Review of Economics & Finance
Submitted on 27/Feb./2013
Article ID: 1923-7529-2013-03-19-15
Xianlei Ma, Justus Wesseler, Nico Heerink, and Futian Qu

Land Tenure Reforms and Land Conservation Investments in China – What Does Real Option Value Theory Tell Us?[1]

Xianlei Ma
Public Administration College, Nanjing Agricultural University
No.6, Tongwei Road, Nanjing, Jiangsu, 210095, China
Tel: +86-258-439-6531 E-mail: maxianlei@njau.edu.cn

Justus Wesseler (Correspondence author)
Agricultural and Food Economics, Research Department of Agricultural Economics, Center of Life and Food Sciences Weihenstephan, Technische Universität München
Weihenstephaner Steig 22, 85354 Freising, Germany
Tel: +49-816-171-5632 E-mail: justus.wesseler@wzw.tum.de

Nico Heerink
Department of Social Sciences, Wageningen University
P.O. Box 8130, 6700 EW Wageningen, The Netherlands
Tel: +31-748-5117 E-mail: Nico.Heerink@wur.nl

Futian Qu
Public Administration College, Nanjing Agricultural University
No.6, Tongwei Road, Nanjing, Jiangsu, 210095, China
Tel: +86-258-439-6531 E-mail: ftqu@njau.edu.cn

Abstract: Land conservation investments can make an important contribution to avoidance and mitigation of land degradation. Lack of tenure security and land transferability may, however, limit the extent to which farmers undertake such investments. Using real option value theory, this paper investigates the expected impact of the market-oriented tenure reforms in China since 1998 on land conservation investment incentives. It postulates that the reforms are more likely to elicit land conservation investments in areas where land markets are developing. This paper further argues benefits of the land tenure reforms will be underestimated if only the intrinsic but not the time value of changes in the investment incentives will be considered. The findings obtained from this research provide a better understanding of the relationship between the land tenure reforms and land conservation investments, and are likely to serve sustainable land management in China and elsewhere.

JEL Classifications: Q15, D130, K110

Keywords: Property rights, Land tenure, Land conservation investment, Real options, China

[1] This research is funded by the European Community (EM-ECW), the Programme Strategic Scientific Alliances of the Royal Netherlands Academy of Arts and Sciences (KNAW) and the Ministry of Science and Technologies of P.R. China and by the National Natural Science Foundation of China (71003051).

1. Introduction

Poverty, agricultural stagnation and resource degradation are frequently interlinked in a vicious circle in many developing countries (Development, 1987). Investments in land conservation - such as terracing, blocking of soil erosion outlets, and application of organic manure - can play a fundamental role in breaking this vicious circle by mitigating soil erosion, restoring soil fertility and soil organic matter, and controlling dry land salinization (Kabubo-Mariara, et al. 2007).

Tenure security and land transferability are generally considered to be important preconditions for undertaking land conservation investments (Feder and Feeny, 1991; Besley, 1995; Banerjee and Ghatak, 2004; Deininger and Jin, 2006). The underlying theoretical argument claims that secure property rights over land encourage land conservation investments through strengthening claims to the fruits of the investment (assurance effect) (Banerjee and Ghatak, 2004), allowing for gains from trade (transferability effect) (Besley, 1995; Deininger and Jin, 2006) and increasing access to capital (collateralizability effect) (Feder and Feeny, 1991).

The existing literature on property right security and land conservation investments neglects two important aspects. First, land conservation investments undertaken by farmers are frequently irreversible. Land conservation investments are linked to specific plots, and it may not be easy to retrieve them or transfer them technically and economically to other plots. More secure property rights provides households with better opportunities to retrieve the costs of investments in land quality by negotiating rental prices or compensations for expropriation that reflect these quality improvements. Second, empirical studies implicitly assume that farmers have no time flexibility in making land investment decisions. More secure land rights, however, may improve the long-term investment environment. As a consequence, rural households can decide to defer land-related investments until the most appropriate moment. Empirical studies of the impact of property right security on land conservation investments focus on immediate benefits and generally fail to take this indirect benefit into account. The neglect of these two aspects may explain, at least partially, why empirical studies have provided mixed results so far (Holden and Yohannes, 2002; Jacoby et al. 2002; Kassie, et al. 2012).

The objective of this paper is to analyze the effect of the market-oriented land tenure reforms in China on farmers' land conservation investment decisions. To this end, we use an integrated framework that takes into account irreversibility of land investment costs and indirect benefits obtained from increased time flexibility. We will argue that failure to take these two factors into account may underestimate the economic benefits of land tenure reforms in China, in particular the environmental benefits.

The approach used in this paper is to identify the main characteristics of the land reforms, link these characteristics to the real option value (ROV) model of investment behavior, and compare the outcomes with those of a net present value (NPV) approach that neglects investment irreversibility and time flexibility aspects.

The paper is organized as follows. Section 2 presents background information on the rural social structure and the land tenure system and its reforms in China. Three basic characteristics of land conservation investments in China are discussed in section 3. These characteristics are used in section 4 to analyze the effect of the market-oriented land tenure reforms on land conservation investments. Section 5 summarizes the main findings and discusses their implications.

