences defined over the composite commodity and other original goods lead to the same choices as the preferences over original disaggregated goods. The assumption of prices of necessities moving together is not unreasonable for the economies in transition.

Restricting attention to necessities is permissible because surveys report economy-wide drops in real income and, consequently, consumption by most of the population in recent years. Poverty increased in Ukraine and Russia over the years of transition (Kakwani, 1995; World Bank, 1996; Klugman, 1997). The share of income spent on food jumped from approximately 40% in 1980s to 60% in 1990s (Van Atta, 1998).

In rural areas, poverty is more pronounced than in urban areas: Perotta (1999b) reports that more than 62% of the Ukrainian rural population is below the official poverty line. The share of income spent on food is consistent with these numbers: Van Atta (1998) reports that food accounts for almost 70% of rural household income in 1996 and 1997. Here, income includes the value of household produced food. With taxes, housing, and utilities accounting for at least 5% of an average rural household income, there is very little room for a substitution of food for other consumption goods. Csaki and Lerman (1997) found that 50% of a 1996 survey of 1,674 collectivist farm employees could not satisfy even the minimum consumption needs of their family. Another 48% of respondents of the survey report that they make just enough for necessities and could not afford anything beyond that.

Urban families, though spending a smaller budget share on food, pay more in unavoidable expenses: on average, an urban family spent 70% of its income on food, housing, utilities, and taxes in 1996 (Van Atta, 1998). Pensioner incomes must be almost completely spent on food. Although no recent data are available, the share of food in pensioner total expenditures has always been higher than the average in Ukraine; it comprised some 50% in 1990 (MSUSSR, 1991). Thus, the low income levels and high shares of household expenditures on food and unavoidable expenses rationalize the form of the utility function used in the analysis.

Separability

The first order conditions for an interior solution to the optimization problem (2.1) take the form

$$\frac{\partial U}{\partial h^p} = U_1 f_1 - U_2 = 0,$$

$$\frac{\partial U}{\partial h^c} = U_1 W - U_2 = 0.$$

Subtracting the second equation from the first, and assuming $U_1 > 0$, we obtain

$$f_1 = W. \tag{2.2}$$

This equation conveys the familiar optimality condition of the farm household model: the SHP labor supply is chosen so that the MRP of labor in SHP production is equal to the marginal return to labor on the collectivist farm, i.e., the wage rate. In addition, this equation demonstrates that production decisions can be made independently of consumption decisions, while the reverse is not true since consumption depends on production through the budget constraint. This property of the AHM is called interchangeably "recursiveness" or "separability" (Singh, Squire, and Strauss, 1986).

A competitive profit-maximizing firm with production function *f* would make its choice of labor exactly according to the rule (2.2). That means, that in the AHM, the household's decision, although made simultaneously, could be thought of as being made in two steps. First, the household maximizes profits as a purely competitive firm, and then the consumption decisions are made given the profits. As it will be shown later in the Chapter, the recursiveness is not preserved when the wage is allowed to be stochastic, that is, the production decision on h^p, does depend on preferences in the case of wage uncertainty.

Uncertain wages

In this section, we extend the model (2.1) to the setting of wage uncertainty. The uncertainty in off-SHP income originates from a possibility of *non-timely payment* of wages.

We assume that instead of a known wage, the agent deals with an uncertain wage with a non-degenerate distribution. The individual still has a choice between off-SHP work for a wage, SHP work, and leisure. The time allocation is decided *ex ante*, while consumption of the food is decided after the uncertainty in wage is realized. The individual is risk averse in food gambles.

The household is assumed to maximize expected utility $E[U]$ subject to the same constraints as before. All the notation of the model (2.1) is preserved, except W is the random hourly wage rate measured in units of food per hour. With the uncertainty, the agent's problem becomes:

$$\max_{T>h^p\geq 0,\, T\geq h^c>0,\, T-h^p-h^c\geq 0} \quad E\left[U\left(Wh^c + f(h^p, m), T - h^p - h^c\right)\right] \tag{2.3}$$

Assumptions

We assume

$$U_1 > 0, \quad U_2 > 0; \tag{S.1}$$

$$U_{11} < 0, \tag{S.2}$$

$$f_1 > 0, \quad f_{11} < 0. \tag{S.3}$$

The assumption (S.1) ensures that marginal utility is positive everywhere over the set of relevant consumption bundles, i.e., the agent is not satiated with the consumption of food and leisure. In the uncertainty setting, (S.2) formalizes risk aversion in food gambles.

Assumptions (S.3) mean that the SHP production function displays positive decreasing marginal product of labor over a relevant range of inputs.

To determine the impact of risk on the agent's decisions, we compare the solution to problem (2.3) to the agent's choices in the case when the random wage W is set identically to its mean. The certainty counterpart of problem (2.3) is

$$\max_{T>h^p\geq 0,\, T\geq h^c>0,\, T-h^p-h^c\geq 0} \quad U\left(E[W]h^c + f(h^p,m)\,,\, T-h^p-h^c\right). \tag{2.3c}$$

Results

Proposition 2.1

Let the assumptions (S.1) – (S.3) hold. Let (h^{p*}, h^{c*}) and (h^{p**}, h^{c**}) be interior solutions to (2.3) and (2.3c) respectively. Then $h^{p*} > h^{p**}$.

Proof of Proposition 2.1

The solution to (2.3) satisfies the following first-order necessary conditions:

$$\frac{\partial E[U]}{\partial h^p} = E[U_1 f_1 - U_2] = 0 \tag{2.4}$$

$$\frac{\partial E[U]}{\partial h^c} = E[U_1 W - U_2] = 0 \tag{2.5}$$

Subtracting (2.5) from (2.4), we get

$$f_1(h^{p*},m) = E[W] - \frac{Cov\left[U_1\left(Wh^c + f(h^p,m), T-h^p-h^c\right), f_1 - W\right]}{E[U_1]} \tag{2.6}$$

The covariance term in (2.6) is positive, because

$\dfrac{\partial U_1\left(Wh^c + f\right)}{\partial W} = U_{11}h^c < 0$ by the assumption (S.2), and $\dfrac{\partial (f_1 - W)}{\partial W} = -1 < 0$.

Consequently, (2.6) implies

$$f_1(h^{p^*}, m) < E[W] \tag{2.7}$$

If the wage W were fixed at its mean, the first order conditions for utility maximization would imply equality in (2.7) instead of the inequality, i.e.

$f_1(h^{p^*}, m) < E[W] = f_1(h^{p^{**}}, m)$.

Since $f_{11}' < 0$ (assumption (S.3)), the statement of the proposition follows.

The proven result is very intuitive: uncertainty in the off-SHP wage forces a risk averse agent to shift towards the certain source of income, SHP production. The uncertainty reduces the mean wage in terms of behavioral actions: the agent responds to the risk as if the wage were below its mean.

Several points on the proof of the Proposition 2.1 are worth stressing. First, the separability of the model is no longer preserved, as the production decision does depend on preferences.

Secondly, the solution to the production decision is no longer parallel to a pure production profit maximizing firm decision, as we had in the case of certainty. A competitive profit maximizing firm under wage rate uncertainty and risk aversion would choose *less* labor than if the wage rate were set to its mean (Turnovsky, 1969). In contrast, our agricultural household model predicts that the labor input will *exceed* the certainty counterpart labor. The difference originates from the restriction on no hired labor for SHP production. Under this restriction, the SHP household is always a *net seller* of labor, $h^{c^*} > 0$. Consequently, the wage affects the household's net income positively rather than negatively as in the pure production firm case. Mathematically, this difference shows up when we sign the covariance term in (2.6): had the h^{c^*} be negative (as for the competitive firm), the covariance term, and the result of the Proposition 2.1 would be reversed.

Note that implicit in Proposition 2.1 are some additional assumptions about preferences. The existence of the interior solution for the problem (2.3c) implies that the utility function is concave in the neighborhood of the solution. The next proposition imposes more restrictions on the utility function and on the structure of randomness in W to provide a stronger statement about the impact of wage uncertainty on labor supply.

We replace the assumption (S.2) with a more restrictive

$$U_{11} < 0, \quad U_{22} < 0, \quad U_{11}U_{22} > U_{12}^2, \quad U_{12} \geq 0. \tag{S.2*}$$

The first three inequalities of the assumption (S.2*) ensure that the utility function is strictly concave. The last inequality in (S.2*) means that incremental utility derived from an additional unit of leisure does not decrease with the amount of food, and that incremental utility derived from an additional unit of food does not decrease with leisure. This assumption is not overly restrictive, as, for example, any CES utility function satisfies it.

Proposition 2.2

Let the assumptions (S.1), (S.2*), and (S.3) hold. Let W be a discrete random variable with a probability distribution $P(W = w) = p, \quad P(W = 0) = 1 - p$, where w is a constant and $p \in (0,1)$. The agent is assumed to know the distribution. Let the necessary first order conditions (2.4) and (2.5) be satisfied for some positive h^{p^*} and h^{c^*}. Then

(i) The pair (h^{p^*}, h^{c^*}) is the solution for the problem (2.3);

(ii) A decrease in probability p of receiving wages increases SHP labor supply h^{p^*}; and

(iii) A decrease in probability of receiving wages decreases wage work labor supply h^{c^*}.

Proof of Proposition 2.2 is provided in Appendix 1.

In the proposition proven, a change in the distribution of wages is modeled via a decline in the probability of receiving wages. This way of changing the distribution can not be referred to as increased uncertainty in receiving wages because both the mean and the variance of the distribution are changing. Indeed, as the probability p declines, the mean of wages $E[W] = pw$ declines. However, the variance $Var[W] = p(1-p)w^2$ either increases or decreases depending on whether p is less than or more than a one half. A more intuitive way of modeling increased uncertainty is as a mean-preserving spread in the distribution. The mean-preserving spread is defined as "stretching" the distribution around a constant mean (Sandmo, 1971). Although we were not able to sign comparative statics of a mean-preserving spread for the wage model, we obtained definite results for a pensioner household model.

Theoretical model of pensioner household

To study the effects of changes in pensions, we adapt the AHM (2.3) by abolishing wage work, and by introducing an unearned fixed income, pensions.

Model set up

An individual (household) maximizes expected utility subject to constraints. The individual derives utility from consumption of *leisure* and *food*. The food can either be produced at the subsidiary household plot (SHP) or bought in the market at a certain price. Unlike in the wage earning household, the pensioner household's income comes from sales of the SHP production and uncertain pensions. The individual has a choice between SHP work and leisure.

The household is assumed to maximize expected utility $E[U]$ subject to a total time constraint, $l + h^p = T$, and to a budget constraint $x = P + f(h^p, m)$. Here x denotes food consumption; l is leisure consumption in hours; $U(x,l)$ is the agent's utility function; $f(h^p, m)$ is the SHP production function; P is the pension measured in units of food; m is the size of subsidiary plot land; h^p is the time spent working in the SHP in hours; and T denotes total hours available to the agent. We keep the notation f_i for a partial derivative of the production function f with respect to the *i-th* argument, and the notation f_{ij} for a second partial derivative of f with respect to the *i-th* and *j-th* arguments respectively, $i, j = 1,2$.

For ease of presentation, and in parallel with Block and Heineke (1973), whose derivations we follow for some results, we change the notation for the derivatives of the utility function. We use the notation U_Y for the first partial derivative of U with respect to the first argument, and U_l denotes the first partial derivative of U with respect to the second argument.

The agent's problem is

$$\max_{T > h^p \geq 0} \quad E\left[U\left(P + f(h^p, m), T - h^p\right)\right]. \tag{2.8}$$

To determine the impact of risk on the agent's decisions, we compare the solution to (2.8) to the agent's choice in the case when the random pension P is set identically to its mean. The certainty counterpart of the model (2.8) is

$$\max_{T > h^p \geq 0} \quad U\left(E[P] + f(h^p, m), T - h^p\right). \tag{2.8c}$$

The certainty model is known as an AHM with absent labor markets (Strauss, 1986). It stems from the work of the Russian economist Chaianov from the 1920s, and is presented in analytic form by Nakajima (1969). In our interpretation of the variables, Nakajima showed for the case of certain pensions that a decline in pensions necessarily increases SHP labor supply. Here we extend the analysis to the case of the uncertainty.

Assumptions

We assume

$$U_Y > 0, \quad U_l > 0; \tag{S.1p}$$

$$U_{YY} < 0, \quad U_{ll} < 0, \quad U_{Yl} > 0; \tag{S.2p}$$

$$f_1 > 0, \quad f_{11} < 0. \tag{S.3p}$$

$$\frac{\partial R}{\partial Y} < 0, \quad \frac{\partial R}{\partial l} = 0, \tag{S.4p}$$

where R is the Arrow-Pratt measure of absolute risk aversion in income gambles,

$$R \equiv -\frac{U_{YY}}{U_Y}.$$

The first inequality in the (S.4p) formalizes the intuitively plausible assumption of diminishing absolute risk aversion. It means that as the agent's income increases, he/she becomes increasingly tolerant to risks, while remaining risk averse. The second inequality in (S.4p) means that the level of leisure consumption does not affect the absolute risk aversion. Cobb-Douglas preferences satisfy (S.4p).

As before, we consider interior solutions only, i.e. the optimizing value of h is positive.

Results

Proposition 2.3

Let the assumptions (S.1p) – (S.4p) hold. Let h^{p^*} and $h^{p^{**}}$ be interior solutions to (2.8) and (2.8c) respectively. Then $h^{p^*} > h^{p^{**}}$.

Proof of Proposition 2.3 is provided in the Appendix 2.

Finally, we analyze the effect of a change in pension distribution on optimal labor supply. The consequence of a decline in the probability of receiving pensions was found to be ambiguous. However, we sign the effect of an increase in pension income uncertainty modeled as a mean-preserving spread. That is, a pure increase in dispersion via a multiplicative parameter is combined with an additive shift in the distribution under the restriction that the mean of the distribution is unchanged.

Proposition 2.4

Let assumptions (S.1p) – (S.4p) hold. Then a mean-preserving spread in the distribution of P increases SHP hours.

Proof of Proposition 2.4 follows closely Block and Heineke (1973); it is provided in Appendix 3.

Conclusions

The share of subsidiary household farming in gross agricultural output increased in many post-Soviet economies. The neo-classical agricultural model leads us to infer that several phenomena occurring in transition economies may cause an increase in the share of SHP labor in the total agricultural labor. The results are summarized in the Tables 2.1 and 2.2.

Table 2.1. Comparative statics results for wage earner subsidiary household plot models

Autonomous variation	Consequential variation in			Reference
	SHP hours	Wage work hours	Total labor supply	
Wage decline	+	?	?	Chandler (1984)
SHP land increase	+	-	-	Chandler (1984)
Wage uncertainty	+	?	?	Proposition 2.1
Decline in probability of receiving wage	+	-	?	Proposition 2.2

Table 2.2. Comparative statics results for pensioner subsidiary household plot models

Autonomous variation	Consequential variation in SHP hours	Reference
Pension decline	+	Nakajima (1969)
SHP land increase	?	Nakajima (1969)
Pension uncertainty	+	Proposition 2.3
Mean-preserving spread in pensions	+	Proposition 2.4

For wage earning households, a decline in real wages increases supply of labor to subsidiary farming. We found that the impact of wage uncertainty for risk averse households is similar to that of declining wages in the certainty case; households increase the subsidiary farming labor supply.

Two features of the model considered allowed signing the effect of wage uncertainty on SHP labor supply: availability of the certain income generating activity, and the restriction on no outside labor. Considering the labor decision from the consumption side of the model, the above-mentioned Block and Heineke (1973)'s 'uncertainty income effect' and 'uncertainty substitution effect' apply to different components of the total labor supply. The total effect of wage uncertainty in a generic labor supply model is ambiguous, because risk averse individuals can not do two things simultaneously: increase work hours to alleviate income uncertainty, while reducing involvement into risky wage work. In contrast, in the AHM setting, households can have both goods: the availability of SHP farming allows them to increase work hours *and* substitute away from the activity affected by uncertainty by increasing SHP hours and reducing wage work.

As for the production side of the SHP model, the restriction on no SHP labor from outside of the household turned out to be crucial. With this restriction, the net effect of wage on household income is always positive, as opposed to the negative one in the purely competitive firm case analyzed by Turnovsky (1969). This difference between the AHM and the production firm models ultimately leads to the opposite results on the effect of uncertainty on labor input used in production in the two models.

Under the assumption of a discretely distributed wage, we proved a negative relationship between probability of receiving wage and subsidiary plot labor supply, and a positive one between probability of receiving wage and wage labor supply. These results provide theoretical support to the intuitive conjecture that was discussed by Bradley (1971, 1973), Cameron (1973b), and was proven previously by Bonin (1977) under overly restrictive assumptions on leisure allocation and preferences.

In the model presented, wages are being modeled as being received as food. Indeed, a share of collectivist farm wages is received in kind in the form of consumption goods (Perotta, 1999). However, inputs for SHP production like forage grain, seeds, and young animals are also common as forms of remuneration for collectivist farm work (ibid.). With costly exchange of the latter forms of wages for food, the production input form of wages may provide an additional stimulus for the growth of subsidiary farming. An analysis of the impact of the non-monetarization of wages on development of subsidiary farming constitutes an interesting question for future research.

As for pensioner households, we showed that an impact of uncertainty in pensions is similar to that in wages for the wage earners: the agents respond as if the pension were below its mean and increase SHP hours. An increase in uncertainty when modeled as a mean-preserving spread increases SHP hours as well. Both results are in parallel to the results of Block and Heineke (1973) on the effect of uncertainty in non-wage income on wage labor supply when wages are certain and unchanged.

Admittedly, the relative impact of pensioner SHP production on overall agricultural production might be not large due to natural limitations on time available and productivity. Yet, the SHP income has always constituted a large share of pensioner household income. Urban pensioners derived 70% and 18% of their income from pensions and SHP, respectively, on average in 1990. Pensions of retired collective farmers constituted 48% of their income, while 46% were derived from subsidiary farming (MSUSSR, 1991). Evaluation of the relative impact of pensioners, and, more broadly, government benefit recipients, on gross SHP production is an empirical question to be addressed when more data on demographics of SHP producers become available.

