Relative Growth of Subsidiary Farming in Post-Soviet Economies: A Labor Supply Story

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Abstract

An agricultural household model (AHM) is applied to analyze the changes in labor supply of post-Soviet households. Extensions of the model are presented in which wage and pension arrears are modeled as income uncertainty. Considering two models, one for wage earning households and another for pensioners, we find that wage and pension uncertainties increase subsidiary farming hours and so does a mean-preserving spread in the distribution of pensions. A decline in the probability of receiving wages not only increases subsidiary farming hours but also reduces wage work hours.

Key words: income uncertainty, wage arrears, agricultural household model, labor supply, economies in transition, subsidiary farming.

RELATIVE GROWTH OF SUBSIDIARY FARMING IN POST-SOVIET ECONOMIES: A LABOR SUPPLY STORY

The breakup of the Soviet Union and the beginning of economic reforms in the early 1990s led to an increase in economic freedom of individuals, particularly in time allocation decisions. At the same time, slowly progressing reforms contributed to the growth of poverty in Russia, Ukraine, and many other post-Soviet countries, especially in rural areas (Kakwani 1996; World Bank 1996; Klugman 1997). Institutional restrictions and lack of new economic opportunities in urban areas resulted in little geographic labor mobility (Bonanno et al., 1993; Mitchneck and Plane 1995) and unchanged rural-urban composition of the Ukrainian population over the years of transition (World Bank 1993; MSU 1996). In this situation, subsidiary subsistence farming became one of the most common coping mechanisms employed by the population to alleviate poverty and ensure food security (O'Brien et al., 1996; Seeth et al., 1998).

Private subsistence agriculture coexisted with collectivized agriculture throughout the Soviet period. 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 the plots were inheritable, and plot output belonged to producers. The producer households consumed most of the production, with any surplus sold either at farmers' markets or through state channels.

In the last decade, the growth of subsidiary farming has been considerable: its share in gross agricultural output increased from a quarter in 1990 to more than a half in Russia and Ukraine by 1998 (Figure 1). In contrast, the share of agricultural land under subsidiary plots increased from approximately 8 percent to only 12 to 15 percent. Recent surveys show the increasing involvement of the population in subsidiary farming, especially in rural areas, where the decline in incomes was steeper than in urban areas and alternative employment opportunities are virtually nonexistent (Csaki and Lerman

1997; Perotta 1999). Very little research has been done on the economics of subsidiary farming, however, and only a few studies deal with its labor supply dimensions.

The absence of research is surprising given the growth of subsidiary farming output and widespread involvement of the post-Soviet population in this economic activity. On average, the share of a Ukrainian household's income derived from subsidiary farming grew from 10 to 30 percent over the years 1990 to 1997 (Van Atta 1998). According to International Labor Office calculations (ILO 1995), every second Ukrainian urban family was growing fruits, vegetables, and potatoes on the subsidiary household plots (SHPs) in 1993. Today, virtually every rural family in the former Soviet Union has subsidiary plots (Csaki and Lerman 1997; Van Atta 1998); this is of great importance given the high proportion of the population in rural areas (for example, 27 percent in Ukraine) and the low mobility of the population in general. Rural households derive more than half of their income from the plots (Van Atta 1998). Similar trends and statistics are observed for Russia, Byelorussia, and Kazakhstan (OECD 1999).

This paper is concerned with two aspects of labor supply of the households with SHPs: wage work labor supply and subsidiary farming labor supply. The study has two objectives:

(i) to analyze the two aspects of labor supply as they are affected by transition period phenomena and

(ii) to extend known analysis to the case of uncertain income.

The economic phenomena we focus on include a decline in real wages and pensions, an increase in subsidiary plot size, and uncertainty in real income originating from nontimely payment of wages and pensions.

