Life satisfaction and influencing factors of the elderly population in rural China

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Introduction

Conservation tillage is a method of production that reduces or minimizes plowing of the soil and results in increased levels of crop residue in the field. It is typically considered to be both cost-reducing and environmentally friendly, with the benefits of controlling soil erosion, increasing soil organic matter, conserving soil moisture, and reducing labor and energy costs. Conservation tillage includes a broad class of tillage practices. By definition of Conservation Technology Information Center (CTIC), any tillage system that covers at least 30 percent of the soil surface with crop residue after planting is referred to as conservation tillage.

Modern technologies of conservation tillage originated in the United States during the 1940s. Since then, the adoption of conservation tillage has been promoted by various factors, including government programs, environmental awareness, technology advances, and climate risks. Up till 2008, over 40 percent of the US cropland was cultivated with conservation tillage methods (CTIC). Conservation tillage has now been adopted in large scale in many countries around the world, not only in developed countries, but also in developing countries such as Brazil and Argentina. Through years of practice, the multiple advantages of conservation tillage have been widely recognized by the international community.

In China, conservation tillage has been introduced since 1970s; however, it has never enjoyed a wide adoption. Up till 2007, the conservation tillage acreage in China summed up to 500 million acres, only about 1.5 percent of the total arable land. In recent years, China has been facing increasing problems of soil erosion and land degradation. Conservation tillage, with both economic and ecological benefits, provides a good avenue for Chinese farmers to conserve land as well as secure food production. There should be a great potential for the development of conservation tillage systems in China.

This paper is aimed to explore the reason(s) behind the slow development of conservation tillage in China. Specifically, the author will investigate the potential obstacles in place for a Chinese agricultural producer to adopt conservation tillage practices, and how the government policies can be used to improve the adoption of conservation tillage in China.

Literature Review

A sizable literature has studied the factors influencing farmers' adoption of conservation tillage systems. Ervin and Ervin (1982) summarized those factors into four categories: physical, economic, personal, and institutional. Agronomic studies have investigated a variety of physical determinants governing the success or failure of conservation tillage in terms of yield response and erosion control. The identified factors include soil properties, land slope, climate condition, and cropping systems (Amemiya, 1977; Fenster, 1977; Phillips et al., 1980; Cosper, 1983; Norwood, 1999). Generally, the experimental results suggest that conservation tillage, when applied on suitable land with favorable weather and proper management, could produce yields at least as high as conventional tillage.

The economic feasibility of conservation tillage practices has been evaluated with consideration of financial constraints and risk preference of farmers. Budgeting procedures and mathematical programming were often employed to compare the expected profit or utility under alternative tillage systems. Factors investigated in these studies include farm income, adjustment costs, planning horizon, government programs, and risk aversion (Epplin et al., 1982; Helms, Bailey, and Glover, 1987; Williams, 1988; Williams, Llewelyn, and Barnaby, 1990; Krause and Black, 1995).

There has been a limited analysis of the adoption of conservation tillage systems in China. Some of the previous literature has summarized the existing problems and difficulties encountered in the adoption process of conservation tillage in China, including the complexity of cropping systems, inadequacy of specialized farming equipments, low level of farmers' knowledge, and lack of basic technical service support (Wang et al. 2003, Sun 2007, Liu 2010). Some researchers investigated farmers' choice behavior in the adoption of conservation tillage and the influencing factors by using a field survey. Peng et al (2009) did a field research on the application of no-till farming on the outskirts of Beijing. They analyzed the problems behind the slow adoption rate of no-till, indicated the necessity of economic compensations to the adoption of conservation tillage practices, and discussed alternative scenarios of compensation schedules. Ma et al (2010) conducted a household survey to farmers in Liaoning Province, analyzing how farmers' education, age and level of knowledge affected their adoption of conservation tillage practices.

One major factor we believe that impedes the adoption of conservation tillage is the very small-scale land production in rural China. The average land cultivated by an individual household is less than 2 acres. This very small-sized farm cannot afford the initial investment required by conservation tillage systems, as well as the yield risks during the early phase of adoption. Therefore, conservation tillage is often considered a community-based technology in China, and its adoption is the consequence of a collective decision at the level of village or production team. In China, such collective decision is highly influenced by government policies. In recent years, Chinese government has launched several demonstration and extension projects to promote the adoption of conservation tillage systems. Researchers found that many of these projects had short-lived effect in promoting the adoption of conservation tillage, and individual farmers often reduced their conservation tillage acreage or even turned back to the conventional tillage system after the projects ended (Ren et al 2009). This phenomenon has prompted our interest to look into the special problems and obstacles in the adoption process of conservation tillage in rural China.