The results provide a theoretical explanation for the growth of involvement of the population in subsidiary farming. In an increasingly volatile economic and political situation in the countries in transition, part-time private plot farming is a way for households to cope with the decline in incomes and the income risk due to non-payments. Admittedly, farming is subject to its own intrinsic volatility due to weather, animal disease, pests, etc. Because of that, farm operators in market economies often diversify income by working off-farm (Huffamn, 1991; Mishtra and Goodwin, 1997). However, in contemporary transition economies, the riskiness of wage income is so high, that it outweighs that of farming. That is why we ignored SHP yield uncertainty in our analysis. Incorporating both types of uncertainties into a model is a subject of future research.

The analysis of income uncertainty conducted suggests that income stabilization policies might have a big impact on labor allocation in agriculture. Currently, subsidiary agriculture absorbs displaced labor from the collective sector of agriculture and other sectors of Ukrainian economy. However, this is a transition phenomenon. Subsidiary farming should decline once real income starts to grow and stabilize.

Is the growth of the subsidiary farming socially desirable? Both yes and no. Many observers point out that subsidiary farming serves as a cushion in times of economic hardship, and this perspective even draws support from some local administrations (O'Brien et al., 1996). However, the growth of this form of private farming also has a negative consequence: it allows a longer period with no fundamental economic restructuring and reform. Van Atta (1998) points out that SHP food production alleviates the edge of the hardship thus easing the pressure for real reforms in the economy.

The subsidiary farming growth is an indication of big distortions in labor markets. Ukraine, like many other former Soviet countries, has a highly educated labor force, and a system that employs engineers and teachers to work on subsidiary plots is a waste of human capital. However, the situation will not change unless the constraints on agricultural production imposed by absent or non-working markets are lifted.

An overall progress with economic reforms in agriculture is imperative to reverse the movement from commercial agriculture to a subsistence one. In particular, development of land and agricultural input markets will allow some of the subsidiary farms to grow into less labor intensive private farms, a process that would entail more specialization and commercialization of agricultural production.

3. LABOR ALLOCATION IN THE CASE OF CERTAINTY

The goal of the study is to extend known theoretical results on the effects of collective sector wage changes on SHP labor supply and use the newly proven results to examine empirically the growth of SHP share in gross agricultural output. First, we use the model considered in the previous chapter to investigate the changes in SHP labor when a certain wage declines. Under reasonable assumptions on SHP technology, the previously known theoretical result is extended to show that the share of SHP hours in total labor supply increases in response to a wage decline. Second, the availability and usefulness of official *oblast*[2]-level Ukrainian data is evaluated for the purposes of the analysis of SHP growth. The results indicate the inherent deficiencies in such data. Next, pre-reform *oblast*-level data are used to show that observed tendencies in the time allocation of collective farmer families are consistent in general with the theoretical results. Finally, the growth of the subsidiary farming share in gross agricultural output is investigated between 1991 and 1996 using *oblast*-level data. We find that as expected from the theory, an increase in the share of SHP output in gross agricultural output is consistent with a decline in average real agricultural wages and rural-urban composition of population. We do not find a statistically significant effect of the availability of agricultural land in the regions on the growth of SHP production, a result that may result from measurement error. Due to severe constraints on data availability, we impose strong assumptions regarding absent statistics on SHP inputs other than land and labor.

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[2] *Oblast* (plural – *oblasti*) is a Russian name for an administrative region. Ukraine has 24 *oblasti* and 1 autonomous republic, Crimea. For ease of reference, we will call all the 25 administrative regions of Ukraine *oblasti*.

Theoretical model

A decline in the collective sector wage was previously proven to increase SHP hours (Chandler, 1984). However, the effects on both total and collectivist farm labor supply are ambiguous. We impose a reasonable assumption on SHP technology in the AHM framework to show that the share of the total labor supply devoted to SHP increases with a decrease in wages.

Assumptions

Assume assumption (S.1) from the previous chapter holds. We repeat it here for ease of presentation:

$$U_1 > 0, \quad U_2 > 0; \qquad \text{(S.1)}$$

We replace (S.2*) with a less restrictive set

$$U_{11} < 0, \quad U_{22} < 0, \quad U_{12} \geq 0. \qquad \text{(S.2**)}$$

In addition, we replace (S.3) with a more restrictive assumption

$f(h^p, m) = A(h^p)^{\alpha} \varphi(m)$, where $\alpha \in (0,1)$, A is a positive constant,

and $\varphi(m) > 0$. (S.3**)

The first two inequalities in (S.2**) formalize decreasing marginal utilities of food and leisure. Assumption (S.3**) means that the SHP production function is log-linear in the labor argument. An example of the function satisfying this assumption is a Cobb-Douglas function.

Theoretical results

<u>Proposition 3.1.</u>

Let the assumptions (S.1), (S.2**), and (S.3**) hold. Let (h^{p*}, h^{c*}) be an interior solution to (2.1). Then a decrease in the wage rate W necessarily increases the share of labor supply devoted to SHP.

Proof of Proposition 3.1.

We re-parameterize the problem (2.1) by replacing the two choice variables h^p, h^c with $h \equiv h^p$, and $k \equiv \frac{h^c}{h^p}$. Then $h^* \equiv h^{p^*}$, $k^* \equiv \frac{h^{c^*}}{h^{p^*}}$. For ease of notation, we suppress the arguments of the function f. With the re-parameterization, (2.1) is equivalent to

$$\max_{h>0,\ k>0} \quad U\big(Wkh + f(h), T-(k+1)h\big) \tag{3.1}$$

The first order necessary conditions for an interior maximum take the form

$$\frac{\partial U}{\partial h} = U_1(Wk + f_1) - U_2(k+1) = 0\,, \tag{3.2}$$

$$\frac{\partial U}{\partial k} = U_1 Wh - U_2 h = 0\,. \tag{3.3}$$

To derive the impact of changes in the exogenous variable W on the optimal k^*, $\frac{\partial k^*}{\partial W}$, we apply standard comparative statics techniques. The details of the derivations are provided in Appendix 4, where we show that $\frac{\partial k^*}{\partial W} > 0$. Returning to the $\left(h^p, h^c\right)$ notation,

$$\frac{\partial}{\partial W}\left(\frac{h^{p^*}}{h^{p^*}+h^{c^*}}\right) = \frac{\partial}{\partial W}\left(\frac{1}{1+k^*}\right) = -\frac{\partial k^*}{\partial W}\cdot\frac{1}{(1+k^*)^2} < 0,$$

and the statement of the proposition is proven.

The result of the proposition means that a decline in wages increases the relative share of SHP hours in the total hours of labor supplied by a household. However, the impact of wage change on the total labor supply, $h^c + h^p = T - l$ is still ambiguous.

Let l^* be the utility-maximizing choice of leisure consumption. The budget constraint the household faces can be written as $Y^S = Y^R = Y$, where the full income of the household, Y, is equal to the full income received, Y^R, and the income spent on food and leisure, Y^S. The full income received, Y^R, is the sum of the value of the household's endowment, plus income from the subsidiary farming, less cost of labor input for the SHP: $Y^R = WT + f(h^p, m) - Wh^p$. The full income is spent on food and leisure consumption, i.e. $Y^S = x + Wl$. Then a Slutsky decomposition of a change in leisure demand into substitution and income effects takes the form

$$\frac{\partial l^*}{\partial W} = \left.\frac{\partial l^*}{\partial W}\right|_U + \frac{\partial\left(Y^R - Y^S\right)}{\partial W} \cdot \frac{\partial l^*}{\partial Y}, \text{ or}$$

$$\frac{\partial l^*}{\partial W} = \left.\frac{\partial l^*}{\partial W}\right|_U + h^{c^*} \cdot \frac{\partial l^*}{\partial Y} \tag{3.4}$$

The well-behaved utility function ensures that the first term on the right-hand side of (3.4), the substitution effect, is negative. The second term, the income effect, is positive, and the total effect is ambiguous. However, Strauss (1986, p.76) noted that the income effect is weighted by household total labor supply *less* labor demand, not by the total labor supply, as if the household were a supplier of labor solely to wage work. If labor is a normal good, the income effect makes a backward bending supply less likely than if the household did not have access to the SHP. In our case, this condition means that if h^{c^*} declines with declining wages, then the tendency is likely to be self-reinforcing: the smaller is h^{c^*}, the smaller is the weight in the income effect in (3.4). Consequently, it is more likely that the leisure demand curve is negatively sloped. Given that h^{p^*} increases with the declining wages, the negatively sloped leisure demand warrants a decline in h^{c^*}. Intuitively, a decline in wage is likely to reduce both the total and the wage work labor supply. Whether this is the case in contemporary Ukraine remains an empirical question to be addressed. However, the overall decline in gross agricultural output does not contradict the conjecture.

Having proved theoretically that a decline in wages is consistent with an increase in SHP share in total labor supply, we turn to empirical evidence.

Methodological problems with *oblast*-level data

The least aggregated SHP related data published officially are at the *oblast*-level. However, the information useful for empirical analysis is limited, both on the output of SHP production and on the inputs that go into it.

SHP output

Official data published on the output of subsidiary farming presumably come from household budget surveys. Yet in addition to sample selection problems in the surveys (see the discussion in the Introduction), a problem of under-reporting of SHP production exists. Perotta (1999b, p.6) notes that "rural households are deeply worried that questions about income, especially income from SHP, are being gathered for the purposes of taxation". Presently, there are no taxes imposed on SHP production. However, sporadic and inconsistent past government policy has taught the population to fear the worst. SHP farming is a part of 'unofficial' income as opposed to 'official' sources such as wages and pensions. It is a legal activity nowadays, but government policy toward SHP has swung from tolerance in the 1930s, to almost a complete ban in the 1950s, and then an acceptance of an annoying reality since 1960s until the end of the Soviet times. The respondents of the survey analyzed by Perotta "reminded interviewers of times in the past when chickens, and even trees were taxed" (ibid.). Given these reasons, the overall production of subsidiary farming might be under-reported. This problem is not exclusive to the aggregated, *oblast*-level data, it starts from household-level surveys. In contrast, SHP input reporting may be greatly improved once household-survey data become available.

SHP land

Although land under SHPs seems to be well documented in the official statistics, it might too be misreported. The problem originates from the difference in land in use and land owned. The official data tend to rely on land owned. However, Csaki and Lerman (1997) found from a 1995 survey of 1674 collectivist farm employees that 74% of respondents did not have any certificate of ownership for their plots. Only 31% of SHP land was in private ownership, while the remaining land was still in use rights from the state.

Inputs other than land and labor

Disposable inputs that go into SHP production are even harder to account for. SHP owners rarely had any agricultural machinery (Csaki and Lerman, 1997). In most of the cases, rural SHP users acquired production inputs from collectivist farms. Recent surveys (Perotta, 1998) confirm that wages in kind remain the major channel of input acquisition for rural residents.

Perotta (1999a) describes a 'by agreement' channel of acquisition of SHP inputs, which in essence is very similar to a grower contracting system in the US. Collectivist farm management distributes livestock, especially cattle to workers, pensioners, and other rural inhabitants. There is an agreement by which the collectivist farm provides feed in exchange for a certain quantity or proportion of livestock produced for the enterprise. As for accounting, both livestock and inputs remain listed in the collectivist farm books, while the production goes on at the SHP, and a good share of output remains in the household. As an example, Baker (1998) mentions a collectivist farm that had 1,200 cows listed on the books while only 450 were found in the collective herd. Sedik, Truebold, and Arnade (1999, p.30) reference stories of the worst collectivist farms fallen into extreme despair, and being "cannibalized by their workers who survive on their private plots".

Virtually no documented information is available on inputs used by urban residents other than land. Anecdotal evidence suggests urban SHP owners use very low amounts of inputs other than land and labor; seeds and seedlings are either home produced or bought at farmers' markets.

SHP labor

No official data are available on labor hours in either SHP or total agricultural production for all *oblasti*. The MSUSSR (1991) provides *oblast*-level breakdowns for time spent working SHP in only 14 out of the 25 *oblasti* of Ukraine, and for the families of collective farmers only. Van Atta (1998) reports that in 1995, rural families were surveyed in the same 14 *oblasti* only.

The closest data on labor are the counts of SHP plots. However, the number of people working a plot depends on family size. In addition, a family might have more than one plot if several adults are eligible for the land (Csaki and Lerman, 1997). Perotta (1999a) reports that only 42% of 705 rural households surveyed in 1997 had one plot of land to work on. Some 37% of the families had two plots, and the remaining 21% used three plots of land for SHP.

In addition to the lack of clear correspondence between the SHP plot and laborer numbers, the aggregate *oblast* counts of SHP plots are not separated by rural and urban residents. The number of SHP plots increased from 9.7 to 11.5 million from 1992 to 1998 (SCSU, 1997; MAPCU, 1999). However, the growth is different for rural and urban families: the number of Ukrainian urban households working SHP doubled from 1985 to 1993, while that of rural households remained almost unchanged over this period (ILO, 1995). The small growth of rural SHP user numbers is explainable by nearly total involvement of rural residents into SHP farming, a situation that existed even before the reforms started. Notwithstanding the abrupt growth of the number of city-based subsidiary farmers, the involvement of rural families into SHP farming is still much greater than that of the urban population. According to household budget surveys conducted in 1997, more rural households possessed household plots than did the urban ones. Of all the families surveyed, 98.9% of rural households had SHPs as compared to 28.5% of urban households (Van Atta, 1998).

Two indicators, land in use and income derived, point to the fact that the bulk of SHP labor comes from the rural population. Land available to the urban population is still less than that in use by rural SHP users. Van Atta (1998) reports that as of Jan.1, 1998, the total agricultural land in use by urban SHP users is less than 9% of the total agricultural land under Ukrainian SHPs. The average family land plot in 1997 was 0.09 ha for urban and 0.52 ha for rural households (ibid.). Even more revealing, the income from the SHP by an urban household was almost one seventeenth that of a rural family consisting of 124 Hrn[3] and 2,149 Hrn in 1997 respectively (ibid.). In addition, urban households depend on SHP much less than do rural ones. Only 4% of an average urban household income comes from SHP, while rural households derive 53% of their income from the subsidiary farming (ibid.). All these data suggest that the majority of the SHP labor comes from the rural population. Given that the urban-rural composition of population varies widely across different *oblasti*, the use of the growth of the count of SHP plots as a measure of the growth of SHP hours with no differentiation by rural-urban residency is of little use.

Although we acknowledge the potential shortcomings of data, we attempt to analyze the development of subsidiary farming with the available data. First, we review empirical evidence from the 1960s on the relationship between wages and SHP labor supply. Next, we consider summaries of 1990 household budget surveys together with World Bank survey results (Lerman, Brooks, and Csaki, 1994) to show that observed relationships between SHP time and wages, and those between SHP time and plot size are in agreement with the theory. Finally, we use more recent data to investigate the growth of the SHP share in gross agricultural output.

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[3] Hrn stands for *hrivna*, the current Ukrainian currency.

Pre-reform empirical evidence

Chandler (1984)'s evidence on 1960s SHP labor

The only known empirical evidence on SHP labor allocation is that provided by Chandler (1984) who analyzed collective farm and SHP labor supply of Soviet collective farmers in 1960s. Chandler fitted collective farm labor supply functions using Soviet republic- average data for the years 1963, 1967, and 1970. SHP labor supply functions were estimated using Soviet republic- average data for 1968. Separate labor supply functions were estimated for able-bodied male and able-bodied female collective farmers. The author obtained mixed results for female collective farmers and explained them by different types of work women do in collective farming, specifically, seasonal versus year-around. The results for the male supply function estimations were consistent with the theoretical predictions: the SHP labor supply depends negatively on wage and positively on plot size. The opposite is true for the collective farm labor supply.

1990 evidence

The 1990 family budget surveys (FBS) can be used to verify consistency with theoretical predictions. Unfortunately, lack of complete data does not allow us to estimate any forms of labor supply functions, although some descriptive analysis is possible.

Summaries of FBS provide average share of time that a collective farmer family spent working SHP in 1990 (MSUSSR, 1991). The averages are reported for 14 out of 25 Ukrainian *oblasti*. The same data source reports average family income separated into four categories: collective farm wages, other wages, pensions and state provided subsidies, and SHP income. All the data are reported in current Ukrainian (then Soviet) currency, Krb.

We constructed several measures of non-SHP income and plotted the data using the *oblast* averages as observations. One of the plots, SHP share in family time versus wages received by the family members, is shown on the Fig. 3.1. The plot reveals a negative trend between the share of SHP time and wages. Use of other non-SHP income measures generates similar plots.

We acknowledge that the plots are not very conclusive evidence on the theoretical predictions. The results proven theoretically state that there is a negative relationship between the share of SHP hours and wages under the assumption of *ceteris paribus*. In this case the assumption means that the families have the same tastes, SHP technology, plots, and other inputs across the 14 regions of Ukraine. We are willing to assume the same preferences and same technology for the SHP production. However, inputs and plots might well differ by regions. Yet, no inputs are reported in the FSB.

Average SHP plots for rural families are provided in Lerman, Brooks, and Csaki (1994). Some 600 collectivist farm employees were surveyed in seven *oblasti* for which we have the SHP time share data from the FBS. We combined the two data sources to plot the SHP time share versus average plot size in Fig. 3.2. As with the wages, the relationship is consistent with theoretical results. The larger are the plots, the higher is the share of time spent working SHP in total hours worked.

Having found that pre-reform data in general do not contradict the theoretical predictions, we turn to current data. Instead of evaluating static relationships, we estimate a change in SHP share in gross agricultural output from 1991 to 1996. Since we have no means to correct for possible measurement error in SHP production, we ignore this problem in our estimation. Proxy variables are used to measure SHP inputs.

Figure 3.1 SHP time share in family labor supply versus wage index (Ukraine average = 100);
1990 averages for 14 Ukrainian *oblasti* ; percent.

Coefficient of correlation = -0.31; p-value = 0.23.

Source: MSUSSR, 1991.