Transition brought about a dramatic decline in incomes: in Ukraine, real wages declined more than five times from 1990 to 1994, and in 1995, approximately 70 percent of the population lived on an official salary received from state organizations (ILO 1995). In many cases, unreformed enterprises continued to rely on the state to meet their payroll, and this contributed to the appearance of a purely transition economy phenomenon: wage and pension arrears (Figure 2). The nontimely payments are especially bad in the state sector and in the largely unreformed agricultural sector. For example, Perotta (1999) reports that agricultural wage arrears lasted for seven months on average in Ukraine in 1997, and there were regions where cash wages have not been paid for two years. The real value of the unpaid wages and pensions depreciated rapidly as the annual inflation rate was 261 percent, 45 percent, and 10 percent in 1995, 1996, and 1997, respectively.

To model the subsidiary farmer's labor supply, the framework of the neoclassical agricultural household model (AHM) is a natural choice. The model, as presented for example, by Strauss (1986), has been used extensively to study economic behavior of peasant households, in which 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 falls into a broader class of home production models (Gronau 1997). Also, the AHM can be thought of as a special case of dual job holdings models (Paxson and Sicherman 1996). Under reasonable assumptions, the AHM predicts a shift of labor supply toward subsidiary farming in response to falling wages and pensions and increased land availability (Nakajima 1969; Chandler 1984). Although only a few recent empirical studies are available on the AHM applied in this context, all of them support these theoretical findings (e.g., Seeth et al., 1998).

The second objective of the study is to address a research question that has received little attention in the literature: the effect of income uncertainty on the two aspects of labor supply (wage work and subsidiary farming) in an AHM framework. Paxson and Sicherman (1996) note that one of the reasons for keeping a second job is that dual job holding offers a "portfolio" of incomes, and thus provides better prospects for dealing with uncertainties. We study the dual job holding for the situation in which one of the jobs held is in farming, and the uncertainty in income originates from a possibility of nontimely payment of wages and pensions.

The dual nature of the AHM, when production decisions are combined with consumption decisions, imposes certain methodological difficulty under the assumption of uncertainty. 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 part of the growth in subsidiary agriculture productivity may be explained by the decreasing probability of timely payment of wages that causes an increased supply of labor to subsidiary farming. Below we discuss the theoretical foundations for this conjecture.

In the case of certainty, under reasonable assumptions the AHM displays a property of recursiveness, which 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, the wage affects the SHP production decision. For a purely competitive firm, randomness in a price of an input *lowers* the amount of an input used in production if a producer is risk averse (Turnovsky 1969). However, because 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, the overall uncertainty effect of wages on SHP labor hours is ambiguous.

As a price of leisure, the wage affects the household's leisure-consumption decision; as a price of household time endowment, the wage affects the household's full income. 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. 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, because the agent can reduce uncertainty by substituting away from the activity, an "uncertainty substitution effect" (Block and Heineke 1973, p. 383) 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, the labor supply decisions considered in a larger model may yield more 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 paper is organized as follows. First, a review of previous research is presented, followed by presentation of two models used, one for wage earners, and another for pensioner households. The paper concludes with a discussion of the results obtained.

Review of Previous Research on the Agricultural Household Model

Several variations of the generic AHM are directly applicable to the time allocation decisions of households with SHPs. In the 1970s and 1980s, the AHM was applied to study collective farm worker behavior. Similar to a generic AHM, a collective farm member allocates his/her time among three alternatives: collective farm wage work, subsidiary household plot work, and leisure. The institution of subsidiary farming imposes two constraints in a generic AHM. First, households can sell labor to the collectivist farm but cannot hire any labor for the SHP. And second, 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 between the basic AHM and the AHM with completely absent labor markets discussed by Strauss (1986).

The AHM-type models of collective farms 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 land causes a decline in both total and wage labor supplies and an increase in the SHP labor supply

(Chandler 1984). A decrease in the wage increases subsidiary plot labor supply (Chandler 1984), a result that is consistent with a recent empirical study by Seeth et al. (1998).

Bradley (1971, 1973) was the first to consider wage uncertainty in the collective farm model. He used a residual wages model, in which the collective's member remuneration from the collective production is determined residually as the collective accounting profit per member. Bradley argued that because of differences in tastes, the effort put into collective farm work would be unequal among collective farm members. Because each worker is uncertain about the quantity of labor supplied to collective production by other households, the payment system leads to uncertainty in wage income. Bradley concluded that workers would respond to the wage uncertainty by redirecting labor activities from collective farm work, in which there was greater uncertainty, toward private plot production and leisure. Cameron (1973b) questioned Bradley's assumption that the uncertainty of the marginal income on the collective farm is greater than that at the private plot. Neither Bradley nor Cameron, however, advanced a rigorous theoretical model to support their conclusions. Furthermore, this entire debate about the relative variability of collective versus private subsidiary production took place more than 20 years ago, in a period of stability in the Soviet Union.