Economic Model

<u>Conversion Cost</u>

We assume that there are n farmers in a village, and each farmer has m_i acres of cropland. The total acreage of cropland in the village is M (i.e. $M = m_1 + m_2 + ... + m_n$). There is a lump-sum conversion cost of adopting conservation tillage, which includes the cost of initial investment in specialized or modified equipment and cost of adaptations in management. The conversion cost is denoted by *C(m)*, where $C'(m) > 0$ and $C''(m) < 0$. It suggests that the adoption cost per acre ($C(m)/m$) decreases as the conservation tillage is adopted on a larger land. So, if mi is very small the per acre adoption cost can be very large for an individual farmer. An individual farmer makes the selection of tillage practice by solving the following optimization problem:

$$(1) \qquad \max_{d=0,1} \sum_{t=1}^{T} \beta^t \pi_{it}^d - d\frac{C(m_i)}{m_i}$$

where *d*=0 indicating the use of conventional tillage, while *d*=1 indicating the adoption of conservation tillage; β is the discount factor, and π_{it} is the profit per acre for individual *i* at time *t*.

According to our above analysis on the conversion cost, $\frac{C(m_i)}{m_i}$ can be very large for an individual farmer with small land, and thus prevent the adoption of conservation tillage. This situation is commonly observed in many areas of rural China, where the average farm size is usually only a few acres and the initial adoption costs of many new farming technologies are overwhelming for any individual farmers. In such case, the adoption decision on new technology such as conservation tillage is often made collectively on the village level. If the village as a whole decides to adopt the conservation tillage, the total conversion cost is $C(M)$, and the average cost for each individual farmer is $\frac{C(M)}{M}$. Notice that $\frac{C(M)}{M} << \frac{C(m_i)}{m_i}$. Therefore, conservation tillage is often considered a community-based technology in China, and its adoption is the consequence of a collective decision at the level of village or production team. In China, such collective decision is highly influenced by government policies. Programs promoting the adoption of conservation tillage would subsidize the village by cost-sharing. Let τ denote the cost-sharing rate, the actual conversion cost is then written as $(1-\tau)C(M)$. The optimization problem specified in equation (1) is rewritten:

$$(2) \qquad \max_{d=0,1} \sum_{t=1}^{T} \beta^t \pi_{it}^d - d(1-\tau)\frac{C(M)}{M}$$

Profit Function

The profit function π_{it}^{d} is

(3) $$\pi_{it}^{d} = py_{it}^{d} - c_{it}^{d}$$

where *p* is crop price, *y* is yield, and *c* is cost of production. The level of yield is stochastic, and its variability is largely attributed to the stochastic weather condition. The weather variable is denoted by ε with mean 0 and variance σ^2. A high value of ε represents weather that is more favorable to production. We represent stochastic production levels by a Just-Pope production function, which specifies the effect of input on the mean of output separately from the effect of input on the variance of output. We consider tillage technology as an input, and its value affect the mean and variance of the output.

(4) $$y_{it} = f_{it}(X) + h_{it}(X)\varepsilon$$

(5) $$\pi_{it}^{d} = p(f_{it}^{d}(X) + h_{it}^{d}(X)\varepsilon) - c_{it}^{d}(X)$$

The expected value and variance of profit are the following:

(6) $$E(\pi_{it}^{d}) = pf_{it}^{d}(X) - c_{it}^{d}(X) = \exp(\frac{-d}{\delta t})E(\pi_{i}^{d})$$

(7) $$Var(\pi_{it}^{d}) = (ph_{it}^{d}(X))^2\sigma^2 = \exp(\frac{(T'-t)d}{\gamma t})\sigma^2$$