2. Rural Social Structure and Land Tenure in China

The prevailing social structure in rural China plays an important role in both the land tenure system and in certain types of land conservation investments. This section will first briefly discuss the background of the current social structure. Next, it will pay attention to the evolution of the system of land tenure in rural China since 1978, which can be divided into two distinct phases. The first phase is the establishment of the household responsibility system (HRS), guided by egalitarian principles. The second phase consists of adjustments of the HRS aimed at increasing tenure security and transferability.

2.1 Rural Social Structure

At the beginning of the foundation of the Peoples' Republic of China, China implemented a policy of collectivization which required farmers to surrender land to collectives, and adopt a shareholding cooperative production way. As a consequence, Chinese farmers were deprived of the bundle of control and income rights (Kung, 2000). From 1953 to 1957, mutual-aid teams and elementary cooperatives were gradually founded. The collective production organization had been further enhanced since the foundation of the people's communes in 1958. During the period of the people's communes the collective land ownership was established, and land has been fully collectivized. The collective production organization was the major rural social structure in China from 1953 to 1978. The collective production organization in the people's communes included three levels: people's commune, production brigade and production team.

The people's communes were gradually dismantled during the implementation of the HRS that started in 1978. The HRS granted farmers land use rights, with the defunct production teams continuing to be the owners of the collective land. The collective production organization has changed significantly since 1978. The people's communes, production brigades and production teams have been transformed into townships, administrative villages and natural villages, respectively. Many joint decisions about local infrastructure investment and maintenance and land reallocations are taken through self-governed rules at the administrative village level, and are sometimes delegated to the natural village level. The social cohesion within natural and administrative villages is still relatively strong and affects a range of economic decisions taken at the local level, including land conservation investments.

2.2 Land Tenure under the HRS

In 1978, the resolution of the Opening and Reform Policy required to dismantle fully collectivized land property rights in order to enhance agricultural productivity. The HRS was firstly introduced as a trial in Xiaogang Village, Fengyang County, Anhui Province in 1979, and then was implemented across the country from 1981 onwards. The HRS allocated collective land resources to individual farm households according to equalitarian principles. The size of the land assigned to households within a village was determined by the household size and/or the number of laborers in a household (Tan, 2006). Farmers were given land use rights for a period of 15 years and the right to obtain a portion of the income derived from the land, while land ownership remained with the collective (see Tan et al. 2011 for a detailed discussion of rural land property rights in China). The implementation of the HRS improved labor monitoring efficiency and gave farmers greater production incentives, leading to a sharp growth in land productivity (McMillan et al., 1989; Lin, 1992). The egalitarian principles underlying this system of land allocation, however, had four important, less desirable consequences.

Firstly, to deal with differences in land quality (particularly soil fertility, irrigation and drainage conditions) within a village, land was divided into different classes. Each household in a village received at least one plot of each land class. A high degree of land fragmentation was the

result, with households having on average 8.4 plots with a plot size of only 0.07 ha in 1986 (Qu, et al. 1995; Tan, 2006).

Secondly, administrative reallocations of land were used by village officials to address demographic changes within a village. Either full-scale or partial land reallocations have been implemented. Under full-scale reallocations all farmland in the village is given back to the collective and, after subtracting proportional shares of land needed for other purposes, redistributed proportionally among village households. Under partial reallocations only the land of those households who experienced demographic changes (birth, death, marriage, migration) was reallocated among these households while leaving the rest of the land unaffected (Deininger and Jin, 2009; Wang et al. 2011). The practice of frequent reallocations in response to changes in household sizes or composition, with households typically not being compensated for investments in the land that they have made, is generally believed to introduce tenure insecurity (see e.g. Lohmar, 2003; Wang, et al. 2011).

Thirdly, the HRS regulations stipulated that land can only be allocated to households residing within a village. Consequently, the land use rights granted to a farm household may be dispossessed by its village when that household moves out of a village. Farmers therefore face the risk of losing land use rights when they leave a village for off-farm work.

Finally, transfers of land use rights possessed by farmers are not allowed under the HRS. This regulation was intended to avoid growing land inequality, but reduced the scope for further efficiency gains in agricultural production. Subsequent reforms in the land tenure system aimed to address in particular these major shortcomings in the system.

2.3 Reforms of the Land Tenure System

The first steps towards reforming the land tenure system can be traced back to the early 1990s. The Land Administration Law (LAL) of 1986, which formally introduced the basis of the HRS, formally granted land rights to farmers. Farmers' land rights are supposed to be secure and extended. In practice, however, farmers' rights were frequently challenged and land transfers mainly took place through administrative reallocations (Vendryes, 2010). The No. 11 Central Document of the Central Committee, the Communist Party of China (CCCPC), issued in 1993, specified that farmers' land rights will be extended by 30 years after the 15-years period has ended. And the No. 16 Central Document of the CCCPC published in 1997 strictly limited village land reallocations or takings. Although these regulations remained declarations of principles and lacked actual implementation procedures and were not binding on any of the parties, they provided important guidelines for the series of land laws that followed (Chen and Davis, 1998).