Bonin (1977) picked up the debate between Bradley and Cameron by explicitly modeling uncertainty in a collective farm model. He considered 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, he also considered the effect of uncertainty in the price of private plot output. Under the assumptions of decreasing absolute risk aversion and fixed leisure, Bonin showed that individuals reallocate work between the two plots toward the less-risky remuneration. When leisure was allowed to vary, Bonin considered only the case of both uncertainties present (from the collective sector and private plot production) and concluded that the effect of the uncertainties on the labor decision could not be signed. Although this result is true for the private plot price uncertainty case, as 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, Finkelshtain and Chalfant (1991), Fafchamps (1992), and 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 by Fabella (1988). But, wage uncertainty has not been studied, probably because nonagricultural income has always been treated as being less volatile than agricultural income in market economies.

The AHM with absent labor markets is directly applicable to studying time allocation decisions of pensioners that have access to SHP (i.e., of those without market wage opportunities). 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 that 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 income uncertainty.

Model of Wage-Earning Household

In this section, we first 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 with those in the case when the wage is set identically to its mean. Finally, we assume a discrete distribution of wages and investigate changes in labor allocation when the probability of receiving wages declines.

Model Setup

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 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} for the 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:

$$\max_{T > h^p \geq 0,\, T \geq h^c > 0,\, T - h^p - h^c \geq 0} U\left(Wh^c + f(h^p, m),\, T - h^p - h^c\right). \tag{1}$$

We will call a solution (h^p, h^c) to (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 SHP farming is considered. Although 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 (1999) 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 holding 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 also might 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 the adoption of new land laws, quitting wage work means both breaking ties to a collective farm that provides wages and also facing the requirement to become a new legal entity—a private farmer. It is common knowledge (see, e.g., Maggs 1971; Perotta 1999) that in addition to wages, the collective farms supplied their workers with payments-in-kind and subsidized inputs to their subsidiary plot production. In rural areas, collective farms remain major providers of social services, such as childcare, utilities, and the like. The preferred access to most of the farm-provided social services is lost once an employee leaves the collectivist farm (Csaki and Lerman 1997; Perotta 1999). Thus, the collective farm work and the SHP work complement each other because one provides social services access while the other ensures a steady income. This situation exemplifies a “complementary” reason for dual job holding (Paxson and Sicherman 1996).

In this study, we treat these fringe benefits as a part of the hourly wage and implicitly assume that after taking these benefits into account, the expected wage is higher than the marginal product of labor in the SHP production. Leaving the collective farm is difficult because of poorly specified leaving procedures, underdeveloped farming infrastructure, high production risks due to underdeveloped input markets, and insufficient business experience for most collective farm workers (Csaki and Lerman 1997; Perotta 1999). 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 1999).

Another implicit assumption is that commodities other than labor could be aggregated in the analysis. That is, utility maximization in the aggregated model (1) yields the same results on labor allocation as an analysis of a model in which 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 a household's limited ability to substitute food for other commodities due to the 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 the original disaggregated goods. The assumption that prices of necessities move together is not unreasonable for transition economies.

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 1996; World Bank 1996; Klugman 1997). The share of income spent on food jumped from approximately 40 percent in the 1980s to 60 percent in the 1990s (Van Atta 1998).

In rural areas, poverty is more pronounced than in urban areas: Perotta (1999) reports that more than 62 percent 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 accounted for almost 70 percent of rural household income expenditures in 1996 and 1997. Here, income includes the value of household-produced food. With taxes, housing, and utilities accounting for at least 5 percent 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 in a 1996 survey that 50 percent of 1,674 collectivist farm employees surveyed could not satisfy even the minimum consumption needs of their families. Another 48 percent of respondents reported 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 percent of its income on food, housing, utilities, and taxes in 1996 (Van Atta 1998). Pensioners must spend almost all of their income 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 percent 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 (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

$$f_1 = W. \tag{2}$$

This equation conveys the familiar optimality condition of the farm household model: the SHP labor supply is chosen so that the marginal revenue product 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, whereas the reverse is not true because consumption depends on production through the budget constraint. This property of the AHM is called interchangeably “recursiveness” or “separability” (Singh et al. 1986).