The expected profit specified in equation (6) is affected by the choice of tillage method (*d*), time period (*t*), and a parameter ($\delta, \delta > 0$). When *d*=0, $E(\pi_{it}^{0}) = E(\pi_{i}^{0})$; when *d*=1, $E(\pi_{it}^{1}) = \exp(\frac{-1}{\delta * t})E(\pi_{i}^{1})$. The expected profit of conventional tillage is stationary, and does not change over time. While, the expected profit of conservation tillage increases over time and approaches to $E(\pi_{i}^{1})$. This specification represents the fact that there exists an adaption period for farmers to master the new tillage method. Additionally, the benefits of conservation tillage are cumulative, and it may take several years for farmers to take full advantage of this new technology. The value of δ represents a farmer's ability of learning and adaptation to new technology. A higher value of δ indicates greater ability, and thus a greater value of expected profit for a farmer adopting conservation tillage, especially during the early phase of adoption ($\partial E(\pi_{it}^{1})/\partial\delta > 0$). Results from field experiments often suggest that the yield under conservation tillage is no less or even greater than the yield under conventional tillage; therefore, we could assume that $E(\pi_i^1) \geq E(\pi_i^0)$. However, due to the existence of the adaptation period, the expected profit of conservation tillage might be smaller than that of conventional tillage. A farmer's adaptation ability to new technology is affected by his/her level of education and knowledge. In rural China, farmers usually have low education level and limited knowledge and information about new tillage methods, and thus low levels of learning and adaptation ability (a small value of δ). This explains why farmers are often reluctant to replace conventional tillage with conservation tillage when experimental data suggest that the latter receives a higher expected return.

Some studies considered conservation tillage to be riskier than conventional tillage, and therefore concluded that risk-averse producers are less likely to adopt conservation tillage systems. However, the study of Ding et al (2009) indicated that because crop residue cover traps soil moisture, conservation till are methods producers can use to reduce their risk associated with unfavorable weather conditions. We believe that the perceived risk of conservation tillage is mainly a result of unfamiliarity with the new tillage practices or lack of management skills. This perception should decrease over time with education, demonstration, and assimilation of the new technology. Therefore, we assume that conservational tillage is risk increasing during the early phase of adoption, and then turns to be risk-reducing after certain time period. There exists an inflection time point. Before that point conservation tillage is riskier, while after that point, conservation tillage is less risky. This idea is represented in the specification of variance of profit in equation (7).

When d=0, $Var(\pi_{it}^{0}) = \sigma^2$; and when d=1, $Var(\pi_{it}^{1}) = \exp(\frac{T'-t}{\gamma * t})\sigma^2$. T' is the inflection time point. As $t < T'$, $Var(\pi_{it}^{1}) > Var(\pi_{it}^{0})$, and conservation tillage is riskier than conventional tillage; as $t \ge T'$, $Var(\pi_{it}^{1}) \le Var(\pi_{it}^{0})$, and conservation tillage turns to be a risk-reducing technology. The parameter γ measures the difference in variance of profit between conventional tillage and conservation tillage. A greater value of γ indicates lower risk in the early phase of adopting conservation tillage.

Expected Utility

As a farmer is commonly assumed to be risk averse, given the stochastic profit function, the farmer should maximize the expected utility of profit:

$$(8)\quad \max_{d=0,1}\sum_{t=1}^{T}\beta^{t}E[U(\pi_{it}^{d})]-d(1-\tau)\frac{C(M)}{M}$$

One utility function form that is frequently used is the negative exponential function. This utility function implies that producers have constant absolute risk aversion of level λ. This means that expected utility is a function of the mean and variance of profit. Maximizing expected utility function gives the following optimization problems:

$$(9)\quad W=\max_{d=0,1}\sum_{t=1}^{T}\beta^{t}[E(\pi_{it}^{d})-0.5\lambda V(\pi_{it}^{d})]-d(1-\tau)\frac{C(M)}{M}$$

We substitute equation (6) and (7) into the maximization problem to determine an individual farmer's optimal choice of tillage practice.

$$(10)\quad \begin{cases} W=\sum_{t=1}^{T}\beta^{t}[E(\pi_{i}^{0})-0.5\lambda^{2}\sigma^{2}], & \text{when } d=0 \\ W=\sum_{t=1}^{T}\beta^{t}[\exp(\frac{-1}{\delta^{*}t})E(\pi_{i}^{1})-0.5\lambda^{2}\exp(\frac{T'-t}{\gamma^{*}t})\sigma^{2}]-(1-\tau)\frac{C(M)}{M}, & \text{when } d=1 \end{cases}$$