The 1998 revision of the LAL stipulates that the duration of land use rights will be extended by another 30 years, that farmers' land use rights are protected by law, that land certificates will be issued to protect farmers' land use rights, that land transfer rights are offered to farmers, and that acceptance by two-thirds of villagers' representatives and approval of higher-level governments is needed for land reallocation within villages. The Rural Land Contract Law (RLCL) of 2002 confirms that farmland tenure security must be maintained for at least 30 years after the nationwide reallocation that started in 1998. It further states that full-scale land reallocations within villages are completely prohibited and that partial land reallocations are only allowed in case of a natural disaster, land expropriation or other special circumstances, in which case they depend on acceptance by two-thirds of villagers' representatives and approval by higher-level (e.g. township) authorities. In addition, it specifies that the collective cannot take (back) land from individual users without providing compensation. An important novel element of the RLCL is the specification of land transfer rights, including the rights of subcontracting (*zhuan bao*), leasing (*chu zu*), exchanging (*hu huan*), transferring (*zhuan rang*) and transferring land through "other means". The RLCL, however,

does not provide clear rules for the inheritance of land use rights. Yet, the RLCL can be seen as important milestone marking a significant increase in transferability and in property rights security (see also Deininger and Jin, 2009).

The Property Law (PL), adopted in 2007, further increased land tenure security in rural (and urban) areas. It implicitly grants farmers with perpetual rights, as it states that farmers should retain and inherit their rights according to relevant rules when the 30 years period has passed. Moreover, the PL for the first time defines farmers' land use rights as usufructuary. Usufruct rights allow a better protection of farmers' interests (Ho, 2005). Further legal support of farmers' interests is provided by the Mediation and Arbitration of Rural Land Contract Disputes Law, adopted in 2009, which sets out principles related to the use of mediation or arbitration to settle land disputes.

In 2008 the third Plenary Session of the 17th CCCPC reconfirmed that the rural land tenure system is characterized by a two-tier management system consisting of collective ownership and farmers' permanent usufructuary rights. It approved a document stipulating that markets for the lease of contracted farmland and transfer of farmland use rights must be set up and improved to allow farmers to sub-contract, lease, exchange and swap their land use rights, or join share-holding entities with their farmland. Participation by farmers in such transfers of land use rights must be voluntarily, with adequate payment and in accordance with the law.

It should be noted that the land tenure reforms do not provide famers with rights to use their land as collateral. The 1995 Guarantee Law prohibits the mortgaging of use rights to arable land. The underlying reason for denying rural households this right is the fear that mortgaging land use rights may drive farmers into landlessness.

In summary, land use rights could not be transferred freely and tenure security was impaired by frequent land reallocations and ambiguous land rights definition after the establishment of the HRS. Subsequent land tenure reforms significantly increased land tenure security and transferability. This was realized by: (1) extending farmers' land rights with a period of 30 years in the 1998 LAL and the 2002 RLCL, and giving them a permanent status in the 2007 PL and the 2008 document; (2) restricting land reallocations in the 1998 LAL, and prohibiting full-scale land reallocations and narrowing the scope of partial land reallocations in the 2002 RLCL; (3) mandatory issuing of land certificates to farmers in the 1998 LAL; (4) defining land use rights as usufruct rights and specifying farmers' compensation for losing land use rights in the 2002 RLCL, and (5) specifying land transfer rights in the 1998 LAL, and identifying the modes of land transfers in the 2002 RLCL and the 2008 document.

3. Characteristics of Land Conservation Investments in China

The improvements in land tenure security and transferability that result from the recent legal reforms in China are expected to encourage longer term investments in the quality of land and hence its productivity. Benefits of productivity enhancements that have an effect also in the future are more likely to be captured by the investor. Examples of land quality improving investments made by farmers include the use of organic manure, well digging, land leveling, surface irrigation, drainage, terracing, and others. Contrary to variable inputs such as seeds, chemical fertilizers, pesticides, and herbicides, these investments contribute more than one season to output and can improve soil quality and agricultural production in the long term. Important characteristics of long-term on-farm land-related investments are the irreversibility of cost, uncertainty of benefits, and flexibility of investment. We discuss each of them in turn.

Cost irreversibility: Land conservation investments are linked to specific plots. It is not easy to retrieve them or transfer them technically and economically to other plots because of immobility of

land. Despite the fact that farmers can retrieve some parts of the benefits by transferring plots with land conservation investments to others via land rental markets, it is often hard to calculate the pure incremental benefits from land conservation investments accurately and, as a result, difficult to get a price agreement. In the case of land rental markets failures, which are common in rural China, this problem is even more serious. Hence there may be important irreversible costs linked with long-term land conservation investments.

Uncertainty of benefits: There may be several sources of uncertainty in reaping the benefits of land conservation investments. One important source is tenure insecurity. Farmers loose (part of) the benefits of investments that they make in a plot, when the use right of the plot in question is taken from them without adequate compensation for the investment. This may happen, for example, when land is reallocated within a village to correct for demographic changes or when land is taken away from farm households moving out of a village for off-farm employment. Other sources of uncertainty include natural disasters, which can seriously damage a crop and depress the benefits of land-related investments, volatility of output and output and input prices, uncertainty in market relationships and the policy environment.