A competitive profit-maximizing firm with production function *f* would make its choice of labor according to the rule (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 makes the consumption decisions given the profits. As will be shown later, 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

Assume that instead of a known wage, the agent deals with an uncertain wage with a nondegenerate 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*, whereas 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 (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:

$$\max_{T>h^p\geq 0,\ T\geq h^c>0,\ T-h^p-h^c\geq 0} E\left[U\left(Wh^c + f(h^p, m)\,,\, T-h^p-h^c\right)\right]. \tag{3}$$

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 (3) with the agent's choices in the case in which the random wage W is set identically to its mean. The certainty counterpart of problem (3) is

$$\max_{T > h^p \geq 0,\ T \geq h^c > 0,\ T - h^p - h^c \geq 0} \quad U\left(E[W]h^c + f(h^p, m)\,,\, T - h^p - h^c\right). \tag{3c}$$

Proposition 1

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

Proof of Proposition 1

The solution to (3) satisfies the following first-order necessary conditions:

$$\frac{\partial E[U]}{\partial h^p} = E\left[U_1 f_1 - U_2\right] = 0 \tag{4}$$

$$\frac{\partial E[U]}{\partial h^c} = E\left[U_1 W - U_2\right] = 0. \tag{5}$$

Subtracting (5) from (4), we get

$$f_1(h^{p*}, m) = E[W] - \frac{Cov\left[U_1\left(Wh^c + f(h^p, m), T - h^p - h^c\right),\ f_1 - W\right]}{E[U_1]}. \tag{6}$$

The covariance term in (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 $\dfrac{\partial\left(f_1 - W\right)}{\partial W} = -1 < 0$.

Consequently, (6) implies

$$f_1(h^{p*}, m) < E[W]. \tag{7}$$

If the wage *W* were fixed at its mean, the first-order conditions for utility maximization would imply equality in (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 Proposition 1 are worth stressing. First, the separability of the model is no longer preserved, as the production decision does depend on preferences.

Second, the solution to the production decision is no longer parallel to the pure production profit-maximizing firm's 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 (6): had the h^{c*} been negative (as for the competitive firm), the covariance term and the result of the Proposition 1 would be reversed.

Note that implicit in Proposition 1 are some additional assumptions about preferences. The existence of the interior solution for problem (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 assumption (S.2) with a more restrictive set

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

The first three inequalities of 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 constant elasticity of substitution utility function satisfies it.

Proposition 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 (4) and (5) be satisfied for some positive h^{p*} and h^{c*}. Then

(i) the pair (h^{p*}, h^{c*}) is the solution for problem (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 is provided in the Appendix, A1.

In the proposition proven, a change in the distribution of wages is modeled via a decline in the probability of receiving wages. Strictly speaking, this way of changing the distribution does not imply 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. But, the variance $Var[W] = p(1-p)w^2$ either increases or decreases depending on whether p is less than or more than 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 (e.g., 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.

Model of Pensioner Household

To study the effects of changes in pensions, we adapt the AHM (3) by assuming no wage work and by introducing an unearned fixed income: pensions.

Model Setup

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 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 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, $i, j = 1,2$.

The agent's problem is

$$\max_{T > h^p \geq 0} \quad E\left[U\left(P + f(h^p, m), T - h^p\right)\right]. \tag{8}$$

To determine the impact of risk on the agent's decisions, we compare the solution to (8) with the agent's choice in the case when the random pension P is set identically to its mean. The certainty counterpart of the model (8) is

$$\max_{T > h^p \geq 0} \quad U\left(E[P] + f(h^p, m), T - h^p\right). \tag{8c}$$

Assumptions

We assume

$U_1 > 0,\ U_2 > 0$; (S.1p)

$U_{11} < 0,\ U_{22} < 0,\ U_{12} > 0$; (S.2p)

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

$R_1 < 0,\ R_2 = 0$, (S.4p)

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

$$R \equiv -\frac{U_{11}}{U_1}.$$

The first inequality in (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).