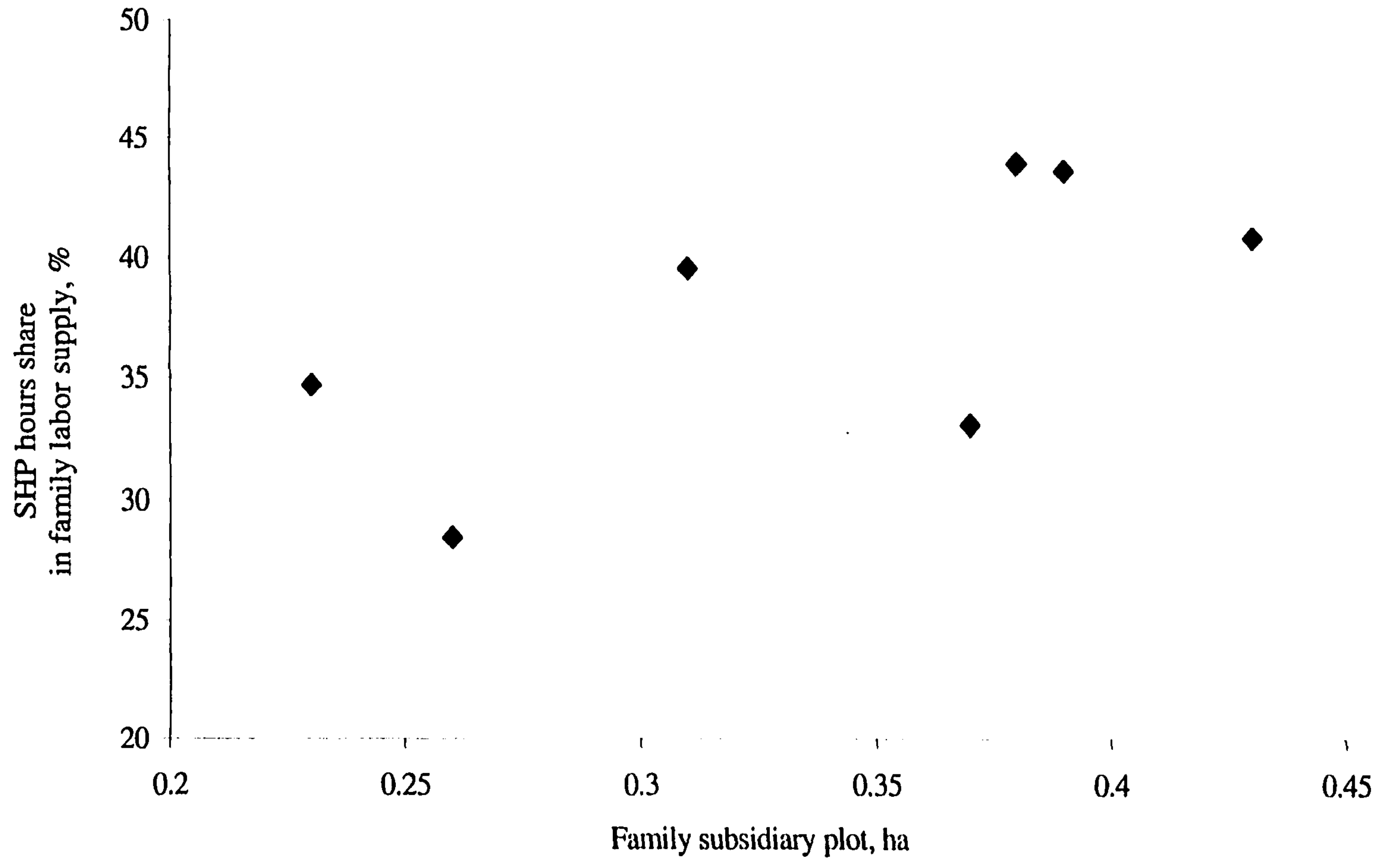

Figure 3.2 SHP time share in family labor supply versus SHP size;
1990 averages for 7 Ukrainian *oblasti;* percent.
Coefficient of correlation = 0.66; p-value = 0.10.
Sources: MSUSSR, 1991; Lerman, Brooks, and Csaki, 1994.

The model

To derive the model to be estimated, we assume existence of two region-level aggregate production functions, one for the SHP sector of agriculture, and the other for the whole agricultural production sector. The two production functions are each of Cobb-Douglas form:

$$Y_s = A_s L_s^{\alpha_1} H_s^{\alpha_2} K_s^{\alpha_3},$$
$$Y_t = A_t L_t^{\beta_1} H_t^{\beta_2} K_t^{\beta_3},$$

where Y_s, Y_t are the outputs of subsidiary plot sector and the gross agricultural output respectively; L_s, L_t denote land in SHP and gross agricultural production respectively; H_s, H_t are the labor inputs in SHP and gross agricultural production respectively; and K_s, K_t are other (capital) inputs in SHP and gross agricultural production respectively. The parameters A_s, A_t represent disembodied technical change and other factors affecting production irrespectively of inputs and regions. The parameters α and β are the elasticities of output with respect to the corresponding inputs;

$$A_s > 0, \quad A_t > 0, \quad \alpha_i \in (0,1), \quad \beta_i \in (0,1), \quad i = 1,2,3.$$

Our primary interest is in the change over time in the share of SHP output in the gross agricultural output, i.e., in the change over time in

$$\frac{Y_s}{Y_t} = \frac{A_s}{A_t} \cdot \left(\frac{L_s}{L_t}\right)^{\alpha_1} \cdot L_t^{\alpha_1 - \beta_1} \cdot \left(\frac{H_s}{H_t}\right)^{\alpha_2} \cdot H_t^{\alpha_2 - \beta_2} \cdot \left(\frac{K_s}{K_t}\right)^{\alpha_3} \cdot K_t^{\alpha_3 - \beta_3}. \tag{3.5}$$

Taking logs and then first differences, we obtain the following specification

$$
\begin{aligned}
\Delta \log\left(\frac{Y_s}{Y_t}\right) = \Delta \log\left(\frac{A_s}{A_t}\right) & \\
& + \alpha_1 \Delta \log\left(\frac{L_s}{L_t}\right) + (\alpha_1 - \beta_1)\Delta \log(L_t) \\
& + \alpha_2 \Delta \log\left(\frac{H_s}{H_t}\right) + (\alpha_2 - \beta_2)\Delta \log(H_t) \\
& + \alpha_3 \Delta \log\left(\frac{K_s}{K_t}\right) + (\alpha_3 - \beta_3)\Delta \log(K_t)
\end{aligned}
\qquad (3.6)
$$

We estimate a version of the above model using *oblast*-level data for 1991 and 1996. Below we discuss measuring the terms on the right hand side of (3.6) and justify dropping some of them from the estimated model.

Modeling right hand side variables

Because of financial difficulties the collectivist farms have run into since the beginning of the economic reforms in 1990, the agricultural sector has not adopted any technical innovations that might have altered production significantly. Consequently, we may safely set $\Delta \log(A_s / A_t) = 0$ in modeling equation (3.6).

Land

Data on total land in agricultural use and agricultural land under SHP are available from official Ukrainian statistics (SCSU, 1997). Since it is not clear whether the SHP land reported is land in use or land owned, we checked the data for consistency.

Intuitively, the demand for SHP land should be higher in the regions with the greatest decline in incomes. However, given a very large drop in real incomes in all regions, and free distribution of land for subsidiary plots, the demand for SHP land is almost infinite and is constrained by federal and local land distribution policies only. Not surprisingly, we found no evidence of a relationship between a decline in real wages and an increase in SHP area for *oblast*-level data.

Given that SHP land was allotted from collectivist farms proportionately to area (see the description of land reform in the Introduction), one might expect variation in the change in SHP area across regions to be determined greatly by the initial supply, i.e. by land availability. Surprisingly, we found no dependency between the increase of the reported SHP land and agricultural land per capita at the *oblast* level. We believe that this is an indication of land reported on ownership, and not on use basis. Current land laws support this explanation. Perotta (1999a) notes that only land located within the boundaries of a settlement (village, town) can be transferred to private ownership for subsidiary farming. That means that the *oblast*-level data are too aggregated to reveal the dependency of privately owned SHP area growth on land availability. To model the growth of land input to SHP production we hypothesize a positive relationship between SHP land in use and agricultural land per rural resident. Consequently, we approximate the changes in SHP land, $\Delta \log(L_s / L_t)$, with agricultural land per rural resident.

For the purposes of the model, we ignore the existence of officially registered private farms. This is justifiable given their lack of visibility in Ukrainian agriculture. As of 1997, the officially registered private farms occupied 2.2% of Ukrainian agricultural land and produced a half of a percent of gross agricultural output only (SCSU, 1997). With this assumption,

$$L_t = L_s + L_c, \quad H_t = H_s + H_c, \quad K_t = K_s + K_c,$$

where L_c, H_c , and K_c denote land, labor, and capital, respectively, of the collective sector of agriculture respectively. With this simplifying assumption, all the land annexed from the collectivist farms went into SHP farming. Thus, the total agricultural land used, L_t, did not change, and this justifies setting $(\alpha_2 - \beta_2)\Delta \log(L_t) = 0$ in (3.6).

Labor

The total labor in agriculture, H_t, consists of hours of collectivist farm work by rural residents, H_c, SHP hours by rural residents, H_s^r, and SHP hours by urban residents, H_s^u, i.e.

$$H_t = H_c + H_s^r + H_s^u,$$

where $H_s = H_s^r + H_s^u$.

Based on the Proposition 3.1, *ceteris paribus*, the share of hours in SHP production in total labor hours is a decreasing function of a relevant wage. Given the almost nonexistent employment opportunities outside of collectivist farms in rural areas, the wage paid by collectivist farms is the one on which labor allocation decisions are made by most of the rural residents.

Average wages paid at the collectivist farms and economy-wide average wages moved in unison over the time period considered (Fig. 1.2). However, the rural and the urban SHP producers differ in a number of ways other than wages that affect their decision on SHP hours. For example, rural residents receive the bulk of SHP inputs through collectivist farms, often as wages in kind. This input acquisition channel is inaccessible for most of the city-based SHP producers. Urban residents have to travel to their plots, and this entails additional costs associated with the SHP production. Other factors like wage arrears and plant closing in heavy industries and mining may affect the decisions of urban population in affected regions. Since we have neither urban-rural composition of SHP producers, nor urban wages for the years of interest by *oblast*, we do not model the urban and rural SHP hours separately. Instead, we treat the real wage in the collective sector of agriculture as the one relevant to the SHP labor allocation decision, and include an additional explanatory variable, the share of rural population in *oblast* population, to control for the urban-rural structure of SHP labor.

Intuitively, if a region is relatively urban, then collective agriculture is relatively small, and a large increase in SHP hours is weighted down by less gross agricultural hours, as compared to a relatively rural region. Consequently, the share of SHP in total agricultural production grows higher simply because the total agricultural production is small. More rigorously, using first order Taylor series approximation, we show that

$$\Delta \log \frac{H_s}{H_t} \approx \Delta \log\left(\frac{H_s^r}{H_s^r + H_c}\right) + \gamma(s_{rural}), \tag{3.7}$$

where s_{rural} is the share of rural residents in the working age population, and γ is a decreasing function of its argument. Derivation of the relationship (3.7) is provided in Appendix 5.

Using the result of Proposition 3.1, we model $\Delta \log\left(H_s^r / (H_s^r + H_c)\right)$ as a function of $\Delta \log(W)$, the change in real agricultural wages. Here W denotes the *oblast*-average real agricultural wage.

Finally, the remaining labor term in (3.6), $(\alpha_1 - \beta_1)\Delta \log(H_t)$, is ignored. Theoretically, the change in total collectivist and SHP labor hours is ambiguous. For the purposes of the model, we may assume that the combined number of hours worked by rural residents in the collective sector and at their SHP, $H_s^r + H_c$, did not change over time. Then any change in H_t comes from an increase in urban population hours. However, as we argued above, labor contribution of urban residents to total SHP labor is relatively small. In addition, the overall sign and magnitude of the term $(\alpha_1 - \beta_1)$ is ambiguous, as no studies are known that estimated labor elasticity α_1 in SHP production. One might expect the elasticity of labor in SHP production to be comparable with that in total agricultural production, thus making the impact of this term small. Thus, we assume that the difference in labor elasticities and small contribution of city-based subsidiary farmers make the term $(\alpha_1 - \beta_1)\Delta\log(H_t)$ negligibly small and ignore it in the model.

Other inputs

The total use of agricultural inputs other than land and labor, K_t, declined considerably over the years of reforms (e.g., World Bank, 1994; Csaki and Lerman, 1997). In addition, although SHP land and labor grew substantially, overall SHP production grew only a little over the last years (Fig. 1.4 and Fig. 1.5). This suggests that similar to the total agricultural production, the use of inputs other than land and labor in SHP production declined. In terms of our model, that means that both K_s and K_t declined over time, and the overall sign of $\Delta\log(K_s / K_t)$ is ambiguous. We assume that K_s and K_t decreased proportionately, i.e. we set $\Delta\log(K_s / K_t) = 0$. As for the change in total other input use, we measure K_t conventionally with total production expenditures less labor expenditures[4].

[4] Due to absent land markets, payments for land are still negligible in the cost of agricultural production in Ukraine (Csaki and Lerman, 1997).

Data

Data on 25 Ukrainian administrative regions (*oblasti*) were constructed using published statistics and the collectivist farm census (for a description of the census, see, for example, Bouzaher, Carriquiry, and Jensen, 1994). Table 3.1 lists sources of raw data; the summary of the data is reported in Table 3.2.

Table 3.1. Definition and sources of variables

Symbol	Variable	Units	Sources of raw data
CCOST	Change in the cost of production net of wages, 1991-96	- -	Author's calculations from collective farm census
CWG	Change in the average real agricultural wage, 1991-96	- -	World Bank, 1996; SCSU, 1997, p.85; Ukrainian Economic Trends, 1998
CYC	Change in the per employee output of collective sector	- -	SCSU, 1997, pp.73, 78, 79, 84
CYST	Change in the proportion of subsidiary farming in gross agricultural output, 1991-96	- -	SCSU, 1997, p.79
LANDAV	Agricultural land per rural resident in 1996	Hectares	MSU, 1996, p.7; SCSU, 1997, p.86
SRURAL	Share of rural residents in the working age population in 1990	- -	World Bank, 1993, p.130
YPW91	Per employee output of collective sector in 1991	Thousand 1983 Krb.	SCSU, 1997, pp.73, 84

Table 3.2. Descriptive statistics of variables [a]

Variable	Units	Sample mean	St. deviation	Minimum	Maximum
CCOST	- -	0.041	0.011	0.017	0.065
CWG	- -	0.202	0.033	0.135	0.250
CYC	- -	0.62	0.10	0.49	0.90
CYST	- -	1.71	0.21	1.42	2.10
LANDAV	Hectares	2.7	1.3	0.6	5.0
SRURAL	- -	0.36	0.14	0.09	0.57
YPW91	Thousand 1983 Krb.	6.6	1.8	2.9	9.3

[a] The unit of observation is *oblast*; 25 observations in total.

Two variables, the change in costs, *CCOST*, and change in wages, *CWG*, were constructed using nominal raw data. Costs of production data were obtained by summing up the nominal costs reported in the census by *oblast*. The resulting figures then were deflated using the GDP deflator. Nominal agricultural wages were reported in official statistics; they were deflated using the CPI. We admit that in the presence of high inflation, reliance on nominal data leads to potential measurement errors. We ignore the problem in the present study because of shortage of data.

Wage data might have some additional drawbacks. The wage reported in the official statistics is the *accrued* wage, and not necessarily the received one. The actually received wages might be higher because of payments in kind. Collectivist farms use wholesale prices to find monetary equivalent of agricultural produce and inputs distributed in lieu of wages.

This practice increases resale value of the wages received in kind. In contrast, for the years after 1994, the wages actually received might be lower than the accrued one because of wage arrears. Lack of data on wages in kind and wage arrears does not allow us to make any corrections.

Econometric model

The following model was fit.

SHP share growth equation

$$\log(CYST_i) = \alpha_0 + \alpha_1 CWG_i + \alpha_2 \log(SRURAL_i) + \alpha_3 LANDAV_i + \alpha_4 \log(CCOST_i) + \varepsilon_i \quad (3.8)$$

Wage growth equation

$$CWG_i = \beta_0 + \beta_1 \log(CYC_i) + \beta_2 \log(YPW91_i) + u_i \quad (3.9)$$

The unit of observation is *oblast*; 25 observations are used in both equations; $i = 1,\ldots,25$.

The SHP share change equation is a direct counterpart of the equation (3.6). Labor hours are modeled as a function of *CWG*, the change in the average real agricultural wage. From the result of the Proposition 3.1, we expect a negative sign on the coefficient α_1. The share of rural population in oblast working age population, *SRURAL*, is included to control for urban-rural composition of SHP labor in accordance with (3.7). From the derivations, we expect a negative sign on the coefficient α_2. The agricultural land per rural resident, *LANDAV*, is included to measure the transfer of land from collectivist farm use towards SHP. From the current land laws, we expect the sign to be positive. Finally, the change in the total cost of production net of labor costs, *CCOST*, measures change in the use of inputs other than land and labor.

The wage equation (3.9) was added to the model to account for endogeneity of wage changes.

Endogeneity of wages

Before 1990, the state exercised strict control over wages in all sectors of economy, including agriculture. This system was temporarily abandoned between April 1991 and November 1992, and enterprises were given some freedom to determine wages (World Bank, 1996). The experiment did not last because monopolies quickly led to rapidly rising prices and higher wages, and this was blamed for accelerated inflation. Agricultural producers lost considerably in this situation, as prices of agricultural output remained under state control and did not grow as fast. Since late 1992, the state essentially returned to the Soviet system of wage control in the collective sector. Currently, the state set wage fund limits are enforced by a highly progressive tax, up to 300% on expenditures in excess to the wage fund limits (ibid.). Since 1993, the farm wage fund has been allowed to vary with production in volume terms (ILO, 1995).