Investment flexibility: Rural land in China is assigned to the households living within a village on the basis of equality. Households that are registered in a village always have access to some of its land, unless a household decides to change its registration and leave the village. Every household has a right to make investments in its land; others cannot deprive the investment opportunity attached to the land. In this situation, rural households can decide to defer land-related investments until the most appropriate moment. In other words, land conservation investments are flexible over time.

In the next section, these characteristics of land conservation investments are used to analyze how the recent land tenure reforms in China affect investment incentives in land conservation investments of rural households. Although the focus is on household investment decisions, many aspects are equally relevant for so-called self-governed investments that are jointly made by households belonging to the same natural or administrative village.

4. Land Tenure Reforms and Land Conservation Investment Incentives: a Real Option Value Analysis

4.1 Real Option Value Theory and Land Conservation Investments

The ROV model is a suitable tool for analyzing the optimal rule of irreversible investments under uncertainty when investors have a flexibility of making decisions (Dixit and Pindyck, 1994; Wong 2007). Empirical studies in an agricultural context, either based on field data - such as Hill (2010) and Hinrichs et al. (2008) - or on an experimental approach - such as Maart-Noelck and Musshoff (2013) - have provided convincing evidence of the existence of a ROV. These studies favor the explanatory power of the ROV over the NPV in understanding investment behavior of farmers.

Given the characteristics of land conservation investments discussed in the previous section, the real option model is a suitable tool for examining farm-level land conservation investment decisions. Two seminal models in this field analyze the value of the option to invest and the optimal rule for exercising that option as well (McDonald and Siegel, 1986; Dixit and Pindyck, 1994). The key principle of real option value (ROV) theory is that, given the presence of uncertainty and irreversibility of benefits and costs, investors value the flexibility to decide about making an investment (Wesseler, 2009). The method used for deriving the critical value (threshold) for making

an investment is to risk-adjust the future pay-offs of an investment so that cash flows are discounted at a 'risk-free' rate.

4.2 Effect of Land Tenure Reforms on Land Conservation Investments

Improved tenure security and alienability allow an investor to sell or rent his investment in the event that profitable outside opportunities arise (Besley, 1995). It also permits a cultivator to overcome the problem of long time horizons, since he does not need to wait through the whole gestation period of an investment in order to reap the full benefit from it (Deininger and Jin, 2006). Another potential effect of land tenure reforms is the benefits from increased access to capital through the use of land as collateral which is expected to stimulate land conservation investments (e.g. Besley, 1995).

The recent land tenure reforms in China are expected to reduce the uncertainty of benefits of land conservation investments. As discussed in section 2, the reforms aim at reducing the frequency of land reallocations, providing farmers with formal land tenure certificates and granting perpetual land use rights. Hence, farmers are less likely to lose a plot in which they made an investment. In the case of China, however, use of land as collateral remains prohibited. The so-called col-lateralizability effect of land tenure reforms is therefore limited.

Farmers who migrate out of their village will generally be compensated for investments that they made in the land. Two categories of migrants need to be distinguished in this respect. Migrants who register in a city will receive a reasonable compensation for their land investments according to relevant recent laws. More secure tenure therefore reduces the threat that not all investment benefits can be reaped for this group. Migrants who maintain their registration in the village, on the other hand, run the risk of losing their land when they do not cultivate it. When land transfers are prohibited, these migrants normally lose all the benefits of their investments. The recent land reforms in China, however, intend to increase land tenure transferability. By renting out their land to other households, migrant households have better opportunities to retrieve the benefits of their investments in land quality by negotiating a rental price that reflects these quality improvements.

The impact of uncertainty of project benefits on a project's net present value can be analyzed with the standard Capital Asset Pricing Model (CAPM). It specifies the present value of an investment project (X) as equation (1):

$$X = \frac{\mathrm{E}[\tilde{X}] - \lambda \mathrm{Cov}(\tilde{X}, \tilde{r})}{1 + r_{\mathrm{f}}} \qquad (1)$$

Where $\mathrm{E}[\tilde{X}]$ is the expected return of the investment opportunity; λ the market price of risk; $\tilde{r}$ the uncertain return of alternative investment opportunities, the market portfolio; $\mathrm{Cov}(\tilde{X}, \tilde{r})$ the covariance of the uncertain returns of the investment opportunity with the uncertain returns of alternative investment opportunities; and r_{f} the risk-free rate of return. Equation (1) implies that an increase in the uncertainty of the project benefits decreases the present value of the project (X) (e.g. Sarkar, 2000).

The effect of tenure (in) security on land conservation investments has been analyzed based on the traditional NPV principle in the prevailing literature (see e.g. Jacoby et al. 2002; Abdulai et al. 2011), we call this the present value effect (PVE). Following the canonical real option models by Dixit and Pindyck (1994)[2] and the link between the CAPM and the real option model by Wong

[2] More complex situations have been discussed in the literature on real option values, including investment and disinvestments (Dixit and Pindyck, 1994), the effects of different stochastic processes (Mbah et al., 2010), and numerical approaches (Trigeorgis, 1998). This paper focuses on the generic model as these model modifications do not change our basic argument.