<u>Proposition 3</u>

Let the assumptions (S.1p) – (S.4p) hold. Let h^{p*} and h^{p**} be interior solutions to (8) and (8c), respectively. Then $h^{p*} > h^{p**}$.

<u>Proof of Proposition 3</u> is provided in the Appendix, A2.

Finally, we analyze the consequences of changes in the distribution of pension income on optimal labor supply and find that the effects of a decline in the probability of receiving pensions are ambiguous. We can, however, sign the effect of an increase in pension income uncertainty when the increase is modeled as a mean-preserving spread. Conventionally, the mean-preserving spread is modeled as a pure increase in dispersion via a multiplicative parameter combined with an additive shift in the distribution under the restriction that the mean of the distribution is unchanged (Sandmo 1971).

Proposition 4

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

Proof of Proposition 4 follows closely Block and Heineke (1973); it is provided in Appendix, A3.

Conclusions and Discussion

The study addressed the increased involvement of the post-Soviet population in subsidiary household farming, a phenomenon virtually neglected in economic literature. The agricultural household model leads us to infer that several phenomena occurring in transition economies may cause an increase in hours of subsidiary farming. The model results are summarized in Tables 1 and 2.

For wage-earning households, a decline in real wages increases the 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 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. The total effect of wage uncertainty in Block and Heineke's (1973) labor supply model is ambiguous, because risk-averse individuals cannot do two things simultaneously—increase work hours to alleviate income uncertainty while reducing involvement in 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.

With respect to subsidiary production alternatives, the restriction on no SHP labor from outside of the household turns out to be crucial. With this restriction, the net effect of the 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 the probability of receiving wages and subsidiary plot labor supply, and a positive one between the probability of receiving wages and wage labor supply. These results provide theoretical support to the intuitive conjecture that was discussed by Bradley (1971, 1973) and Cameron (1973b), and was proven previously by Bonin (1977) under overly restrictive assumptions on leisure allocation and preferences.

In the model presented, wages are modeled as being received as food. Indeed, a share of collective farm wages is received in-kind in the form of consumption goods (Perotta 1999). However, inputs for SHP production such as forage grain, seeds, and young animals, are also common forms of remuneration for collectivist farm work (Perotta 1999). 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 nonmonetarization 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 was below its mean and they increase SHP hours. An increase in uncertainty when modeled as a mean-preserving spread increases SHP hours as well. Both results are in parallel with the results of Block and Heineke (1973) on the effect of uncertainty in nonwage income on wage labor supply when wages are certain and unchanged.

Admittedly, the relative impact of pensioner SHP production on overall agricultural production might not be large due to natural limitations on time availability and productivity. Yet the SHP income has always constituted a large share of pensioner household income. In 1990, urban pensioners derived 70 percent of their income from pensions and 18 percent from SHP. Pensions of retired collective farmers constituted 48 percent of their income, while 46 percent was 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 the demographics of SHP producers become available.

The results provide a theoretical explanation for the growth of involvement of the population in subsidiary farming and suggest that income stabilization policies might have a relatively large effect on labor allocation within the current institutional structure. 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 nonpayments. Admittedly, farming is subject to its own intrinsic volatility due to weaÿÿÿÿ, animal disease, pests, etc. Because of that, farm operators in market economies often diversify income by working off-farm (Huffman 1991; Mishra and Goodwin 1997). But, in contemporary transition economies, the riskiness of wage income is so high that it is likely to outweigh that of farming. For this reason we ignored SHP yield uncertainty in our analysis; however, incorporating both types of uncertainties into a model could be done.

Is the growth of 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 draws support even 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 of time to occur with no fundamental economic restructuring and reform. Van Atta (1998) points out that SHP food production dulls the edge of the hardship, thus easing the pressure for real reforms in the economy.