The development of wage control legislation suggests that changes in agricultural wages might be correlated with the collective sector performance. To account for this tendency, we used an instrumental variables approach.

Two variables, the change in the per employee collective sector output 1991-1996, *CYC*, and the per employee output in the collective sector in 1991, *YPW91*, were used as the instruments for the change in wage. Presumably, the smaller was the decline in the collective sector output, the smaller was the decline in the real agricultural wages. Thus, the sign of β_1 is expected to be positive. The 1991 output per worker is used as an instrument based on the belief that the regions of high agricultural output would have more support for agriculture from the *oblast* administration. Then, the administration's favor might show up as a smaller decline in the real agricultural wages, i.e. the sign of β_2 is positive.

Estimation results

Estimation results are summarized in the Table 3.3. The system of equations (3.8) – (3.9) was fitted using two stage least squares method. We conducted Hausman specification tests (e.g., Greene, 1997) to check whether the use of the wage equation is necessary. Under the null hypothesis of exogenous change in real wage, an additional variable included in the equation (3.8), *CWGres*, would have an insignificant coefficient. Here *CWGres* is the residual obtained from the estimation of the wage equation (3.9). Since the coefficient of the *CWGres* turned out to be significant at the 5 percent level of significance, we rejected the null hypothesis of exogenous *CWG* for the equation (3.8). Thus, the model (3.8) - (3.9) was estimated.

Checking for heteroscedasticity

Residuals from both equations (3.8) and (3.9) were investigated to check for possible heteroscedasticity originating from the sample construction. The variance of a mean of n observations is σ^2 / n, where σ^2 is the variance of one observation. Since some of the explanatory variables are functions of *oblast* averages, the error terms in both (3.8) and (3.9) might have variances proportional to the inverse of the *oblast* working age

Table 3.3 Results of two stage least squares analysis [a]

Variable	Estimate	Standard error
SHP share growth equation		
Intercept	1.35	0.38*
CWG	-2.38	0.83*
log(SRURAL)	-0.127	0.047**
LANDAV	0.019	0.019
log(CCOST)	0.166	0.076**
$R^2 = 0.63$		
Wage growth equation		
Intercept	0.150	0.026*
log(CYC)	0.227	0.038*
log(YPW91)	0.088	0.019*
$R^2 = 0.62$		

[a] Standard errors are in parenthesis.
*Indicates statistical significance at the 1% level of significance.
** Indicates statistical significance at the 5% level of significance.

population. However, the plots of residuals versus fitted values and versus the *oblast* working age population did not reveal any tendencies. Therefore, we concluded that the errors ε_i and u_i in (3.8) and (3.9) are not heteroscedastic.

Parameter estimates

The model provided moderate fit, $R^2 = 0.63$ for the SHP share change equation, and $R^2 = 0.62$ for the wage equation. In the wage growth equation, the signs of the instrumental variables are as expected. The results imply that changes in average real agricultural wage are related to the decline in the per employee collective sector output and pre-reform collective sector productivity.

In the SHP share change equation, the signs of the variables pertaining to land and labor are as expected. The results suggest that higher growth in the share of SHP production in gross agricultural production is associated with deeper decline in the collective sector wages, and higher share of rural population. We focus on significance and sign, since the magnitude of the estimates is difficult to interpret given the substitution of observed measures in place of the theoretical model variables.

The effect of land availability is positive, but insignificant. This might be a consequence of the possible error in the measurement of the expansion of land under SHP. Measurement errors are known to bias the corresponding coefficient estimates toward zero; this is referred to as attenuation of the estimates (Fuller, 1987).

The coefficient of *log(CCOST)* is positive and significant. By the model construction, the coefficient measures the difference in the elasticities of agricultural output with respect to other inputs in SHP and gross agricultural production. The positive difference found suggests that a one- percent increase in other inputs would produce a higher percentage increase in SHP production than that in the gross production. This suggests that given the current land and labor allocation between SHP and the collective production, the former is more constrained by restricted access to other inputs.

Conclusions

We investigated the consequences of wage decline on the composition of labor in agricultural production under the current institutional structure in Ukraine. The theoretical model predicts that the share of SHP hours in total labor supply will increase with a wage decline. Empirical evidence from pre-reform times supports the theory in general.

The estimation of the change in the growth of the share of SHP in gross agricultural production revealed relationships consistent with the theoretical result, when the effect of the change in real wages is interpreted as the reason for change in the composition of the total labor supply in agriculture.

As more data become available, a larger system of equations may be estimated, where the relationship between the change in the real wages and the change in the collective sector output is modeled completely. Presently, we treat the change in the per employee output of the collective sector as an exogenous variable in the equation (3.9). Yet, endogenous explanatory variables lead to inconsistent estimates. Lack of data does not allow us to model the link between the change in the per employee output of the collective sector and the change in SHP share of gross output. Ideally, a system of at least four equations would be desirable to estimate. The system would consist of an SHP production function, collective sector production function, a wage equation, and an equation, corresponding to decisions on labor allocation between the sectors.

The results obtained highlight the necessity of improved data collection on SHP production, and especially on inputs used. SHP is becoming an increasingly important component of gross agricultural production in Ukraine. Therefore, it should receive the necessary attention in both economic research and policy analysis. For example, there is a considerable debate going on among Ukrainian policymakers on strategic approaches to privatization in agriculture. Should the private farming grow from-the-bottom-up, that is from SHP farming to private farms? Alternatively, should it grow from-the-top-down, i.e. by dividing large collectivist farms into production subdivisions with autonomy of decisions and financial responsibilities? Clearly, for either approach, reforms must occur in development of land and agricultural input markets. Of course, the best approach may differ by regions depending on local conditions. Yet, appropriate agricultural policy depends on the answer to the question, as the best feasible tax, credit, or investment policies might well differ depending on what approach is chosen. Good understanding of how different sectors interact presently is required to inform such policy alternative.

4. TECHNICAL EFFICIENCY OF GRAIN PRODUCTION

In this study of Ukrainian grain producing farms, we estimate a frontier production function, examine the changes in technical efficiency at the earliest stages of the economic reforms, and evaluate the relationship between technical efficiency and farm workforce composition. The analysis includes quantifying the changes of production, input use, and the efficiency over time in order to obtain estimates of the effects of factors associated with technical inefficiency and the elasticities of grain production with respect to the different inputs and returns-to-scale. A combination of the three favorable factors: the time period analyzed, the quality of data, and the model employed, makes our study differ from previous research. Our study covers the beginning of the reforms, utilizes farm-level data reported in physical units, and employs an inefficiency model that allows for simultaneous estimation of the parameters of both the frontier production function and the inefficiency effects. To our knowledge, no study has accomplished similar analysis for any of the countries of the former Soviet Union.

Background and justification

Concept of technical efficiency

Technical efficiency of a producer refers to the ability of a production unit to achieve maximum possible output given the technology and quantities of inputs available. *Technical inefficiency* of a particular firm could be defined as the amount by which firm's output falls short of the maximum possible output obtainable given the technology and input quantities (see, for example, Lovell, 1993; Coelli, Prasada Rao, and Battese, 1998). The function relating the quantities of inputs to the maximum possible output is called the *production frontier* function.

The existence of technical inefficiency of firms engaged in production has been a subject of debate. Stigler (1976) observes that measured technical inefficiency may be a reflection of a failure to incorporate the right variables and to specify the right economic objective of the production unit. Muller (1974) argues that if all inputs are taken into account, measured productivity differences should disappear except for random disturbances.

However, the problem of inclusion of all inputs is a difficult one. Some inputs, as information, or managerial ability, knowledge and experience are not easy to measure. Moreover, even when some of these inputs are measurable, for example, by years at the current occupation, or by years of formal schooling, another problem arises.

Managerial ability is an input that is applied *when needed,* as is information. The need for these inputs, in turn, is not generally uniform over time or over producers. The need increases when the normal production process is disturbed by an unexpected event, like equipment failure. Droughts, floods, and sudden weather changes are examples of other events randomly affecting agricultural production. Since the need for the managerial input depends on a random event, the amount of the input applied is random. Consequently, the input can not be treated as are other regular inputs. One of the possible ways to treat this randomness is to refer to the concept of technical inefficiency.

Variation in managerial ability is a part of the variation in technical efficiency. The other possible sources of the differences in technical efficiency among farms are differences in access to information, differences in access to credit, or differences in organizational structures of farms (Lovell, 1993). These factors all refer to the *physical ability* of the producer to achieve the best practice frontier.

In addition to the question of the *physical ability* to achieve the frontier, the question of *eagerness* to achieve the frontier comes up in many settings. The incentives of the manager and workers to achieve highest possible production given the resources available may be affected by ownership structure of a farm. Regulatory changes affecting the degree of competitiveness of an industry environment, for example, opening up for international trade, may also change the pressure on producers to do their best (Lovell, 1993). The technical efficiency framework allows quantifying the effect of changes in these factors on production, making it a valuable tool for policy analysis.

Ability to deal with disequilibria

Managerial ability is one of the instances of what Schultz (1975) called the *ability to deal with disequilibria*. He defined this concept as the ability of individuals to "perceive, to interpret correctly, and to undertake action that will appropriately reallocate their resources" (Schultz, 1975, p.827) in response to a changed economic environment. Schultz argued that changes in economic conditions increase demand for the ability to regain equilibrium in a new environment.

Loosely speaking, the random disturbances affecting production alter the "equilibrium" of normal production. In this situation the manager's, or more generally, the farm's ability to regain the "equilibrium" comes into play. This way, farm's technical efficiency reflects in part farm's ability to deal with disequilibria, and the farm's ability to deal with disequilibria explains in part variation in technical efficiency among farms.

Inefficiency explanatory variables

In the current study, the differences in technical efficiency performance of collectivist farms are explained by exploring the link between efficiency and the ability to deal with economic disequlibria. Schultz (1975) argued that the person's ability to deal with economic disequilibria is enhanced by education and experience. Accordingly, we focus on the factors representing farm human capital.

In addition, the effect of farm production infrastructure on technical efficiency is analyzed in this study. The effect of changes in conditions under which the farms operate is captured by a year variable. These conditions include institutional and other infrastructure constraints.

The process of reforms in formerly planned economies might be thought of as the process of adjustment and reallocation of resources as the economy moves from one equilibrium state corresponding to a planned system to another corresponding to a more market oriented system. Under the old system, the production environment remained stable over many years, and farm managers knew from their experience how the system worked, and what were the objectives and incentives of economic agents involved in production: farm workers, local administration, government procurement agencies, and party officials. This knowledge allowed them to achieve successfully their goals, like maintaining appropriate social status and local power through fulfillment of state production plans. The production possibilities frontier was well known from experience, and particularly, the managers gained knowledge on how to organize, motivate, and monitor employees.

The start of the reforms meant drastic changes in the known economic environment: prices started to reflect scarcity of economic resources and financial results started to play an increasingly important role in valuation of farm performance. The number of choices for farm workers increased: in particular, the workers now had more choice in the number of hours to work at the collectivist farm. The altered possibilities increased the demand for the managers' ability to make efficient choices to achieve a new equilibrium in the economic system with the changed rules, objectives, and constraints.

Why focus on grain?

The analysis of this study focuses on grain. Although state and collective farms were very diversified agricultural enterprises, most of them produced grains.

Grain is one of Ukraine's most important agricultural products. Ukraine produced on average 47.4 million tons of cereals per year in 1986-1990. Grains were grown on some 14,541 thousand hectares on average over the years 1989-1992, an area which represents 44 to 45 percent of the total Ukrainian area sown. Grains are the essential crop for both livestock production and human consumption. Wheat accounted for 49% of the total area cultivated under cereals on average in 1989-1993. Barley, the most important feed grain, accounted for 19%, followed by maize (15%) (World Bank, 1994). The significance of grain comes also from the fact that it is one of the commodities used by government in barter trade with other former Soviet Union countries (Pogozheva and Chenard, 1997). Currently, over 90% of Ukrainian grain is still produced by the former state and collective farms (Valdes et al., 1997).

Because of this significance both during and after the Soviet time, farm managers regarded grain production as the most important one, and were motivated to do their best with this crop. Thus, they accumulated ample experience in growing grain. Hence, changes in and determinants of collectivist farm technical efficiency should be revealed better in grain production than in any other product.

Literature review

Technical efficiency measurement techniques

There are two primary methods, *econometric* and *mathematical programming*, for construction of production frontiers and the measurement of efficiency relative to the constructed frontiers (see, for example, the surveys by Bauer (1990); Greene (1993); Coelli, (1995b); Sieford (1996); Coelli, Prasada Rao, and Battese (1998)).

The *econometric* approach involves estimation of a frontier production model of the general form (for panel data)

$$y_{it} = f(x_{it};\beta) + v_{it} - u_{it},$$

where y_{it} is output for farm i in year t; $f(.)$ is a known function of its arguments, x_{it} is a vector of inputs for farm i in year t; β is a vector of parameters to be estimated, v is the random error term, u is a non-negative measure of technical inefficiency. Alternative assumptions about distribution of the inefficiency measure u, estimation methods, and functional forms for the function $f(.)$, lead to different modifications of this model.

The *mathematical programming* approach, also called data envelopment analysis (DEA), involves construction a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. Alternative assumptions about returns to scale and input or output orientation of efficiency measures distinguish the models.

The essential differences between the models concern two characteristics: treatment of random noise, and flexibility in the structure of production technology. The econometric approach discriminates between the noise and inefficiency, while the programming approach piles noise and inefficiency together and calls the combination inefficiency. The econometric approach is parametric, because it requires specification of a functional form for the function *f(.)*. Consequently, misspecification of the function could lead to spurious inefficiency being estimated, while the nonparametric DEA approach is less prone to this type of error.

Although neither approach is uniformly the best in all instances, the analysis of agricultural production in former Soviet countries calls for the econometric approach.

Agricultural production is inherently variable, due to weather, fires, pests, diseases, etc. As Coelli and Battese (1996) argue, this makes DEA a less favorable technique than the stochastic approach, for the latter does not assume that all the deviations from the frontier are due to inefficiency. Furthermore, FSU data were tabulated manually, at least until recently and especially in rural areas. Consequently, the available data on production are likely to have substantial measurement error (Brock, 1997).

Inefficiency explanation

Since the first studies on technical efficiency, researchers tried not only to *evaluate*, but also *explain* differences in efficiency scores of different firms. The natural candidates on the inefficiency explanatory variables were various socio-economic variables (see, for example the surveys of Battese (1992), and Bravo-Ureta and Pinheiro (1993)). The identification of these factors might be of significant use to policy makers attempting to raise average level of farmers' technical efficiency. Variables affecting the ability of the manager, like education and experience, farm size, changes in institutional constraints, access to credit, and utilization of extension services are among the factors used to explain variation in technical efficiency.

The first studies estimated the stochastic frontier assuming mean of technical inefficiency to be constant among farms and regressed later the estimates of the predictors of technical efficiency on farm-specific variables. As Battese and Coelli (1995) argue, the assumption of farm-independent mean of technical inefficiency made on the first stage of the estimation of the stochastic frontier, is not consistent with the assumptions of the second stage when the means are assumed to be functions of farm-specific variables. Thus, the simultaneous estimation of inefficiency effects with the stochastic frontier is a technique preferred to the two-stage analysis. The models proposed by Huang and Liu (1994) and Battese and Coelli (1995) allowed for the simultaneous estimation of both production frontier and inefficiency explaining model.

The Battese and Coelli (1995) model presented later in the text is used in our analysis.

Efficiency of agricultural production in formerly planned economies

There have been considerable applications of frontier methods in agriculture (Battese 1992; Bravo-Ureta and Pinheiro, 1993; Coelli, 1995b). However, little research exists on the efficiency of agriculture in the formerly planned economies.

Data have been limited, especially at the farm level, and the work on productivity and efficiency in agriculture was first done using country level data (Koopman, 1989; Carter and Zhang, 1994), and regional within-country aggregates (Boyd, 1987, 1988; Brada and King, 1993; Hofler and Payne, 1993, 1995; Sotnikov, 1998; Sedik, Truebold, and Arnade, 1999). Recent studies exist that use farm-level data to study production efficiency. Brock (1994, 1997) analyzed farm-level data to study production efficiency using a "whole farm" production function. Only a few studies examine farm level technical efficiency of a single crop in the formerly planned economies (e.g., Skold and Popov, 1990, 1992; Johnson et al., 1994; Bayarsaihan, Battese, and Coelli, 1998).

In the planned economy setting, in addition to the question of the *ability* to achieve the frontier, the question of *willingness* to achieve the frontier deserves special interest. The incentives of manager and workers to achieve the highest possible production given the resources available may be affected by breaking the link of ownership between the farm workers and the means of production.

Within country studies on productivity and efficiency of Socialist agriculture can be divided in two groups. One group has addressed the question of whether efficiency of collectivist agriculture is significantly lower than that of the private one. The other group has analyzed efficiency of collectivist agriculture without referring to the private one.

Studies comparing private and collectivist agriculture

The first group of studies were carried out for Yugoslavia and Poland, because these are the only Socialist countries where socialist and private sectors of agriculture were comparable in terms of size and output mix.

Boyd (1987) compared efficiency of socialist and private sectors using Yugoslavian regional data for the period 1956-1979. First, sector production functions were estimated and were found to be different. Next, an aggregate production function was estimated and sector intercepts were compared to capture the difference in efficiency. The intercepts were higher for the private sector. However, the author argued that different input elasticities and different economies of scale make the comparison between the two sectors dependent on factor endowments. He concluded that the socialist enterprises can not be called more inefficient than the private ones. Similar methodology produced similar results for Poland (Boyd, 1988).

Brada and King (1993) used a linear programming method to compare technical efficiency of Poland socialist and private sectors. The sample used for this study was that of Boyd (1988) consisting of observations on 17 counties over the years 1960-1974. As in the previous studies, no differences in the levels of technical efficiency between the two sectors were found. However, the dispersion of efficiency levels was found to be smaller for the private farms.

Hofler and Payne (1993, 1995) reexamine Boyd's (1987) work by applying a stochastic production frontier model. They find the private sector to be more efficient than the cooperative one in two of the three regions of Yugoslavia studied.