(2007), we can get the optimal investment rule when farmers have the option to postpone investments:

$$F(X_0) = \max_{t^*} \mathrm{E}\{[X(t^*) - I]\mathrm{e}^{-(r_\mathrm{f}+\lambda\rho\sigma)t^*}\} \quad (2)$$

Solving Equation (2) according to the standard real option pricing approach provides the investment trigger X*:

$$X^* = \frac{b}{b-1}I, \text{ with} \quad (3)$$

$$b = \frac{1}{2} - \frac{\alpha-\lambda\rho\sigma}{\sigma^2} + \sqrt{\frac{1}{2} - \frac{\alpha-\lambda\rho\sigma}{\sigma^2} + \frac{2r_\mathrm{f}}{\sigma^2}} \quad (4)$$

Equations (3) and (4) give the threshold of a land conservation project, X^*, which depend on the irreversible cost (I), the market price of risk (λ), the risk-free rate of return (r_f), the correlation coefficient between the return of the project and the return on the opportunity cost – the market portfolio (ρ), the drift or growth rate (α), and the volatility (uncertainty) of the project benefits (σ). The relationship between σ and X^* can be can be either positive or negative (Weaver and Wesseler, 2004; Wong, 2007) as a change in uncertainty affects the value of the project X as well as the real option value of the project $F(X)$. This implies that a reduction in the uncertainty of project benefits, caused for example by improved tenure security, may decrease or increase the threshold of the land investment project depending on the combination of the effect on the value of the project and on the real option value. We hereby call the overall effect on the real option value the option value effect (OVE). Whether farmers undertake a land conservation investment project immediately after the land reforms depends on whether or not as a result the present value of the project (X) is larger than the (new) threshold (X^*).

Figure 1 shows that the overall investment incentives of China's market-oriented land tenure reforms hence depend on the combination of PVE and OVE. The upper part of the figure shows the impact of the market-oriented tenure reforms on tenure security and land transferability, as discussed in section 2.2. Improved tenure security and land transferability are both expected to reduce the uncertainty in investment project benefits, as argued in section 4.2. In its turn, a reduction in the uncertainty of investment project benefits affects the present value of a project (equation (1) in section 4.2) as well as the option value of the project (equations (3) and (4) in section 4.2). Both the PVE and the OVE raise the overall land conservation investment incentives (bottom of Figure 1).

4.3 Land Tenure Reforms and the Timing of Land Conservation Investments

The PVE and OVE of increased tenure security may affect the timing of undertaking land conservation investments. This section analyzes the optimal timing of land investments under different institutional settings, i.e. before and after the land tenure reforms and with/without functioning land markets.

As discussed above, land tenure was more insecure and land was formally not transferable before the land tenure reforms started. As a result, the uncertainty in reaping the benefits of land investment projects was relatively high (see Figure 2). In Figure 2 the horizontal measures the present value of the project (X), while the vertical axis measures the ROV ($F(X)$) and the net present value of the project (X-I), where I denotes the cost of the project. The line X - I intersects the horizontal axis at a 45° angle. Point I at the horizontal axis gives the threshold of undertaking the project in NPV analysis. The tangency point of the ROV curve $F(X)$ with the line X - I gives the critical value X^* of the project in ROV analysis. Figure 2 shows that the present value of the project (X^a) is much smaller than the threshold of undertaking the project (X^*), which implies that a rational farmer will not undertake the investment. Even when we ignore the real option value of undertaking

the project, and employ the traditional NPV approach, the investment is unlikely to take place because the present value of the project (X^a) is smaller than the investment cost (I). This explains why the literature based on the conventional NPV approach also points out weak and insecure land tenure discourages farmers' land conservation investments (Jacoby et al., 2002; Deininger and Jin, 2006). Applying the real option approach we obtain the real option value, shown in the graph as $F(X^a)$. In this case, the time value of the option is positive but small. The intrinsic value of the option, however, is zero as the option is "out of the money".