The growth of subsidiary farming is an indication of large 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 an inefficient use of human resources. The situation will not change, however, unless the reforms progress. In particular, genuine restructuring of existing enterprises that makes them financially responsible for the results of their operation and the development of a more friendly business climate would allow entrepreneurship to bloom and create income opportunities for the skilled population. As for agriculture, the 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 than exists today.

Table 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 1
Decline in probability of receiving wage	+	-	?	Proposition 2

Table 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 3
Mean-preserving spread in pensions	+	Proposition 4

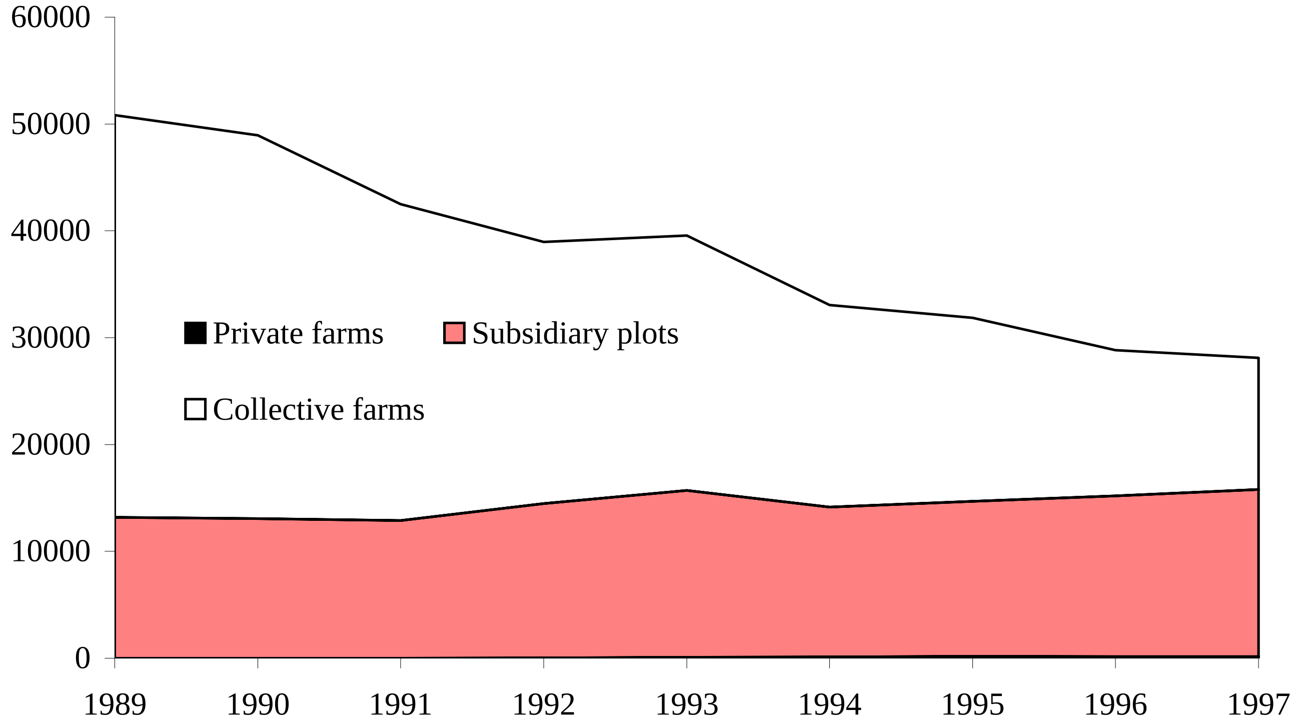

Figure 1. Ukraine: Agricultural production; million 1983 Krb.
Source: Adapted from Csaki and Lerman 1997