The relatively recent study of Piesse, Thirtle, and Turk (1996) utilize farm-level data on 4 cooperative and 12 private dairy farms in Slovenia (former Yugoslavian republic) for the years 1974-1990. The non-parametric programming approach and econometric approach results were compared. For the econometric method, the production function was first estimated using panel data model with varying intercepts and common slope coefficients. Then the corrected ordinary least squares technique was applied. Both approaches showed the private sector to be more technically efficient, and its productivity to grow faster than the cooperative sector. The cooperatives remained more productive because private farms were too small.

Technical efficiency studies on collective agriculture alone

Skold and Popov (1990) estimated the inefficiency model with a Translog frontier production function and half-normal inefficiency term (Aigner, Lovell, and Schmidt, 1977) separately for 5 crops on a sample of 115 state and collective farms from Stavropol Region, Russia, 1986-1988. The average efficiency varied from 0.55 for vegetables to 0.83 for grain.

Skold and Popov (1992) related differences in technical efficiency estimates to farm organizational structures, management characteristics, and labor payment methods. The inefficiency model with a Cobb-Douglas frontier production function and half-normal inefficiency term (Aigner, Lovell, and Schmidt, 1977) was estimated separately for 5 crops on a sample of 71 state and collective farms from Stavropol Region, Russia, 1986-1987. The two-stage approach to the inefficiency explanation was used.

Skold and Popov (1992) found that collective farms were more efficient than state farms. This was explained by the practice of rescuing failing collective farms by the by state and converting into state farms. Contrary to expectations, the impact of alternative technology programs sought to improve allocation and timing of fertilizer and pesticide use was found insignificant. It may be explained that the program increased resource use (fertilizer), a change captured in the traditional production function inputs; the improved timing of input application turned out to be not as effective in increasing yield, as was the increased quantities of inputs applied. Farm organizational structure mattered for grain and sunflower production efficiency only. Years of manager's experience had a positive effect, though significant in vegetable production only. No difference in efficiency achieved under different payment schemes was revealed, probably because all the forms of labor payments gave similar salary levels.

Bouzaher, Carriquiry, and Jensen (1994) (also reported in Johnson et al., (1994)) estimated the inefficiency model with a Cobb-Douglas frontier production function and time varying inefficiency term (Battesse and Coelli, 1992) separately for 4 crops and 3 soil-climatic zones of Ukraine. The data used came from the collective farm census: 11,440 farms, 1986-1991. Declining over time technical efficiency was found. The "tails" of the farm-level distributions of technical efficiency scores were examined to identify farm indicators differing between the most efficient and the least efficient farms. State farms turned out to be more efficient that the collective ones. The more efficient farms had more processing and subsidiary workers, higher assets value per hectare of agricultural land, and a lower portion of revenue from livestock.

Brock (1994) applied a Cobb-Douglas "whole farm" production function in the analysis of 345 collective and state farms in Volgograd Region, Russia, 1991. An inefficiency model with a half-normal inefficiency term (Aigner, Lovell, and Schmidt, 1977) was tested and rejected in favor of the traditional production function. The author found a strong negative effect of land quality on productivity. The unexpected finding was explained by ideologically-based output pricing policies that discriminated against farms with high quality lands (the composite output of the farm was measured in current rubles). State order (measured by the share of output sold to state) was found to have no effect on productivity. The author argued that although state order should improve productivity by guaranteeing input supplies, it suppresses realization of local comparative advantage by stipulating output mix.

Brock (1997) used the inefficiency model with a Cobb-Douglas *whole farm* frontier production function and time varying inefficiency term (Battesse and Coelli, 1992) to analyze how land quality, access to transportation, and state procurement influence collectivist farm performance in Russia. A sample of 173 state and 143 collective farms in Volgograd Region, Russia, 1988 – 1990, was used. First, the model was estimated separately for six soil-climatic zones. Then the means of efficiency scores were compared between two groups of farms to test whether factors of interest affect inefficiency (separately for the six zones). The insignificant effect of state order found in the results was explained as in Brock (1994). A positive, though insignificant, effect of transport access, as measured by whether or not a farm is located near mainline transport links, was attributed to poor quality of rural transport system. Insignificant differences in the means of efficiency were found between state and collective farms. Efficiency declined with soil quality in two zones, and increased with state procurement share in one zone.

Bayarsaihan, Battese, and Coelli (1998) used a panel of data on 48 Mongolian farms over 1976-1989 to study the changes in and determinants of efficiency of grain production. Two econometric models were used. The inefficiency model with a Translog frontier production function and time varying inefficiency term (Battesse and Coelli, 1992) was estimated separately for three sub-periods corresponding to different policy regimes. Farm technical efficiency was found to decrease significantly over the period 1976-1980, decrease slowly over 1981-1985, and increase slowly over the period 1986-1989, result that are consistent with the changes in incentive policies.

Inefficiency explanatory variables were available for provinces, not individual farms, and for 1987-1989 only. These variables were assigned to farms according to the province where the farm belonged. The constructed data were used to estimate the inefficiency model with a Translog frontier production function and the inefficiency term depending on province- and time-specific variables (Battese and Coelli, 1995). The efficiency was positively related to the levels of technical education and experience of farm workers, the degree of management autonomy, and the amount of Russian technical assistance.

Sedik, Truebold, and Arnade (1999) addressed changes of efficiency over 1991-1995 with *oblast*-level data on collectivist farm crop production from 74 regions of Russia. Four models were estimated. A DEA model with an output oriented measure of efficiency with both variable and constant return to scale variations was fit. The stochastic frontier model with Cobb-Douglas frontier production function and time varying inefficiency term (Battesse and Coelli, 1992), and that with the inefficiency term depending on *oblast*- and time-specific variables (Battese and Coelli, 1995) were considered. The last model was used to analyze the factors affecting inefficiency.

Efficiency declined with time, especially for the least efficient regions. Movement toward concentration of production increased efficiency. The more efficient regions had more employees per farm and smaller farms. State procurement increased efficiency, which according to the authors, means that state procurement might reduce transaction and search costs for farms allowing them to concentrate on production only. Another possible explanation, not considered by the authors, is that signing up for state order eased timely input acquisition, and this contributed to an increase in farm output. An increase in input prices relative to output prices led to improved efficiency, presumably, through encouragement of efficient input use. An increasing share of subsidies in revenues lowered efficiency.

More precipitation led to more efficiency, higher temperatures led to less efficiency. Authors reasonably explained this finding as the incidence of drought would show up as apparent technical inefficiency.

The share of value of crops raised privately was negatively related to the efficiency of collective sector. The explanation of the authors supports the working hypothesis of the previous two chapters of the dissertation. Intentional or de facto provision of inputs to SHP production (including labor) increases the amount of crops raised privately and lowers availability of the inputs for collective production. The last, in turn, if not reflected in the amounts of inputs used up for collective production, shows up as a spurious inefficiency in this sector.

Data

The data for our analysis come from a random survey of state and collective farms in Ukraine during 1989-92 (Carriquiry, 1993). Since little internal restructuring has occurred since this period, the clear advantage of the detailed input and output data reported in physical units overweighs the possible disadvantage of using seven year old data.

The data were collected in 1992 retrospectively for 1989-1991. The survey was designed as a random sample of state and collective farms across agro-climatic zones and was stratified by farm size. The Ukrainian Institute for Agrarian Economics (UIAE) supervised the administration of the survey. The data were based on farm-kept written records that are the source for standard statistical questionnaires filled out at the end of each year. Of the original 80 farms surveyed, data for 41 from two administrative regions, the *Kyivska oblast* and *Cherkaska oblast* of the mixed soil-climatic zone, were complete and used for the analysis. The mixed soil-climatic zone has average annual precipitation of 450 to 600 mm and has predominantly highly favorable black soils. This zone takes up about one third of total Ukrainian agricultural land. Comparison of sample means with those of the census data confirms that the sample is representative for the mixed soil-climatic zone of Ukraine.

Descriptive statistics

Table 4.1 shows changes over 1989-1992 typical for Ukraine's agricultural sector as the large collectivist farms started to downsize. The average farm size in the sample in 1989 was 2,403 hectares of agricultural land with 384 farm workers, 327 of whom were engaged in agricultural production.

The average decline in the land holdings of the farms over the period was 7.6%, because of obligatory transfer of land to state reserves (see the description of land reform in the Introduction).

The average decline in the total number of farm and agricultural workers was 13% and 11%, respectively. The decrease in the working population on the farms can be attributed to at least three factors: workers leaving farms to move to cities, retirement, and quits to farm privately.

The migration of working age population from rural to urban areas prevailed in the pre-reform Soviet Union for a long time, because Soviet official development policies favored industrial urban growth for the expense of agriculture (Bonanno et al., 1993; World

Table 4.1. General farm-level indicators [a]

Indicator	Units	1989	1990	1991	1992	Avg. change per farm 1989-92
Agricultural experience of manager	years				25.6 (7.4)	
Agricultural land	hectares	2403 (971)	2350 (948)	2236 (857)	2196 (830)	-7.6% (9.6%)
Total farm workers	number	384 (123)	376 (121)	359 (118)	335 (120)	-13% (10%)
Agricultural workers	number	327 (97)	317 (97)	305 (97)	290 (98)	-11% (12%)
Ratio of non-agricultural to total farm	number	0.145 (0.053)	0.154 (0.054)	0.146 (0.053)	0.129 (0.050)	-8% (26%)
Agricultural workers per hectare of agricultural land	number	0.143 (0.033)	0.142 (0.032)	0.142 (0.029)	0.137 (0.030)	-3% (15%)
Share of agricultural land under grains	number	0.482 (0.053)	0.484 (0.059)	0.485 (0.053)	0.458 (0.056)	-5% (10%)
Pensioners	number	369 (130)	370 (132)	372 (133)	373 (130)	1% (10%)
Ratio of pensioners to total farm workers	number	0.97 (0.22)	0.99 (0.24)	1.05 (0.24)	1.14 (0.30)	17% (17%)
Ratio of non-agricultural to total farm expenditures	number	0.047 (0.045)	0.078 (0.087)	0.098 (0.104)	0.196 (0.155)	600% (815%)

[a]All the indicators reported are average per farm, the numbers in parentheses are the standard deviations

Source: UIAE survey of Ukrainian farms

Bank, 1994). The UIAE (1993) reports specifically that the rural population of the two administrative regions represented in the data declined by more than 22% from 1970 to 1990.[5]

The other possible explanations for the decline in collective sector employment are in quits and layoffs due to retirement and shift to private farming. Aggregate Ukrainian statistics show virtually unchanged rural population over the years (SCSU, 1997). What do those who left do for a living? Most of them are, probably, retirees. According to census data, in 1989, some 29% of workers in agriculture were older than fifty (ILO, 1995). Given that the official retirement age in Ukraine is 55 for women and 60 for men, it is quite possible that a big share of those who left collective farming retired. This explanation is consistent with pensioner data in the sample: on average, the number of pensioners per worker increased by 17% over the period.

As for those not retired, private farming is the only alternative to collectivist farm employment in rural areas. For families with more than one adult, an employment of one member at the collectivist farm might be enough to keep all the benefits of input acquisition, while other family members work SHP.

On average, the share of farm resources devoted to activities other than agricultural production declined 8%, as measured by the share of workers not involved in the main production. In 1992, about 13% of farm employees were social, maintenance, repair,

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[5] As transition developed, the rural out-migration decreased, and even reversed in many parts of the former Soviet Union (Mitchnek and Plane, 1995; Wegren, 1995). The researchers convincingly argue that in the presence of overall difficulties with food people prefer to have the household plots where at least food can be produced. However, since 1991-92 are the first years of reforms, it is likely that better opportunities in cities were still attracting younger people from villages during the years covered by our data.

construction, or processing workers. The share of non-agricultural production expenditures in total farm expenditures increased from less than 5% in 1989 to almost 20% in 1992. However, because of the complex system of subsidies, bonuses, and other price distortions, it is not clear whether there was an increase in this measure in real terms. In addition, a part of this increase might be attributed to problems of keeping adequate financial accounting in the situation of high inflation. Prices doubled from 1990 to 1991, and increased almost 20 fold from 1991 to 1992. To avoid the considerable error that might be introduced while relying on the data in monetary units, we employ data only in physical units for our analysis.

Partial productivity indicators

Table 4.2 shows the grain production and input use based on the survey results. On average, total grain production declined by 35% over the four years, although the area under grains declined by only 12%. A part of the decline in yield can be attributed to poor weather in 1991 and moderately inferior weather in 1992 (prolonged drought during the summer combined with high temperatures), although input shortages aggravated the situation. Application of inputs changed dramatically, as application of chemicals per hectare went down 20%, organic fertilizer per hectare dropped 16%, and labor use per hectare increased more than 90% on average over the four years. The decline in the application of chemicals must be attributed to sharp increases in the prices of agricultural inputs relative to prices of agricultural output. The decrease for organic fertilizer comes from the downsizing of livestock operations (Csaki and Lerman, 1997). In this situation, the farms substituted the inputs that were readily available (labor and land) for more expensive and relatively scarce inputs (chemicals, fertilizer).

Table 4.2. Partial productivity and input use indicators [a]

Indicator	Units	1989	1990	1991	1992	Avg. change per farm
Yield	tons per hectare	4.27 (0.79)	4.00 (0.73)	2.88 (0.60)	3.18 (0.74)	-25.4% (8.5%)
Production	tons	4936 (2690)	4562 (2558)	3205 (1796)	3183 (1778)	-35% (10%)
Area planted	hectares	1173 (550)	1149 (542)	1104 (510)	1020 (469)	-12% (10%)
Labor per hectare planted	hours	24 (12)	27 (13)	28 (15)	35 (17)	93% (184%)
Fertilizer per hectare planted	kilograms	7603 (5952)	7624 (5950)	6598 (5264)	6385 (5556)	-16% (23%)
Chemicals per hectare planted	kilograms	6.5 (1.5)	6.3 (1.6)	5.7 (1.4)	5.2 (1.4)	-19% (15%)
Fuel per hectare planted	liters	83 (14)	83 (14)	82 (13)	82 (12)	-0.9% (5.7%)

[a]All the indicators reported are average per farm, the numbers in parentheses are the standard deviations

Source: UIAE survey of Ukrainian farms

Labor use per hectare increased on average by 90%, an observation that seemingly contradicts the relative decline in collectivist farm labor analyzed in the previous two chapters of the dissertation. However, the times considered in the previous two studies and the current one are different. The average increase in the labor hours may be spurious, as increasing the number of hours has been the only way to increase the farm wage bill in the situation of state controlled per hour wages and farm gate output prices.[6] We emphasize that the labor hours are those *reported* in the collectivist farm books, and as such may be subject to over-reporting. The high variation across the farms in the sample in the change in the labor hours per hectare may be an indication of the reporting problems. Because of data shortage, the issue is ignored in the present study, but the observations suggest that the question of reported versus actually used labor in collectivist farm production needs to be examined more directly in future research.

The increase in the labor hours may also be genuine, as shortage of other inputs may have forced the farms to switch to manual labor wherever possible. The increase in the hours in grain production does not imply similar increases in other crop and livestock product production. Consequently, the reported increase in labor use in the sample does not contradict the predicted relative decline in the collectivist farm labor hours analyzed in the previous two chapters. In any case, we used the best available reported use of labor inputs in the current study.

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[6] The limitations on farm wage fund discussed in the previous chapter do not apply here as the time periods considered are different.

We were surprised to find that the reported diesel fuel used per hectare did not change over time, because fuel is the agricultural input that experienced the highest price increase (Csaki and Lerman, 1997). The lack of change may reflect the deliberate over-reporting of fuel use on farm accounts to ensure enough allotment from the state in the future. Although Brock (1994) did not find deliberate over-reporting in the farm annual accounts, it is not clear whether the author refers to both input utilization and output or to the output only. Alternatively, the unchanged fuel use may reflect the adequate provision of inputs due to the preferred status of grain production. Since we have no means to check or to correct for the possible error in the measurement of this input, at this point we ignore this potential problem in estimation.

Method

The model that allows for simultaneous estimation of both the parameters of the production frontier function and those of the inefficiency effects model is employed for the analysis. Battese and Coelli (1995) proposed the model. The inefficiency explanatory variables are chosen to track the changes over time and to explain the variation across farms by the variation in farm organization, in managerial ability, in access to markets, and in availability of resources.

In this study, a Translog stochastic frontier production function is assumed to be the appropriate model for the analysis of the state and collective farm data for the two *oblasts*. The model to be estimated is defined by

$$Y_{it} = \beta_0 + d_{91} + \sum_{j=1}^{5} \beta_j x_{ijt} + \sum_{j\le k}^{5} \sum_{=1}^{5} \beta_{jk} x_{jit} x_{kit} + V_{it} - U_{it} \,, \qquad (4.1)$$

where the subscript, i, indicates the observation for the i-th farm in the survey ($i =$ 1,2,...,41), and the subscript, t, indicates the observation for the t-th year (t = 1,2,3,4). Y represents the logarithm of the total grain production (in metric tons) on the given farm in the given year; β_i, β_{jk} , ($i =$ 0,1,...,5; j, k = 1,2,...,5) represent the unknown parameters, associated with the explanatory variables in the production function; d_{91} is a dummy variable, which has value 1 if $t = 3$, and value 0 otherwise; and x_is ($i =$ 1,2,...,5) represent the logarithms of the total amounts of land under grain production (in hectares), labor in grain production (in 1,000 hours), organic fertilizer applied for grain production (in 100 tons), chemicals applied for grain production (in tons), and diesel fuel used in grain production (a proxy for machinery services) (in 1,000 liters) respectively.