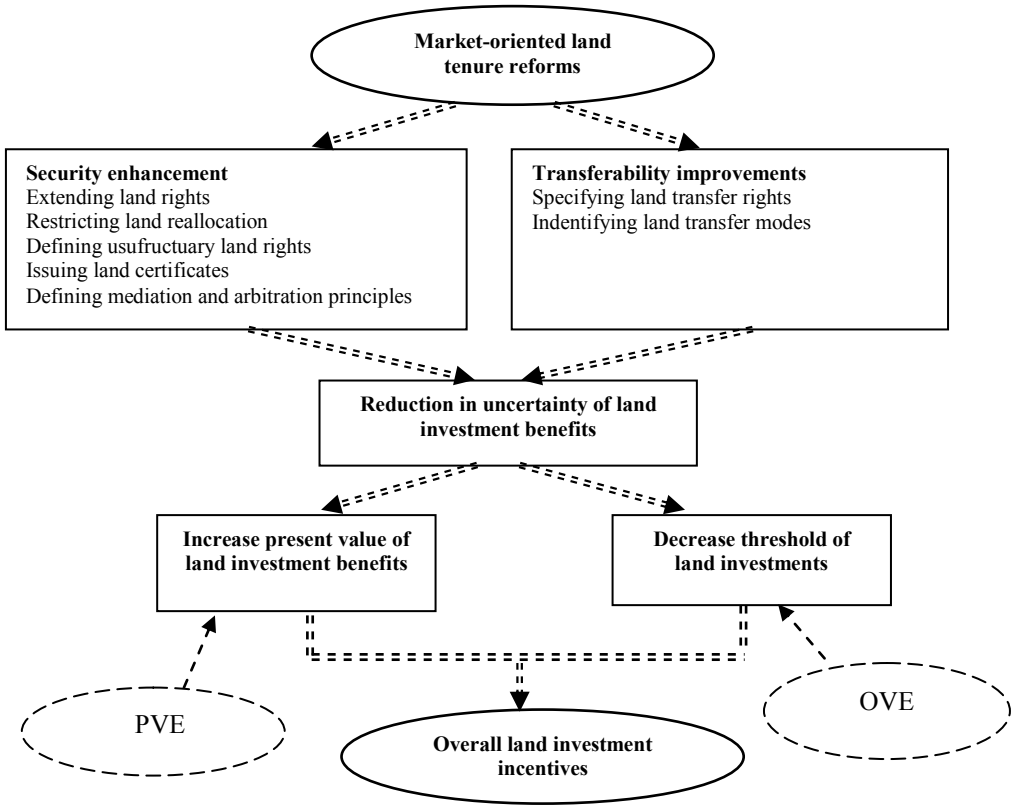

Figure 1. Impact of land tenure reforms on land conservation investments: a framework

As argued above, China's recent land tenure reforms significantly improve land tenure security and transferability, and thereby decrease the uncertainty of the benefits of investments in land. It is likely, however, that the magnitude of the reduction in uncertainty of benefits differs between different regions for at least two reasons. In the first place, the flexibility and ambiguity that is inherent to the land laws and land use regulations allow for a flexible interpretation and adaptation of the land laws by local actors (Piotrowski, 2009). For example, recent land laws restrict the use of land reallocations by village leaders, but land reallocations still do occur and their frequency shows large regional differences (Wang et al., 2011). Secondly, even when the interpretation and implementation of land laws and land use regulations is the same, the degree of uncertainty in the benefits that can be derived from land investments may differ if there exist differences in the presence of well-functioning land markets. In villages where land markets are absent, as still seems to be the case in large parts of rural China (Brandt et al., 2002), farmers are less certain that they can reap the full benefits of an investment.

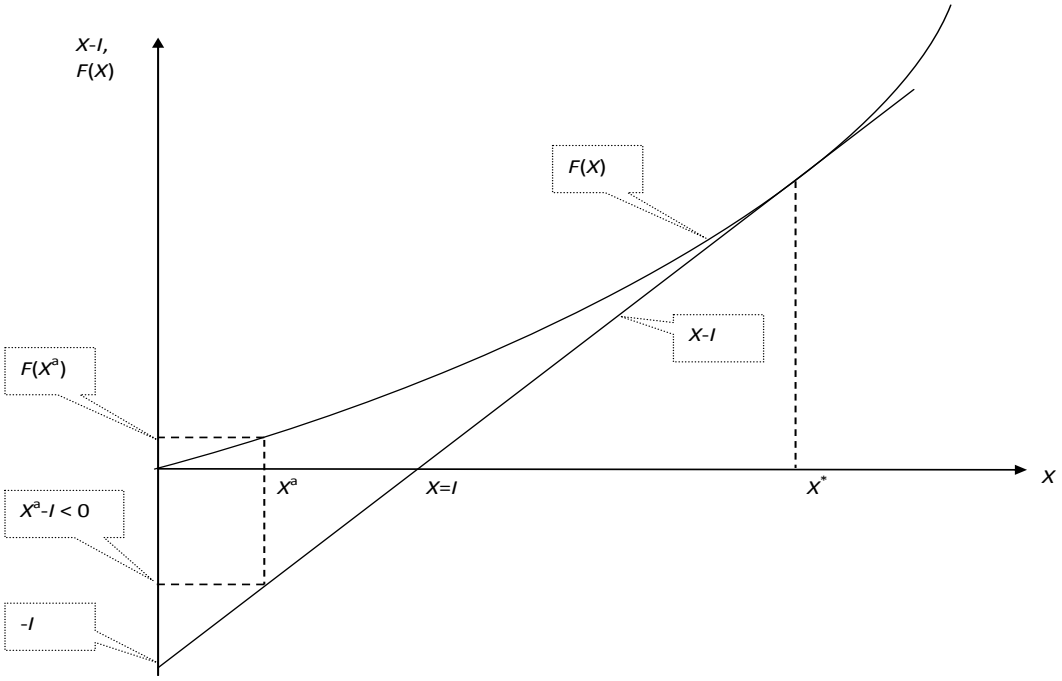

Figure 2. The value of land conservation investment under high uncertainty in ROV and NPV analysis

Figure 3 illustrates the impact of a reduction in uncertainty of project benefits. As a result of the lower degree of uncertainty, the reasonable assumption has been made the present value of a land conservation investment increases from X^a to X^b. This is the PVE specified in equation (1). But the curve of the real option value function of the project simultaneously shifts downwards from $F(X)$ to $G(X)$, and thereby decreases the threshold of undertaking the project from X^* to $X^{*'}$. This is the OVE specified in equations (3) and (4). If the traditional NPV approach is used, a profit maximizing farmer will undertake the project immediately because X^b-$I > 0$. However, in the example in Figure 3 the value of X^b is smaller than the value of the ROV threshold $X^{*'}$. In other words, a profit maximizing farmer is expected to require a higher value for immediate investment because he has the option to postpone the investment until some uncertainty has been eliminated.