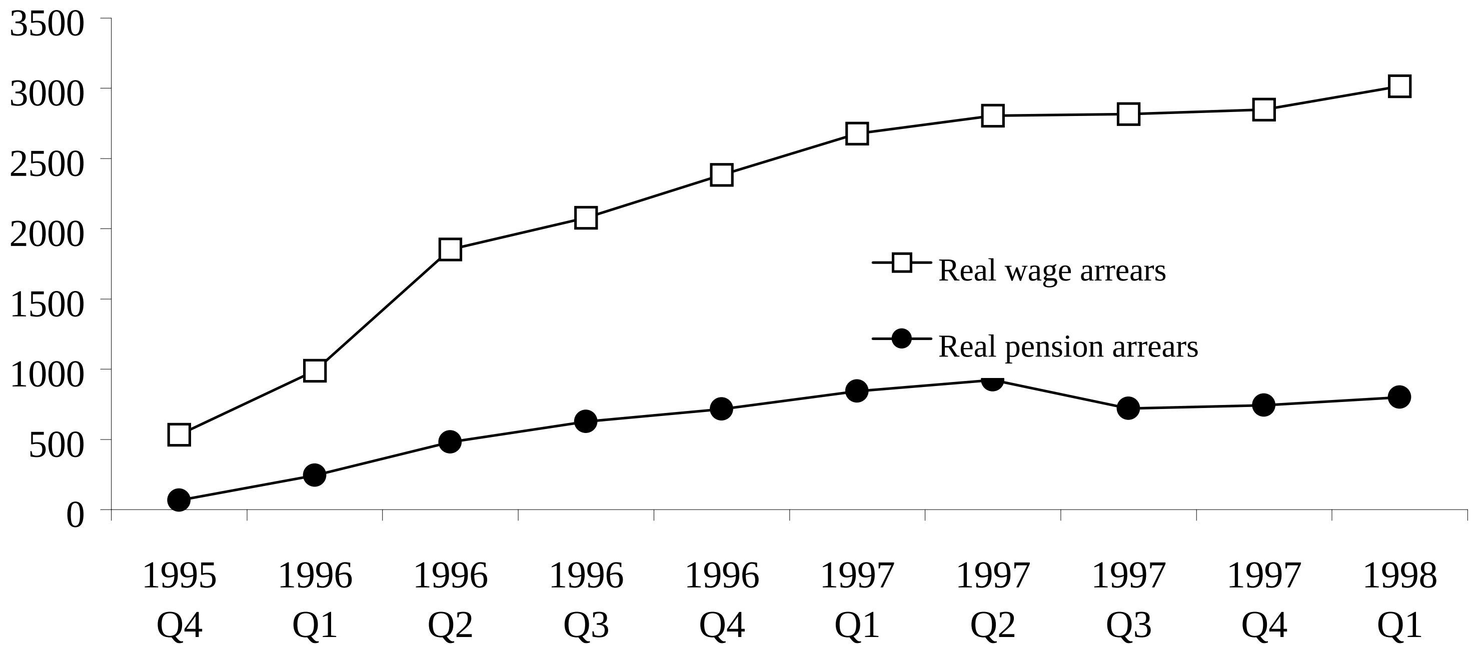

Figure 2. Ukraine: Wage and pension arrears; million 1990 Krb.
Source: Ukrainian Economics Trends: Monthly Update, 1998
http://intranz.eerc.kiev.ua/data/tacis_data

Appendix

A.1. Proof of Proposition 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

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

The first-order necessary conditions for an interior maximum (4) and (5) take the form

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

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

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, (6) takes a transparent form

$$f_1 = pw\frac{U_1^+}{pU_1^+ + (1-p)U_1^-}$$, 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,

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

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

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

$$\frac{\partial^2 E[U]}{\partial h^{p2}} = p \cdot \left\{ U_{11}^+ f_1^{\,2} - 2U_{12}^+ f_1 + U_{22}^+ \right\} + (1-p) \cdot \left\{ U_{11}^- f_1^{\,2} - 2U_{12}^- f_1 + U_{22}^- \right\}$$

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

$$\frac{\partial^2 E[U]}{\partial h^{c2}} = p \cdot \left\{ U_{11}^+ w^2 - 2U_{12}^+ w + U_{22}^+ \right\} + (1-p) \cdot U_{22}^-$$

$$\frac{\partial^2 E[U]}{\partial h^p \partial h^c} = p \cdot \left\{ U_{11}^+ wf_1 - U_{12}^+ (w + f_1) + U_{22}^+ \right\} + (1-p) \cdot \left\{ -U_{12}^- f_1 + U_{22}^- \right\}.$$