Discussion on Policy Tools

An individual farmer's choice of tillage practice can be affected by several parameters that are influenced by government policies. The first parameter is the subsidy rate (τ). In rural China, some demonstration program has fully subsidized the adoption of conservation tillage (i.e., τ=1). In such case, farmers' conversion cost is reduced to zero; however, researchers found that some farmers turned back to the conventional tillage methods after the program ended. This is because the existence of adaptation period, during which producers cannot take the full advantage of the new technology. The new technology seems to yield lower expected returns and higher risks during the early phase of adoption, and therefore depreciates farmers' incentive of adoption. Farmers with greater learning and adaptation ability (represented by parameter δ) are more likely to adopt conservation tillage, because they can master the new technology faster and easier. The government, in addition to sharing the cost of conversion, should also provide enough education, training, and on-site technical support to help improve farmers' adaptation ability to new tillage method, and thus enhance their incentive of adoption.

The government could also provide insurance protection for farmers adopting conservation tillage to alleviate their risks during the early phase of adoption. As explained in the last section, conservation tillage at the beginning of adoption could increase the yield risk brought up by bad weather conditions. Suppose the government provides free insurance coverage for farmers adopting conservation tillage. The amount of the indemnity paid to a farmer is denoted by $I(\varepsilon)$. Substitute the indemnity payment into the profit function:

(11) $$\pi_{it}^{d} = p(f_{it}^{d}(X) + h_{it}^{d}(X)\varepsilon) - c_{it}^{d}(X) + dI(\varepsilon)$$

The expected value and variance of profit are the following:

(12) $$E(\pi_{it}^{d}) = pf_{it}^{d} - c_{it}^{d} + dE(I(\varepsilon)) = \exp(\frac{-d}{\delta t})E(\pi_{i}^{d}) + d\bar{I}(\varepsilon)$$

(13) $$Var(\pi_{it}^{d}) = (ph_{it}^{d} + I'(\bar{\varepsilon}))^{2}\sigma^{2} = [\exp(\frac{(T'-t)d}{\gamma t}) + I'(\bar{\varepsilon})]\sigma^{2}$$

where $\bar{I}(\varepsilon) = \int_{\varepsilon} I(u)f(u)du > 0$ indicating that the average value of indemnity payment should be greater than zero, and $I'(\bar{\varepsilon}) < 0$ indicating that lower indemnity payment for better weather condition. After incorporating the insurance program, the expected profit of conservation tillage is higher and the variance of conservation tillage is smaller. Substituting equation (12) and (13) into equation (14), we have

$$(14) \quad W = \sum_{t=1}^{T} \beta^t \{[\exp(\frac{-1}{\delta * t}) E(\pi_i^1) + \bar{I}(\varepsilon)] - 0.5\lambda^2 [\exp(\frac{T'-t}{\gamma * t}) + I'(\bar{\varepsilon})]\sigma^2\} - (1-\tau)\frac{C(M)}{M},$$

when *d*=1. With insurance program, farmers are more likely to adopt conservation tillage.

Conclusion and Future Work

In this paper, we construct a theoretical model to explain a farmer's adoption decision of conservation tillage. Our goal is to explore potential reasons behind the low adoption rate of conservation tillage in China. In the model, we consider obstacles specific to a typical farmer in rural China. One important factor is the very small farm size for most farmers in rural China. This results a very high conversion cost for any individual farmer. Therefore, the adoption decision of conservation tillage is often made at collective level. A collective decision is harder to be reached than individual decision. And also, a collective decision is highly influenced by government policies. Therefore, government support is very important for the promotion of conservation tillage. In addition, farmers' low ability of learning and adaptation to new technology could depreciate their incentives to adopt conservation tillage. Greater risk of conservation tillage in its early phase of adoption would also dampen its adoption. We suggest that government sponsored extension program and insurance program for adoption of conservation tillage can help reduce such impediments.

In the future, we plan to use field experimental data to simulate a representative rural community's adoption decision under different weather conditions, and explore policy tools that are most effective in promoting the adoption of conservation tillage in China.

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