It should also be noticed that the improvements in land tenure security and transferability provide an indirect economic benefit to investment projects that are not undertaken immediately, because the ROV has increased from $F(X^a)$ to $G(X^b)$. This increase can be considered as an economic benefit of the land tenure reforms. In general $G(X^b) > F(X^a)$, and hence the ROV increases, even though the real option value function $F(X)$ moves downwards to $G(X)$.[3]

The situation depicted in Figure 3 would change considerably if the reduction in uncertainty increases the value of the project such that $X^b > X^{*'}$. In that case the option to invest in land conservation is expected to be exercised immediately. In that case the PVE is sufficiently large to induce investment. This situation is more likely to occur in areas where well-functioning land transfer markets exist as they allow farmers who transfer their land to recapture a larger share of benefits of their land investments.

[3] A reduction in uncertainty will reduce the downward movement of the underlying stochastic process either in the form of changes in the probability distribution or in the form of reduced losses in case of bad outcomes, with a larger real option value $G(X^b) > F(X^a)$ as the overall effect (Shreve, 2004).

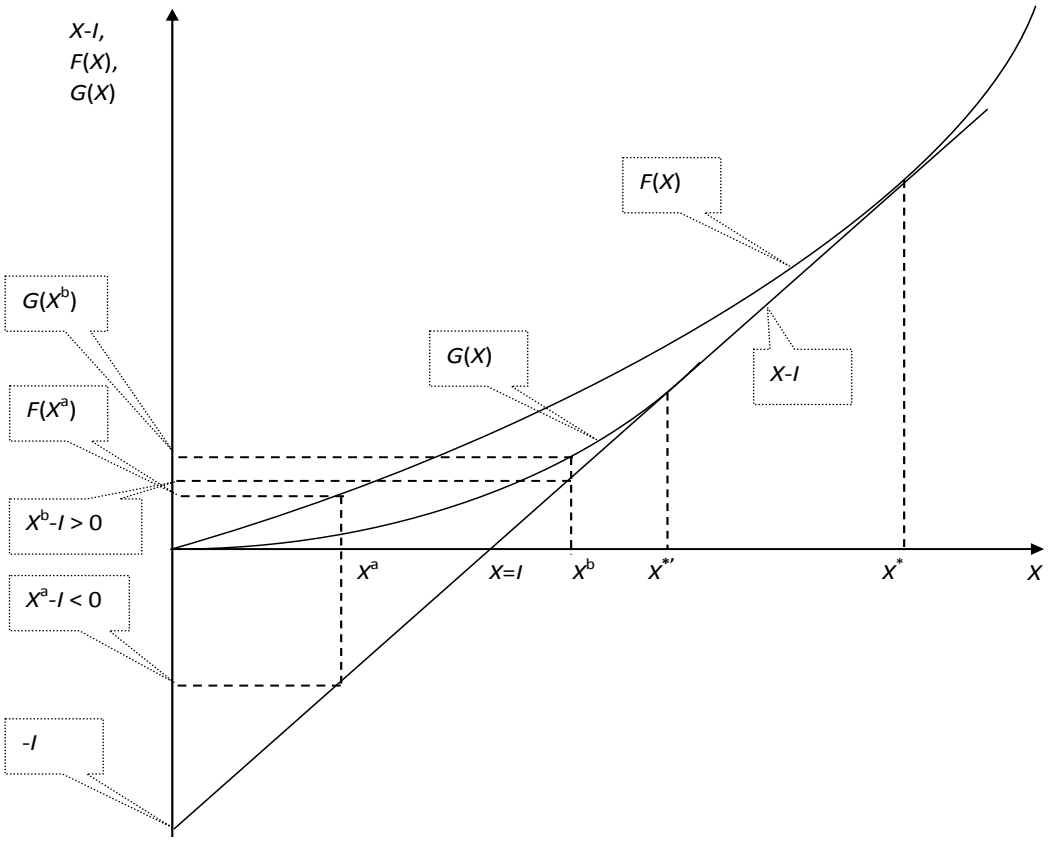

Figure 3. Changes in the real option value of land conservation investments induced by lower uncertainty in ROV and NPV analysis

5. Conclusion

The available literature on tenure security and land investments, in China and other parts of the world, focuses on the changes in net present value generated by improved security. This paper argues that land investments in China are characterized by cost irreversibility, uncertainty of benefits, and investment flexibility, and that changes in the real option value should therefore also be taken into account.