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 $\frac{\partial^2 E[U]}{\partial h^{p2}}$ 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 $\frac{\partial^2 E[U]}{\partial h^{c2}}$ 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, $(1-p)^2$, and $p(1-p)$, we obtain

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

$$+\, p^2 \cdot \{U_{11}^+U_{11}^+w^2 f_1^{\,2} - 2U_{11}^+U_{12}^+wf_1(w + f_1) + U_{11}^+U_{22}^+(w^2 + f_1^{\,2})$$

$$+\, 4U_{12}^+U_{12}^+wf_1 - 2U_{12}^+U_{22}^+(w + f_1) + U_{22}^+U_{22}^+\}$$

$$-\, p^2 \cdot \{U_{11}^+U_{11}^+w^2 f_1^{\,2} + U_{12}^+U_{12}^+(w^2 + 2wf_1 + f_1^{\,2}) + U_{22}^+U_{22}^+$$

$$-\, 4U_{11}^+U_{12}^+ f_1^{\,3} + 2U_{11}^+U_{22}^+ f_1^{\,2} - 4U_{12}^+U_{22}^+ f_1\}$$

$$+\, (1-p)^2 \cdot \{\, U_{11}^-U_{22}^- f_1^{\,2} - 2U_{12}^-U_{22}^- f_1 + U_{22}^-U_{22}^- \,\}$$

$$-\, (1-p)^2 \cdot \{\, U_{12}^-U_{12}^- f_1^{\,2} - 2U_{12}^-U_{22}^- f_1 + U_{22}^-U_{22}^- \,\}$$

$$+\, p(1-p) \cdot \{\, U_{11}^+U_{11}^-(w^2 f_1^{\,2} - 2U_{11}^+U_{12}^-w^2 f_1 + U_{11}^+U_{22}^-w^2 - 2U_{12}^+U_{11}^-wf_1^{\,2}$$

$$+\, 4U_{12}^+U_{12}^-wf_1 - 2U_{12}^+U_{22}^-w + U_{22}^+U_{11}^- f_1^{\,2} - 2U_{22}^+U_{12}^- f_1 + U_{22}^+U_{22}^-$$

$$+\, U_{11}^+U_{22}^- f_1^{\,2} - 2U_{12}^+U_{22}^- f_1 + U_{22}^+U_{22}^- \,\}$$

$$-\, p(1-p) \cdot \{\, -2U_{11}^+U_{12}^-wf_1^{\,2} + 2U_{11}^+U_{22}^-wf_1 + 2U_{12}^+U_{12}^- f_1(w + f_1)$$

$$-2U_{12}^+U_{22}^-(w + f_1) - 2U_{22}^+U_{12}^- f_1 + 2U_{22}^+U_{22}^- \,\}.$$

Simplifying, we get

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

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

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

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

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

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,

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

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

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

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

where

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

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 $\dfrac{\partial h^c}{\partial p}$:

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

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

$$\begin{aligned} \det(B) = \frac{1}{p} \cdot \{ & U_2^- \cdot \left((1-p) f_1 \left\{ U_{11}^- f_1 - U_{12}^- \right\} + f_{11} \left\{ pU_1^+ + (1-p)U_1^- \right\} \right) \\ & - U_1^- f_1^2 \cdot \left(pU_{12}^+ + (1-p)U_{12}^- \right) + U_1^- f_1 \left(pU_{22}^+ + (1-p)U_{22}^- \right) \\ & + p\left\{ U_{11}^+ f_1 - U_{12}^+ \right\} \cdot \left[U_1^- f_1 w - U_2^- (w - f_1) \right] \quad \} \\ & < 0 \end{aligned}$$

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 3

The solution to (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

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

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 Proposition is proven.

A.3. Proof of Proposition 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., $\frac{d\theta}{d\gamma} = E[P]$. The effect of the mean-preserving spread is then assessed by evaluating $\frac{dh^{p*}}{d\gamma}$ at $\gamma = 1, \quad \theta = 0$.

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

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

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

The covariance is positive, because

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

as shown in the proof of the Proposition 3. Then, by (A.15), $\frac{dh^{p*}}{d\gamma} > 0$, and the Proposition is proven.

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