The V_{it}s are assumed to be iid N(0, σ_V^2) random errors, independently distributed of the U_{it}s. The U_{it}s are non-negative random variables, associated with technical inefficiency of production, which are assumed to be independently distributed, such that U_{it} is obtained by truncation (at zero) of the normal distribution with variance σ_u^2, and mean, μ_{it}, where the mean is defined by

$$\mu_{it} = \delta_0 + \delta_1(nonagw_{it} / totw_{it}) + \delta_2 age_i + \delta_3 dis_i + \delta_4(agw_{it} / totland_{it}) + \delta_5 t \,, \qquad (4.2)$$

where δ is a (6 x 1) vector of unknown parameters to be estimated. The variable $nonagw_{it}$ / $totw_{it}$ is the ratio of the number of workers on the farm that are not involved in agricultural production to the total number of the workers on the farm; age_i is the age of the given farm manager in years; dis_i is the distance from a given farm to the nearest city in kilometers; agw_{it} / $totland_{it}$ is the number of agricultural workers on the farm per hectare of the total farm land; and t is the year of observation (t = 1,2,3,4).

The *nonagw/totw* ratio reflects farm organization and measures the extent of the farm self-reliance in the maintenance of its productive and social infrastructure. The higher this ratio, the more of the farm labor resources are devoted to facilities construction and maintenance, machinery repair, processing, childcare provision, and other non-agricultural activities. To some extent, the higher this ratio, the less the farm depends on the state and/or on the developing markets for its operation. This variable is expected to have a negative effect on the size of the technical inefficiency effects, i.e., as the relative share of nonagricultural activities on the farm increases, so does the infrastructure quality on the farm, which in turn, increases the technical efficiency of the farming operations. The high *nonagw/totw* ratio could also be thought of as insurance that a farm has against the difficulties of the transition period, a time when the old state controlled system of farming support had already deteriorated while new private intermediaries had not yet emerged.

The *age* variable is included to check whether the younger and, presumably, more reform-oriented managers or the older, more experienced ones achieve higher levels of technical efficiency.

The distance to the nearest city is expected to have a negative effect on the technical inefficiency as the further the farm is located from the alternative sources of employment, the better are the chances of keeping the most productive labor on the farm, and the higher is the average quality of labor inputs.

The *agw/totland* ratio is included in the model to control for the relative labor abundance of the farm; the time variable captures the changes in inefficiency over time. We also have included a dummy variable d_{91} into the stochastic frontier specification to account for poor weather conditions in 1991. The descriptive statistics of the variables used in estimation are presented in Table 4.3.

The parameters of the model, i.e. the β's, the δ 's, and the variance parameters $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$, are simultaneously estimated using the method of maximum likelihood. We used program FRONTIER 4.1 developed by Coelli (Coelli, 1996) that computes the parameter estimates by maximizing a nonlinear function of the unknown parameters in the model subject to the constraints.

Table 4.3. Summary statistics for variables in the stochastic frontier production function [a]

Variable	Units	Sample Mean	Sample St. Deviation	Minimum	Maximum
Production	tons	3972	2361	1219	18574
Land	hectares	1112	517	268	2850
Labor	1,000 hours	32	29	6	219
Fertilizer	100 tons	79	78	14	596
Chemicals	tons	6.6	3.7	1.6	21.4
Fuel	1,000 liters	93	51	24	285
Ratio of non-agricultural to total workers	number	0.143	0.053	0.041	0.317
Agricultural workers per agricultural land	number per hectare	0.141	0.031	0.081	0.245
Distance to city	km	35	16	10	85
Manager's age	years	46.9	8.2	30	65

[a] 41 farms, 4 years, 164 observations in total

Results

Table 4.4 reports maximum likelihood estimation results. Several generalized likelihood-ratio tests regarding the stochastic frontier coefficients, inefficiency model, and variance parameters, are summarized in Table 4.5.

Production frontier estimates

The estimated standard errors of some of the coefficients in the stochastic frontier are large relative to their estimates, which indicates that the individual coefficients may not be statistically significant. However, the generalized likelihood-ratio test rejects the composite hypothesis that second order variables in the Translog model are zero. That means that given the assumption of a Translog specification, a Cobb-Douglas function is not an adequate representation of the stochastic frontier function. Sufficient conditions for strict quasi-concavity of the frontier production function at the data means are not satisfied. We considered imposing concavity of the function by assuming the Cobb-Douglas functional form. However, since our data rejected this functional form, we went with a more flexible Translog functional form.

Using the maximum-likelihood estimates for the parameters of the frontier, the elasticities of frontier output with respect to land, labor, organic fertilizer, chemicals, and fuel, were estimated at the means of the input variables to be 0.76, 0.13, 0.08, 0.05, and 0.02, respectively. The results of most of the known studies on efficiency of agriculture in Eastern Europe and the former Soviet Union are not strictly comparable with ours, because the inefficiency models used in these studies are not for grain, but for an aggregate farm output (either for the aggregate "crops", or for the "whole farm" production function).

Table 4.4. Maximum-likelihood estimates for parameters of the stochastic frontier

Variable	Parameter	Estimate	St. Error of Estimator [a]
Stochastic Frontier			
Constant	β_0	14.4	1.5
Year 1991 Dummy	d_{91}	-0.187	0.029
ln (land)	β_1	-7.25	0.72
ln (labor)	β_2	0.03	0.88
ln (fertilizer)	β_3	0.01	1.02
ln (chemicals)	β_4	0.19	0.95
ln (fuel)	β_5	7.23	0.89
$(\ln(\text{land}))^2$	β_{11}	1.49	0.19
$(\ln(\text{labor}))^2$	β_{22}	0.010	0.035
$(\ln(\text{fertilizer}))^2$	β_{33}	-0.048	0.040
$(\ln(\text{chemicals}))^2$	β_{44}	-0.181	0.097
$(\ln(\text{fuel}))^2$	β_{55}	1.03	0.27
ln (land) x ln(labor)	β_{12}	-0.01	0.24
ln (land) x ln(fertilizer)	β_{13}	-0.17	0.29
ln (land) x ln(chemicals)	β_{14}	-0.20	0.29
ln (land) x ln(fuel)	β_{15}	-2.59	0.39
ln (labor) x ln(fertilizer)	β_{23}	0.084	0.073
ln (labor) x ln(chemicals)	β_{24}	0.018	0.091
ln (labor) x ln(fuel)	β_{25}	-0.06	0.19
ln (fertilizer) x ln(chemicals)	β_{34}	0.06	0.14
ln (fertilizer) x ln(fuel)	β_{35}	0.27	0.20
ln (chemicals) x ln(fuel)	β_{45}	0.35	0.25
Inefficiency Model			
Constant	δ_0	0.72	0.14
Non-ag./Total Workers	δ_1	-0.71	0.32
Age	δ_5	-0.0031	0.0018
Distance to City	δ_3	-0.0017	0.0011
Ag.Workers/Total Land	δ_2	-2.40	0.58
Year	δ_4	0.106	0.014
Variance Parameters			
	σ^2	0.0155	0.0022
	γ	1.0000	0.0010
ln (Likelihood)		124.70	

[a] The standard errors for the estimators are obtained by the computer program Frontier 4.1; they are correct to two significant digits

Table 4.5. Generalized-likelihood-ratio tests [a]

Null Hypothesis	Meaning of Hypothesis	ln (H_0)	λ	D.F.	Critical Value [b]	Decision
Stochastic Frontier						
H_0: $\beta_{ij} = 0$	Frontier is of Cobb-Douglas form	107.68	26.97	15	25.00	Reject H_0
H_0: $\beta_1 = \beta_{1j} = 0$	Var.*land* does not affect stochastic frontier	112.90	23.60	6	12.59	Reject H_0
H_0: $\beta_2 = \beta_{2j} = 0$	Var.*labor* does not affect stochastic frontier	110.63	28.13	6	12.59	Reject H_0
H_0: $\beta_3 = \beta_{3j} = 0$	Var.*fertilizer* does not affect stochastic frontier	113.89	21.61	6	12.59	Reject H_0
H_0: $\beta_4 = \beta_{4j} = 0$	Var.*chemicals* does not affect stochastic frontier	109.28	30.84	6	12.59	Reject H_0
H_0: $\beta_5 = \beta_{5j} = 0$	Var.*fuel* does not affect stochastic frontier	117.73	13.94	6	12.59	Reject H_0

[a] The generalized likelihood-ratio statistic is computed as $\lambda = -2\log[L(H_0)/L(H_1)]$, where $L(H_0)$ and $L(H_1)$ are the likelihood functions evaluated at the restricted and unrestricted maximum-likelihood estimator for the parameters of the model. If the null hypothesis, H_0, is true, and does not involve $\gamma = 0$, then the statistic has approximately chi-squared distribution with parameter equal to the number of restrictions imposed by H_0. If a null hypotheses includes $\gamma = 0$, then, since by its definition has γ to be non-negative, the statistic has asymptotically a mixed chi-squared distribution (Coelli, 1995a). Koddle and Palm (1986) provide critical values for the statistics in such tests.

[b] The critical values correspond to 5 percent level of significance

Table 4.5. (Continued)

Null Hypothesis	Meaning of Hypothesis	ln (H_0)	λ	D.F.	Critical Value	Decision
Inefficiency Model						
H_0: $\gamma = \delta_0 = \delta_1 = \ldots = \delta_4 = \delta_5 = 0$	Inefficiency effects are absent from the model	72.81	103.77	7	13.40	Reject H_0
H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$	Inefficiency effects are not a linear function of the explanatory variables	74.79	99.81	5	11.07	Reject H_0
H_0: $\delta_1 = 0$	*nonagw/totw*does not affect inefficiency linearly	121.81	5.77	1	3.84	Reject H_0
H_0: $\delta_2 = 0$	*age* does not affect inefficiency linearly	121.16	7.08	1	3.84	Reject H_0
H_0: $\delta_3 = 0$	*dis* does not affect inefficiency linearly	121.90	5.60	1	3.84	Reject H_0
H_0: $\delta_4 = 0$	*agw/totland* does not affect inefficiency linearly	116.20	17.00	1	3.84	Reject H_0
H_0: $\delta_5 = 0$	Inefficiency does not change linearly with time	91.26	66.87	1	3.84	Reject H_0
H_0: $\gamma = 0$	Inefficiency effects are not stochastic	120.39	8.61	2	5.14	Reject H_0

In comparison with available grain production efficiency analysis, our land elasticity is much larger than the ones obtained for the Stavropol region of Russia, 1986-1988, by Skold and Popov (1990, 1992), and for Mongolia, 1986-1989, by Bayarsaihan, Battese, and Coelli (1998). Their estimates were in the range of 0.21-0.34. At the same time, our land elasticity is close to the value 0.71 found by Johnson et al.(1994) for Ukraine, who used a different model and relied on farm-level data in rubles for several inputs for the years 1986-1991. Wyzan (1981) found the land elasticity to be 0.62 when estimating a grain production function for the whole USSR with republic-level aggregated data for 1960-1976.

The estimated labor elasticity 0.13 falls in the range from 0.040 to 0.223 reported in the grain studies mentioned above. In addition, labor elasticities in this range were reported in many of the efficiency studies that aggregated output. Among others, Hofler and Payne (1995) found similar elasticities for Yugoslavia, 1961-1979; Brock (1994) - for Russia, 1991; Carter and Zhang (1994) - for nine centrally planned economies, 1965-1989. The other input data (organic fertilizer, chemicals, and fuel) were not available in the previous grain efficiency studies.

The relatively small elasticities for inputs other than land prompted us to check whether each of the input variables has a non-zero impact on the frontier function. Because the generalized likelihood-ratio tests of the hypotheses are preferred to the asymptotic t-tests in maximum likelihood estimation, the hypotheses that the coefficients of the corresponding input variables are zero, for each input variable separately, were tested. The tests were rejected as reported in Table 4.5, which means that the impact of each of the input variables on the frontier production function is statistically significant. The returns to scale parameter was found to be 1.03, implying constant returns to scale for grain production on the state and collective farms. This result is consistent with earlier studies for Ukraine (Johnson et al., 1994) and Russia (Skold and Popov, 1990, 1992).

(In)efficiency model estimates

The major interest of our study is the inefficiency model. Figure 4.1 provides frequency distributions of the efficiency estimates. The average technical efficiency in the sample was estimated as 0.82, 0.76, 0.68, and 0.60 for the four years of data (1989-92), respectively. Estimates in this range are found in earlier studies of inefficiency in agricultural production (Battese (1992), Bravo-Ureta and Pinheiro (1993)).

The null hypothesis that inefficiency effects are absent from the model is strongly rejected at the 5% level of significance, and so is the null hypotheses that the explanatory variables in the model for the technical inefficiency effects have zero coefficients. The null hypotheses that individual effects of the explanatory variables in the model for the technical inefficiency effects are zeros were tested as well. The results presented in Table 4.5 show that all five null hypotheses were rejected.

The estimated coefficient of year is positive which means that technical efficiency declined over time, a result that is consistent with earlier findings obtained with a different model and a different Ukrainian farm data set (Johnson et al., 1994). The results illustrate that the economic reforms are costly in terms of technical efficiency, probably because the old production ties, like the state input distribution system, severely deteriorated with the start of economic reforms, while new production intermediaries have not yet emerged. In this situation, the decline in the precision of timing of input application due to problems of availability is not captured by the quantities of inputs applied to production, and this may

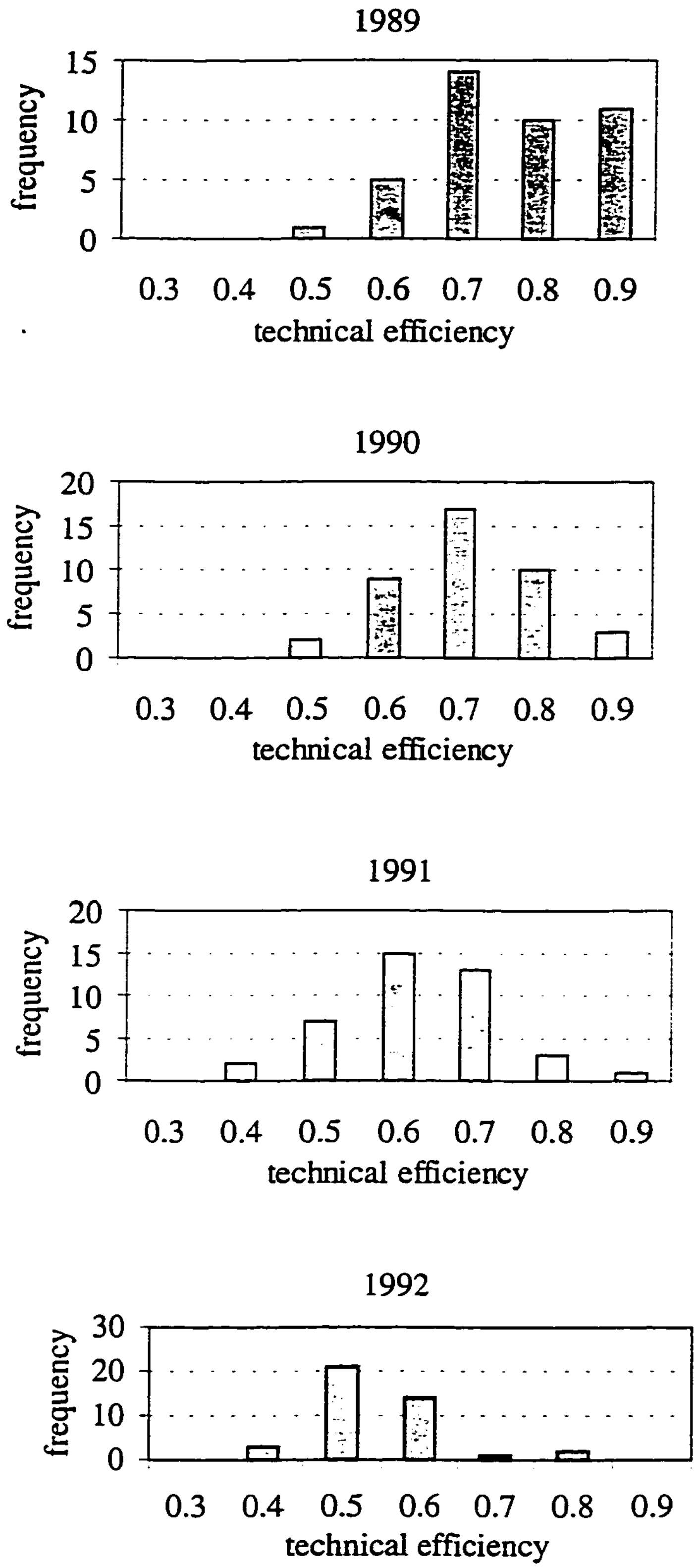

Figure 4.1. Frequency distribution of technical efficiency by years

have resulted in the estimated negative effect of the coefficient of year on efficiency.

The number of agricultural workers per hectare was found to have positive effect on technical efficiency, which suggests that abundance of labor resources for production is important for achieving effective utilization of inputs. The model employed by Johnson et al. (1994) did not estimate the impact of farm-specific variables on inefficiency simultaneously with estimation of the stochastic frontier. However, a similar relationship was found by comparing the means of the number of agricultural workers per hectare for the fifty least and fifty most efficient farms (the number of farms in the sample was 3,798).

The coefficient of the share of non-agricultural workers in the total number of farm workers is negative, and indicates that technical inefficiency in grain production decreases with an increase of this share, and, presumably, with an increase in the quality of the farm infrastructure. This result suggests that in the absence of an adequate market environment, the agricultural production units that invest relatively more (in terms of labor force) into farm infrastructure achieve higher levels of technical efficiency in agricultural production.

Unfortunately, the data used do not discriminate among different types of farm non-agricultural production activities. These activities might mean investment into other production (eg., production facilities construction, processing, marketing), or improvement in farm living conditions (eg., catering, child care provision, road maintenance). Improved farm living conditions are likely to increase the quality of available labor resources directly as workers can get better recreation and rest, and are pushed into less shirking and absenteeism caused by health and child care problems.

The average quality of labor resources also may be affected indirectly through prevention of quits of productive workers. The potential loss of farm-provided social benefits is considered as one of the main reasons for a farm employee's decision to remain on the collectivist farm as opposed to starting his or her own private farm (Lerman, Brooks, and Csaki, 1994). Hence, investment into farm social infrastructure might be a valuable tool used by farm managers to retain workers from leaving the farms. The decrease in the number of workers might be undesirable because those who leave, on average, possess above average skills, both general and agriculture-specific. According to official statistics, the rural share of the total working age population has remained stable, around 28%, over the past years; therefore the major alternative to the former state or collective farm employment seems to be private farming. The finding of Csaki and Lerman (1997), that private farmers are on average better educated than collectivist farm employees suggests that departure of farm workers toward private farming lowers the average level of education of collectivist farm workers. Thus, workers' leaving may have led to lower productivity in collectivist farms as education and experience became increasingly important in the success of adjustment to rapidly changing economic environment of Ukraine.

Independently of whether the increase in the share of farm non-agricultural production activities means more production or social workers, the increase in the share means also that the farm-provided jobs not only enhance farm production and/or general infrastructure, but also lead to additional income for the rural population. The importance of this additional income is made all the more important by the shrinking scale of main production as outlined above, and consequently, lower farm revenues and wage bill. The additional non-agricultural production jobs might have provided greater income security for farm families thus reducing further the possibility of leaving collectivist farms. In sum, the farm's non-agricultural production activities may have made collectivist farms more attractive place for living, and in this way kept the average skill level of workers from declining.[7]

The effect of the age of the manager on technical efficiency was estimated to be positive; i.e., other things equal, the older the manager is, the less technical inefficiency the farm displayed. This is consistent with the results of Skold and Popov (1992), who found a similar, though weak, relationship between manager's experience and technical efficiency in grain production for a sample of 136 Russian farms observed over the years 1986-87. A similar positive impact of manager's experience on technical efficiency have been found in studies on Third World agriculture (see the survey of Bravo-Ureta and Pinheiro (1993)).

These findings can be explained by the manager's ability to deal with disequlibria in the sense described by Schultz (1975). The estimation results suggest, then, that those more experienced managers were more up to the task of achieving technical efficiency. The improvement of ability to avoid improvident decisions with experience may have been captured in the positive relationship found between manager's age and technical efficiency.

The coefficient of distance to the nearest city was found to be negative, i.e. *ceteris paribus*, the farms located further from the cities are less technically inefficient (i.e., more efficient). One interpretation is that the advantage in location may have allowed the farms to compete better with cities for workers. More energetic workers from rural farms located closer to cities could commute to jobs in these cities, lowering the average skill/effort level

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[7] Following this argument, another explanatory variable of inefficiency, the number of agricultural workers per hectare, captures a part of the effect of the share of non-agricultural workers in the total number of farm workers on inefficiency. Further separation of the effects of these two explanatory variables on technical inefficiency would require specification of a labor mobility model. The data available are not able to support this analysis.

of the available labor on these farms.[8] In addition, the farms located closer to cities had easier access to the less productive (in agricultural tasks) city workers and students recruited for harvest time. In this way, relative efficiency would be related to the distance from the city through its effect on the quality of the productive labor of the farm even if workers do not leave the rural area permanently. Unfortunately, lack of additional data on commuters and temporary urban labor does not allow us to investigate this argument further and the explanation offered remains only a conjecture.

The estimate for the variance parameter, γ, is estimated to be close to one. If this parameter is zero, then σ_u^2 is zero, and the model reduces to a traditional production function with the explanatory variables (*nonagw/totw*, *age*, *dis*, *agw/totland*, and, *t*) all included in the production function. This would mean that inefficiency effects are not stochastic. The last null hypothesis, H_0: $\gamma = 0$, which specifies that the explanatory variables in the model for the technical inefficiency effects are not stochastic, is rejected by the data.[9]

Conclusions

Grain production and input use data in physical units together with overall farm operations information were used to estimate a stochastic frontier model in which inefficiency effects are modeled as a function of farm-specific variables and time. The magnitudes of the production function and efficiency estimates do not differ much from

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[8] An estimated 160,000 workers commuted to the city of Kyiv from nearby rural communities at the beginning of the 1990s (Bohdan, 1992).

[9] In this case, the parameter δ_0 is not identified, and consequently, the number of degrees of freedom for the test statistic is two.

other findings obtained for the formerly planned economies with different models and different data sets. Our results indicate that the traditional production function model is likely to be inadequate for the farm-level analysis of grain production.

The results illustrate that the process of transformation of Ukrainian agriculture started in 1990 is costly in terms of technical efficiency; efficiency declined over the 1989-1992 period. The relative abundance of labor and distance to a nearest city were both found to have a positive effect on technical efficiency. Older, and consequently, more experienced managers were found to be able to achieve higher levels of technical efficiency, a result, that is consistent with Schultz (1975)' hypothesis on the value of the improving with experience ability to deal with disequilibria.

It must be noted, that the ability to deal with disequilibria might even better be revealed in the analysis of allocative efficiency, where the latter is defined as the ability of a farm to use the inputs in optimal proportions corresponding to their respective prices. Lack of financial data precludes us from exploring this problem. The estimation suggests that investments of farm labor resources in infrastructure also improved technical efficiency.

The results illustrate that the introduction of reforms has not immediately reversed the decline in efficiency in Ukraine's agriculture. Moreover, the more efficient farms were found to be less market-oriented, a result associated with maintenance of farm infrastructure. Lack of data prevented us from separating the effects of different types of farm non-agricultural activities on technical efficiency. Further research is needed on how farm organization affects agricultural production efficiency in Ukraine, and other countries in economic transition. The results highlight the importance of analysis of production at the farm level because production efficiency varies across farms and this should be taken into account for both research and policy considerations.

5. CONCLUSIONS

The three dissertation essays investigated productivity changes in post-Soviet primary agriculture. The first two studies examined the causes and impact of reallocation of labor between the collective and subsidiary plot sectors. The third study analyzed technical efficiency of former collective and state farms in grain production at the early stages of the reforms.

The findings obtained help to explain dramatic changes observed in the productivity of the collective and subsidiary plot sectors and attribute part of the change to rational labor supply behavior of households that had access to the plots. Decline in wages, uncertainty in wages, decreased probability of receiving wages, and increased availability of land for subsidiary farming are all consistent with the relative increase of labor hours in subsidiary farming at the expense of collective farming hours. Similarly, decline and increased uncertainty in government-provided social benefits are consistent with increased involvement of pensioner households in subsidiary subsistence farming.

Econometric analysis showed that a large portion of the variation in the growth of the subsidiary farming share in gross agricultural output among Ukrainian regions can be explained by variations in the rate of the decline of agricultural wages, urban-rural composition of population, rural land availability, and application of inputs other than land and labor.

Technical efficiency of the former collective and state farms was studied using stochastic production frontier analysis. The results of estimation suggest that technical efficiency declined over 1989-1992. The technical efficiency was found to be affected by workforce composition of the farms and several human capital factors.

The issues of agricultural productivity and labor are critical policy issues in contemporary Ukraine, Russia, and some other former Soviet Union republics. Currently, the reforms in Ukraine are at a standstill stage. There is a great need for research to guide policymakers in understanding the reasons for and consequences of the current deadlock and to design policies to resume progress in reforms. Our results help in understanding economic reasons behind the current situation. The findings of the first two studies identified causes of reallocation of labor to subsidiary household plots, a sector that is not fully supported by institutional reforms. The findings of the third study point to human capital factors as important determinants of technical efficiency achieved in the collective sector of agriculture. The results highlight the importance of labor response considerations when designing policies to support transition agriculture.

APPENDIX: DETAILS OF PROOFS

A.1. Proof of Proposition 2.2

The statement (i) is proven by checking the second order conditions at (h^{p*}, h^{c*}). Statements (ii) and (iii) are proven by applying standard comparative static techniques to the first order conditions at the interior maximum.

With the discretely distributed W, (2.3) is equivalent to

$$\max_{h^p>0,\ h^c>0} \quad p\cdot U\left(wh^c+f(h^p,m),T-h^c-h^p\right)+(1-p)\cdot U\left(f(h^p,m),T-h^c-h^p\right) \qquad \text{(A.1)}$$

The first order necessary conditions for an interior maximum (2.4) and (2.5) take the form

$$\frac{\partial E[U]}{\partial h^p}=p\cdot\left\{U_1^+f_1-U_2^+\right\}+(1-p)\cdot\left\{U_1^-f_1-U_2^-\right\}=0, \qquad \text{(A.2)}$$

$$\frac{\partial E[U]}{\partial h^c}=p\cdot\left\{U_1^+w-U_2^+\right\}+(1-p)\cdot\left\{-U_2^-\right\}=0. \qquad \text{(A.3)}$$

Here $U_i^+\equiv U_i\left(wh^c+f(h^p,m),T-h^c-h^p\right)$, $U_i^-\equiv U_i\left(f(h^p,m),T-h^c-h^p\right)$, $i=1,2$.

For ease of presentation, we suppress the arguments of the function f in the derivations to follow.

Note, that under the assumptions of the Proposition, (2.6) takes a transparent form

$f_1=pw\dfrac{U_1^+}{pU_1^++(1-p)U_1^-}$, i.e. $f_1<w$ at the optimum.

A sufficient second order condition for an interior maximum is that the matrix of second derivatives of the expected utility,

$$D = \begin{bmatrix} \dfrac{\partial^2 E[U]}{\partial h^{p2}} & \dfrac{\partial^2 E[U]}{\partial h^p \partial h^c} \\ \\ \dfrac{\partial^2 E[U]}{\partial h^c \partial h^p} & \dfrac{\partial^2 E[U]}{\partial h^{c2}} \end{bmatrix}, \tag{A.4}$$

is negative definite at (h^{p*}, h^{c*}).

The second derivatives of expected utility evaluated at (h^{p*}, h^{c*}) are given by

$$\frac{\partial^2 E[U]}{\partial h^{p^2}} = p \cdot \left\{U_{11}^{+} f_1^2 - 2U_{12}^{+} f_1 + U_{22}^{+} \right\} + (1-p) \cdot \left\{U_{11}^{-} f_1^2 - 2U_{12}^{-} f_1 + U_{22}^{-}\right\}$$

$$+ f_{11}\left\{pU_1^{+} + (1-p)U_1^{-}\right\}$$

$$\frac{\partial^2 E[U]}{\partial h^{c^2}} = p \cdot \left\{U_{11}^{+} w^2 - 2U_{12}^{+} w + U_{22}^{+}\right\} + (1-p) \cdot U_{22}^{-}$$

$$\frac{\partial^2 E[U]}{\partial h^p \partial h^c} = p \cdot \left\{U_{11}^{+} w f_1 - U_{12}^{+}(w + f_1) + U_{22}^{+}\right\} + (1-p) \cdot \left\{-U_{12}^{-} f_1 + U_{22}^{-}\right\}$$

Here $U_{ij}^{+} \equiv U_{ij}\left(wh^c + f(h^p), T - h^c - h^p\right)$, $U_{ij}^{-} \equiv U_{ij}\left(f(h^p), T - h^c - h^p\right)$, $i,j=1,2$.

The derivative $\dfrac{\partial^2 E[U]}{\partial h^{p2}}$ is negative, because the terms in the first two curly brackets are negative by the assumption (S.2*), and the third additive term is negative by (S.3) and (S.1). Similarly, because of (S.2*), the derivative $\dfrac{\partial^2 E[U]}{\partial h^{c2}}$ is also negative. Consequently, to ensure that the second order conditions are satisfied, it remains to show that det(D) is positive, where D is given by (A.4).

Calculation of det(D):

$$\det(D) = \frac{\partial^2 EU}{\partial h^{c2}} \cdot \frac{\partial^2 EU}{\partial h^{p2}} - \left(\frac{\partial^2 EU}{\partial h^p \partial h^c}\right)^2$$

Substituting the expressions for the derivatives, collecting the terms with f_{11}, and then collecting the remaining terms with p^2, $(1\text{-}p)^2$, and $p(1\text{-}p)$, we obtain

$$
\begin{aligned}
\det(D) = \quad & f_{11}\{pU_1^+ + (1-p)U_1^-\}\frac{\partial^2 E[U]}{\partial h^{c2}} \\
& + p^2 \cdot \{U_{11}^+ U_{11}^+ w^2 f_1^2 - 2U_{11}^+ U_{12}^+ w f_1 (w + f_1) + U_{11}^+ U_{22}^+ (w^2 + f_1^2) \\
& \qquad + 4U_{12}^+ U_{12}^+ w f_1 - 2U_{12}^+ U_{22}^+ (w + f_1) + U_{22}^+ U_{22}^+ \} \\
& - p^2 \cdot \{U_{11}^+ U_{11}^+ w^2 f_1^2 + U_{12}^+ U_{12}^+ (w^2 + 2wf_1 + f_1^2) + U_{22}^+ U_{22}^+ \\
& \qquad - 4U_{11}^+ U_{12}^+ f_1^3 + 2U_{11}^+ U_{22}^+ f_1^2 - 4U_{12}^+ U_{22}^+ f_1 \} \\
& \qquad\quad + (1-p)^2 \cdot \{ U_{11}^- U_{22}^- f_1^2 - 2U_{12}^- U_{22}^- f_1 + U_{22}^- U_{22}^- \} \\
& \qquad\quad - (1-p)^2 \cdot \{ U_{12}^- U_{12}^- f_1^2 - 2U_{12}^- U_{22}^- f_1 + U_{22}^- U_{22}^- \} \\
& \qquad\quad + p(1-p) \cdot \{ U_{11}^+ U_{11}^- (w^2 f_1^2 - 2U_{11}^+ U_{12}^- w^2 f_1 + U_{11}^+ U_{22}^- w^2 - 2U_{12}^+ U_{11}^- w f_1^2 \\
& \qquad\qquad + 4U_{12}^+ U_{12}^- w f_1 - 2U_{12}^+ U_{22}^- w + U_{22}^+ U_{11}^- f_1^2 - 2U_{22}^+ U_{12}^- f_1 + U_{22}^+ U_{22}^- \\
& \qquad\qquad + U_{11}^+ U_{22}^- f_1^2 - 2U_{12}^+ U_{22}^- f_1 + U_{22}^+ U_{22}^- \} \\
& \qquad\quad - p(1-p) \cdot \{ -2U_{11}^+ U_{12}^- w f_1^2 + 2U_{11}^+ U_{22}^- w f_1 + 2U_{12}^+ U_{12}^- f_1 (w + f_1) \\
& \qquad\qquad - 2U_{12}^+ U_{22}^- (w + f_1) - 2U_{22}^+ U_{12}^- f_1 + 2U_{22}^+ U_{22}^- \}
\end{aligned}
$$

Simplifying, we get

$$\det(D) = \{ f_{11}\left[pU_1^{+} + (1-p)U_1^{-}\right]\frac{\partial^2 E[U]}{\partial h^{c2}}$$

$$+ p^2(w-f_1)^2\left[U_{11}^{+}U_{22}^{+} - U_{12}^{+}U_{12}^{+}\right]$$

$$+ (1-p)^2 f_1^2\left[U_{11}^{-}U_{22}^{-} - U_{12}^{-}U_{12}^{-}\right]$$

$$+ p(1-p)\cdot\{ \quad (w-f_1)^2U_{11}^{+}U_{22}^{-} + w^2 f_1^2 U_{11}^{+}U_{11}^{-} + f_1^2 U_{22}^{+}U_{11}^{-}$$

$$- 2wf_1^2U_{12}^{+}U_{11}^{-} - 2f_1 w(w-f_1)U_{11}^{+}U_{12}^{-} + 2f_1(w-f_1)U_{12}^{+}U_{12}^{-}\} \quad \}$$

Every additive term in the last expression is positive: the term with f_{11} is positive because $f_{11}<0$ by (S.3), the sum in the square brackets is positive by (S.1), and the second derivative is negative as proven above. The terms with p^2 and $(1-p)^2$ are positive because the expressions in the square brackets are positive by (S.2*). The term with $p(1-p)$ is positive because every additive term there is positive by (S.2*) and $f_1<w$. Thus, det(D) is positive, and statement (i) is proven.

To derive the impact of changes in the exogenous variable p on the optimal h^{p*} and h^{c*}, that is, $\frac{\partial h^{p*}}{\partial p}$, $\frac{\partial h^{c*}}{\partial p}$, we apply standard comparative statics techniques:

$$\begin{bmatrix} \frac{\partial^2 E[U]}{\partial h^{p2}} & \frac{\partial^2 E[U]}{\partial h^p \partial h^c} \\ \\ \frac{\partial^2 E[U]}{\partial h^p \partial h^c} & \frac{\partial^2 E[U]}{\partial h^{c2}} \end{bmatrix} \cdot \begin{bmatrix} \frac{\partial h^{p*}}{\partial p} \\ \\ \frac{\partial h^{c*}}{\partial p} \end{bmatrix} = \begin{bmatrix} -\frac{\partial^2 E[U]}{\partial h^p \partial p} \\ \\ -\frac{\partial^2 E[U]}{\partial h^c \partial p} \end{bmatrix}, \tag{A.5}$$

where all the second derivatives are evaluated at (h^{p*}, h^{c*}).

Differentiating with respect to p and using the first order conditions,

$$\frac{\partial^2 E[U]}{\partial h^c \partial p} = U_1^+ w - U_2^+ + U_2^- = \frac{1}{p} U_2^-,$$

$$\frac{\partial^2 E[U]}{\partial h^p \partial p} = U_1^+ f_1 - U_2^+ - U_1^- f_1 + U_2^- = \frac{1}{p} \{U_2^- - U_1^- f_1\}$$

To find the effect of changes in p on h^{p*}, we solve (A.5) for $\frac{\partial h^{p*}}{\partial p}$:

$$\frac{\partial h^{p*}}{\partial p} = -\frac{\det(A)}{\det(D)}, \tag{A.6}$$

where

$$\det(A) \equiv \det \begin{bmatrix} \frac{\partial^2 E[U]}{\partial h^p \partial p} & \frac{\partial^2 E[U]}{\partial h^p \partial h^c} \\ \frac{\partial^2 E[U]}{\partial h^c \partial p} & \frac{\partial^2 E[U]}{\partial h^{c2}} \end{bmatrix} = \frac{\partial^2 E[U]}{\partial h^p \partial p} \cdot \frac{\partial^2 E[U]}{\partial h^{c2}} - \frac{\partial^2 E[U]}{\partial h^p \partial h^c} \cdot \frac{\partial^2 E[U]}{\partial h^c \partial p}.$$

Substituting the expressions for the derivatives and collecting the terms with U_2^-, we obtain

$$\det(A) = \frac{1}{p} \cdot \{U_2^- \left[p(w - f_1)\{U_{11}^+ w - U_{12}^+\} + (1-p) f_1 U_{12}^-\right]$$

$$- U_1^- f_1 \left[pw(U_{11}^+ w - U_{12}^+) + pU_{22}^+ + (1-p)U_{22}^- - pU_{12}^+ w)\right] \ \}$$

$$= \frac{1}{p} \cdot \{U_1^- f_1 \left[pU_{12}^+ w - pU_{22}^+ - (1-p)U_{22}^-\right] + U_2^- U_{12}^- (1-p) f_1$$

$$- p\{U_{11}^+ w - U_{12}^+\} \cdot \left[U_1^- f_1 w - U_2^- (w - f_1)\right] \ \}$$

The two additive terms in the first line of the last expression are both positive by (S.1), (S.2*), (S.3). The term in the curly brackets in the second line is negative by (S.2*).

To sign the term in the square brackets, we use the following expression obtained by subtracting (A.3) multiplied by $(f_1+kw)/h$ from (A.2) multiplied by w:

$$U_1^- f_1 w = (w - f_1)\left\{\frac{p}{(1-p)} U_2^+ + U_2^-\right\}$$

With the last expression,

$$\left[U_1^- f_1 w - U_2^-(w - f_1)\right] = (w - f_1) U_2^+ \frac{p}{(1-p)} > 0,$$

and $\det(A) > 0$. Then, by (A.6), $\dfrac{\partial h^p}{\partial p} < 0$, and statement (ii) is proven.

To sign the effect of changes in p on the optimal h^c, we solve (A.5) for $\dfrac{\partial h^c}{\partial p}$:

$$\frac{\partial h^c}{\partial p} = -\frac{\det(B)}{\det(D)}, \qquad \text{(A.7)}$$

where

$$\det(B) \equiv \det\begin{bmatrix} \dfrac{\partial^2 E[U]}{\partial h^{p2}} & \dfrac{\partial^2 E[U]}{\partial h^p \partial p} \\ \\ \dfrac{\partial^2 E[U]}{\partial h^c \partial h^p} & \dfrac{\partial^2 E[U]}{\partial h^c \partial p} \end{bmatrix} = \frac{\partial^2 E[U]}{\partial h^{p2}} \cdot \frac{\partial^2 E[U]}{\partial h^c \partial p} - \frac{\partial^2 E[U]}{\partial h^c \partial h^p} \cdot \frac{\partial^2 E[U]}{\partial h^p \partial p}$$

Substituting the expressions for the derivatives and collecting the terms with U_2^- and $U_1^- f_1$, we obtain

$$\det(B) = \frac{1}{p} \cdot \{U_2^- \cdot \left((1-p) f_1 \left\{U_{11}^- f_1 - U_{12}^-\right\} + f_{11}\left\{pU_1^+ + (1-p)U_1^-\right\}\right)$$

$$- U_1^- f_1^2 \cdot \left(pU_{12}^+ + (1-p)U_{12}^-\right) + U_1^- f_1 \left(pU_{22}^+ + (1-p)U_{22}^-\right)$$

$$+ p\left\{U_{11}^+ f_1 - U_{12}^+\right\} \cdot \left[U_1^- f_1 w - U_2^-(w - f_1)\right] \ \}$$

$$< 0$$

by the same token as for det(A). Then, by (A.7), $\dfrac{\partial h^c}{\partial p} > 0$, and statement (iii) is proven.

A.2. Proof of Proposition 2.3

The solution to (2.8) satisfies the following first-order necessary condition:

$$\frac{\partial E[U]}{\partial h^p} = E\left[U_Y f_1(h^p, m) - U_l\right] = 0\,, \tag{A.8}$$

or

$$f_1(h^p, m) = \frac{E\left[U_l\right]}{E\left[U_Y\right]}. \tag{A.9}$$

From (S.4p), $-(U_{YYY}U_Y - (U_{YY})^2) < 0$, or $U_{YYY} > 0$. Then, by the Jensen's inequality,

$$E\left[U_Y\left(P + f(h^p, m), T - h^p\right)\right] \quad > \quad U_Y\left(E[P] + f(h^p, m), T - h^p\right)$$

In addition, (S.4p) imply $-(U_{YYl}U_Y - U_{YY}U_{Yl}) = 0$, or $U_{YYl} < 0$, and by the Jensen's inequality,

$$E\left[U_l\left(P + f(h^p, m), T - h^p\right)\right] \quad < \quad U_l\left(E[P] + f(h^p, m), T - h^p\right).$$

Thus, for any h^p,

$$\frac{E\left[U_l\left(P+f(h^p,m),T-h^p\right)\right]}{E\left[U_Y\left(P+f(h^p,m),T-h^p\right)\right]} \quad < \quad \frac{U_l\left(E[P]+f(h^p,m),T-h^p\right)}{U_Y\left(E[P]+f(h^p,m),T-h^p\right)} \tag{A.10}$$

Consider

$$\psi_{unc}(h^p) \equiv \frac{E\left[U_l\left(P+f(h^p,m),T-h^p\right)\right]}{E\left[U_Y\left(P+f(h^p,m),T-h^p\right)\right]}, \qquad \psi_{cert}(h^p) \equiv \frac{U_l\left(E[P]+f(h^p,m),T-h^p\right)}{U_Y\left(E[P]+f(h^p,m),T-h^p\right)}$$

Then (A.10) means that for any h^p,

$$\psi_{unc}(h^p) \quad < \quad \psi_{cert}(h^p). \tag{A.11}$$

The assumptions of the Proposition imply that $\psi_{cert}(h^p)$ is an increasing function of h^p:

$$\frac{\partial\psi_{cert}(h^p)}{\partial h^p} \quad = \quad \frac{(U_{lY}f_1-U_{ll})U_Y-(U_{YY}f_1-U_{lY})U_l}{U_Y^2} \quad > \quad 0. \tag{A.12}$$

By the definition of h^{p*} and h^{p**},

$$f_1(h^{p*}) \quad = \quad \psi_{unc}(h^{p*}), \qquad f_1(h^{p**}) \quad = \quad \psi_{cert}(h^{p**}). \tag{A.13}$$

To finish the proof, suppose that the statement of the proposition is not true. We will show that this supposition leads to a contradiction. Thus, suppose

$$h^{p*} \quad \leq \quad h^{p**}. \tag{A.14}$$

Then

$f_1(h^{p*}) \overset{(S.3p)}{\geq} f_1(h^{p**}) \overset{(A.13)}{=} \psi_{cert}(h^{p**}) \overset{(A.12),(A.14)}{\geq} \psi_{cert}(h^{p*}) \overset{(A.11)}{>} \psi_{unc}(h^{p*})$, i.e. $f_1(h^{p*}) > \psi_{unc}(h^{p*})$, a result, that obviously contradicts (A.13). The contradiction achieved means that the supposition (A.14) is wrong, and the statement of the Proposition is proven.

A.3. Proof of Proposition 2.4

A mean-preserving spread (e.g., Sandmo, 1971) amounts to introduction of two shift parameters, one multiplicative and one additive. That is, P is replaced by $\gamma P + \theta$ so that $dE[\gamma P + \theta] = 0$, i.e. $\dfrac{d\theta}{d\gamma} = E[P]$. The effect of the mean-preserving spread is then assessed by evaluating $\dfrac{dh^{p^*}}{d\gamma}$ at $\gamma = 1$, $\theta = 0$.

By applying standard comparative statics techniques to the first-order conditions (A.8),

$$\frac{dh^{p^*}}{d\gamma} = -\frac{\dfrac{\partial^2 E[U]}{\partial h^p \partial \gamma}}{\dfrac{\partial^2 E[U]}{\partial h^{p2}}}, \tag{A.15}$$

where the second derivatives are evaluated at h^{p^*}. The derivatives are given by

$$\frac{\partial^2 E[U]}{\partial h^{p2}} = E\left[U_{YY} f_1^2 - 2U_{Yl} f_1 + U_{ll} + U_Y f_{11}\right] < 0,$$

$$\frac{\partial^2 E[U]}{\partial h^p \partial \gamma} = E[(U_{YY} f_1 - U_{Yl})(P - E[P])] = Cov[U_{YY} f_1 - U_{Yl}, P].$$

The covariance is positive, because

$$\frac{\partial}{\partial P}(U_{YY} f_1 - U_{Yl}) = U_{YYY} f_1 - U_{lYY}, \text{ and } U_{YYY} > 0, \quad U_{lYY} < 0,$$

as shown in the proof of the Proposition 2.3. Then, by (A.15), $\dfrac{dh^{p^*}}{d\gamma} > 0$, and the Proposition is proven.

A.4. Proof of Proposition 3.1

Applying standard comparative statics techniques,

$$\begin{bmatrix} \dfrac{\partial^2 U}{\partial h^2} & \dfrac{\partial^2 U}{\partial h \partial k} \\ \\ \dfrac{\partial^2 U}{\partial k \partial h} & \dfrac{\partial^2 U}{\partial k^2} \end{bmatrix} \cdot \begin{bmatrix} \dfrac{\partial h^*}{\partial W} \\ \\ \dfrac{\partial k^*}{\partial W} \end{bmatrix} = \begin{bmatrix} -\dfrac{\partial^2 U}{\partial h \partial W} \\ \\ -\dfrac{\partial^2 U}{\partial k \partial W} \end{bmatrix}, \tag{A.16}$$

where all the second derivatives are evaluated at *(h*, k*)*:

$$\frac{\partial^2 U}{\partial k^2} = h^2 \left\{U_{11} W^2 - 2U_{12} W + U_{22}\right\},$$

$$\frac{\partial^2 U}{\partial h \partial k} = h(k+1)\left\{U_{11} W f_1 - U_{12}(W + f_1) + U_{22}\right\} = \frac{k+1}{h} \cdot \frac{\partial^2 U}{\partial k^2},$$

$$\frac{\partial^2 U}{\partial h^2} = (k+1)^2 \left\{U_{11} W^2 - 2U_{12} W + U_{22}\right\} + U_1 f_{11} = \frac{(k+1)^2}{h^2} \cdot \frac{\partial^2 U}{\partial k^2} + U_1 f_{11}$$

$$= \frac{k+1}{h} \cdot \frac{\partial^2 U}{\partial h \partial k} + U_1 f_{11}$$

$$\frac{\partial^2 U}{\partial h \partial W} = k(k+1)h(U_{11} W - U_{12}) + U_1 k,$$

$$\frac{\partial^2 U}{\partial k \partial W} = kh^2 (U_{11} W - U_{12}) + U_1 h \quad .$$

The derivative $\frac{\partial^2 U}{\partial k^2}$ is negative, because the term in the curly brackets is negative by the assumption (S.2**). The derivative $\frac{\partial^2 U}{\partial h \partial k}$ is negative as it is proportional to $\frac{\partial^2 U}{\partial k^2}$. Finally, $\frac{\partial^2 U}{\partial h^2}$ is negative because $\frac{\partial^2 U}{\partial k^2}$ is negative, and the assumption (S.3**) implies diminishing marginal return to labor in SHP production.

Solving (A.16) for $\frac{\partial k^*}{\partial W}$ yields

$$\frac{\partial k^*}{\partial W} = -\frac{\det(B)}{\det(D)}, \tag{A.17}$$

where

$$\det(D) \equiv \det\begin{bmatrix} \frac{\partial^2 U}{\partial h^2} & \frac{\partial^2 U}{\partial h \partial k} \\ \frac{\partial^2 U}{\partial k \partial h} & \frac{\partial^2 U}{\partial k^2} \end{bmatrix} = \frac{\partial^2 U}{\partial h^2} \cdot \frac{\partial^2 U}{\partial k^2} - \left(\frac{\partial^2 U}{\partial k \partial h}\right)^2,$$

$$\det(B) \equiv \det\begin{bmatrix} \frac{\partial^2 U}{\partial h^2} & \frac{\partial^2 U}{\partial h \partial W} \\ \frac{\partial^2 U}{\partial h \partial k} & \frac{\partial^2 U}{\partial k \partial W} \end{bmatrix} = \frac{\partial^2 U}{\partial h^2} \cdot \frac{\partial^2 U}{\partial k \partial W} - \frac{\partial^2 U}{\partial h \partial k} \cdot \frac{\partial^2 U}{\partial h \partial W}.$$

Since the det(D) is evaluated at the utility-maximizing point *(h^*, k^*)*, the second order necessary conditions imply $\det(D) \geq 0$. However, assumptions (S.1), (S.2**), and (S.3**) ensure a strict inequality:

$$\det(D) = \left(\frac{(k+1)^2}{h^2} \cdot \frac{\partial^2 U}{\partial k^2} + U_1 f_{11}\right)\frac{\partial^2 U}{\partial k^2} - \frac{(k+1)^2}{h^2} \cdot \left(\frac{\partial^2 U}{\partial k^2}\right)^2$$

$$= U_1 f_{11} \frac{\partial^2 U}{\partial k^2} > 0$$

Substituting the expressions for the derivatives, we obtain

$$\det(B)=\left(\frac{k+1}{h}\cdot\frac{\partial^2 U}{\partial h\partial k}+U_1 f_{11}\right)\left\{kh^2(U_{11}W-U_{12})+U_1 h\right\}$$

$$-\frac{\partial^2 U}{\partial h\partial k}\left\{k(k+1)h\left(U_{11}W-U_{12}\right)+U_1 k\right\}$$

$$=U_1\left\{f_{11}kh^2\left(U_{11}W-U_{12}\right)+U_1 f_{11}h+\frac{\partial^2 U}{\partial h\partial k}\right\}$$

Note that the equation (2.2) is still valid when the parameters (h,k) replace the pair (h^p,h^c). To see that, subtract (3.2) multiplied by h from (3.3) multiplied by $(k+1)$.

Combining assumption (S.3**) with (2.2), we obtain $f_{11}=\frac{\alpha-1}{h}W$. Then

$$\det(B)=U_1\left\{\left(U_{11}W-U_{12}\right)Wh(1+\alpha k)+U_1(\alpha-1)W+h(k+1)\left(U_{22}-U_{12}W\right)\right\}.$$

Since every additive term in the last expression is negative, $\det(B)<0$. Then, by (A.17), $\frac{\partial k^*}{\partial W}>0$.

A.5. Derivation of relationship (3.7)

Denote

H_s^{r0} - SHP time by rural residents in 1991,

H_s^{u0} - SHP time by urban residents in 1991,

H_c^0 - collective agricultural production time (by rural residents) in 1991.

Similarly,

H_s^{r1} - SHP time by rural residents in 1996,

H_s^{u1} - SHP time by urban residents in 1996,

H_c^1 - collective agricultural production time (by rural residents) in 1996.

Then, by definition,

$$\Delta \log\left(\frac{H_s}{H_t}\right) = \log\left(\frac{\left.\frac{H_s}{H_t}\right|_{1996}}{\left.\frac{H_s}{H_t}\right|_{1991}}\right) = \log\left(\frac{\frac{H_s^{r1}+H_s^{u1}}{H_s^{r1}+H_s^{u1}+H_c^1}}{\frac{H_s^{r0}+H_s^{u0}}{H_s^{r0}+H_s^{u0}+H_c^0}}\right) \tag{A.18}$$

We use the Taylor series approximation to expand the exponent of the last log term in (A.18) as a function of two variables, (H_s^{u0}, H_s^{u1}), around the point $(H_s^{u0}=0, H_s^{u1}=0)$:

$$\frac{\frac{H_s^{r1}+H_s^{u1}}{H_s^{r1}+H_s^{u1}+H_c^1}}{\frac{H_s^{r0}+H_s^{u0}}{H_s^{r0}+H_s^{u0}+H_c^0}} \approx \frac{\frac{H_s^{r1}}{H_s^{r1}+H_c^1}}{\frac{H_s^{r0}}{H_s^{r0}+H_c^0}} \cdot M , \tag{A.19}$$

where

$$M \equiv 1 + \frac{H_c^1 H_s^{u1}}{H_s^{r1}\left(H_s^{r1}+H_c^1\right)} - \frac{H_c^0 H_s^{u0}}{H_s^{r0}\left(H_s^{r0}+H_c^0\right)}.$$

Given low labor mobility in Ukraine, and virtually unchanged rural population over the years 1991-1996, we may assume

$H_s^{r1} + H_c^1 = H_s^{r0} + H_c^0$.

Then,

$$M = \left(\frac{H_s^{u0}}{H_s^{r0}+H_c^0}\right) \cdot \left\{\frac{H_s^{r0}+H_c^0}{H_s^{u0}} + \frac{H_c^{r1}H_s^{u1}}{H_s^{r1}H_s^{u0}} - \frac{H_c^0}{H_s^{r0}}\right\}. \tag{A.20}$$

The term in the curly brackets is positive, because it is equal to

$$\frac{1}{H_s^{u0}H_s^{r0}H_s^{r1}}\left\{H_c^0 H_s^{r1}\left(H_s^{r0}-H_s^{u0}\right) + \textit{positive terms}\right\} ,$$

and the difference $H_s^{r0} - H_s^{u0}$ is positive as rural involvement into SHP production was higher than that of urban population in 1991.

The term in the round brackets of (A.20) is the ratio of urban SHP labor to total agricultural labor in 1991. It varies positively with the share of urban population in the total working age population of an *oblast*. Thus, the term M can be thought of as a decreasing function of the share of rural residents in the total working age population of an *oblast*. Finally, combining (A.18) and (A.19), we obtain

$$\Delta \log \frac{H_s}{H_t} \approx \Delta \log \frac{H_s^r}{H_s^r + H_c} + \log(M)$$

$$\approx \Delta \log \frac{H_s^r}{H_s^r + H_c} + \gamma(s_{rural}),$$

where s_{rural} is the share of rural residents in the working age population, and γ is a decreasing function of its argument.

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