Using real option value theory, this paper shows that the market-oriented land tenure reforms which aim at improving land tenure security and land transferability in China have both a present value effect (PVE) and an option value effect (OVE) on land conservation investments. The PVE represents the conventional impact of tenure (in) security on the present value of a land investment project. The OVE represents the change in the real option value of a land investment project. The OVE of improved tenure security and land transferability is to decrease the threshold of undertaking the investment project. If the OVE is ignored, we may underestimate the impact of market-oriented land tenure reforms on land value, and also incorrectly predict the likelihood of farmers' undertaking investments in their land. In fact, by improving tenure security and land transferability, China's market-oriented land tenure reforms improve the long-term investment environment of land and eventually increase land value and famers' welfare, whether or not these land-related

investments are immediately observable. Therefore, further implementation of the market-oriented land tenure reforms in China is expected to enhance farmers' incentives for undertaking land conservation investments. Besides land-related laws and regulations, supplementary measures may be taken to improve household perceptions of tenure security, such as provision of information about the importance of land certificates for pursuing rights in land conflicts.

In addition, provided that the market-oriented land tenure reforms are implemented in a satisfactory way, the presence of well-functioning land transfer markets will be a crucial factor influencing the likelihood of making land conservation investments. A number of factors, such as the household registration system, insufficient off-farm employment opportunities, and lower level of trust among households, currently prohibit the development of land transfer markets in some parts of China and other developing countries (Zhang et al., 2004; Holden and Ghebru, 2005; Feng, 2006; Whalley and Zhang, 2007). The absence of well-functioning land markets reduces the possibilities to retrieve the benefits of an investment in land quality, and thereby decreases the positive impact of the land tenure reforms on land conservation investments. Market-oriented land tenure reforms therefore need to be accompanied by measures to remove existing barriers in the rural land transfer market in order to fully realize their potential impact on land conservation investments. Measures that may be considered in this respect include provision of sufficient and stable off-farm employment jobs, reduction in discrimination on urban and rural residents associated with the household registration system, and enhancement of trust among households in China.

This analysis has two important implications for future research. Firstly, it shows that market-oriented land tenure reforms provide economic benefits to farm households either by stimulating investments in the quality of their land (visible direct benefit) or by improving the long-term investment environment of their land (invisible indirect benefit in the form of real option value). We suggest that future research in this field collects panel data at the household level that allows to estimate the invisible indirect benefit of policy reforms using real option model approaches (see e.g. Carey and Zilberman, 2002; Rahim et al., 2007; Wesseler et al., 2007; Towe et al., 2008; Wesseler, 2009). Secondly, this analysis shows that the presence of well-functioning land markets is crucial for realizing the full potential impact of market-oriented land tenure reforms on investment incentives. Future research in this field may therefore take prevailing land market conditions into account when analyzing changes in investment incentives caused by land tenure reforms, and test whether reform-induced changes in investment incentives differ significantly between areas with well-functioning land markets and areas with thin or absent land markets.

References

[1] Abdulai, A., V. Owusu and R. Goetz (2011), "Land tenure differences and investment in land improvement measures: Theoretical and empirical analyses", *Journal of Development Economics*, 96(1): 66-78.

[2] Banerjee, A. V. and M. Ghatak (2004), "Eviction threats and investment incentives", *Journal of Development Economics*, 74(2): 469-488.

[3] Besley, T. (1995), *Property Rights and Investment Incentives: Theory and Evidence from Ghana*, Journal of Political Economy, 103(5): 903-937.

[4] Brandt, L., S. Rozelle and M. A. Turner (2002), "Local Goverment Behavior and Property Rights Formation in Rural China", Working Papers 11988, University of California, Davis, Department of Agricultural and Resource Economics.

[5] Carey, J. M. and D. Zilberman (2002), "A model of investment under uncertainty: Modern irrigation technology and emerging markets in water", *American Journal of Agricultural Economics*, 84(1): 171-183.

[6] Chen, F. and J. Davis (1998), *Land Reform in Rural China Since the Mid-1980s*. Rome, FAO.

[7] Deininger, K. and S. Jin (2006), "Tenure security and land-related investment: Evidence from Ethiopia", *European Economic Review*, 50(5): 1245-1277.

[8] Deininger, K. and S. Jin (2009), "Securing property rights in transition: Lessons from implementation of China's rural land contracting law", *Journal of Economic Behavior & Organization*, 70(1): 22-38.

[9] Development, W. C. o. E. a. (1987), *Our Common Future*. Oxford: Oxford University Press.

[10] Dixit, A. K. and R. S. Pindyck (1994), *Investment Under Uncertainty*, Princeton: Princeton University Press.

[11] Feder, G. and D. Feeny (1991), "Land tenure and property rights: Theory and implications for development policy", *The World Bank Economic Review*, 5(1): 135-153.

[12] Feng, S. (2006), *Land Rental Market and Off-farm Employment-rural Households in Jiangxi Province, P.R.China*, Wageningen University. Ph.D. Dissertation.

[13] Hill, R. V. (2010), "Investment and abandonment behavior of rural households: an empirical investigation", *American Journal of Agricultural Economics*, 92(4): 1065-1086.

[14] Hinrichs, J., O. Musshoff and M. Odening (2008), "Economic hysteresis in hog production", *Applied Economics*, 40(3): 333-340.

[15] Ho, P. (2005), *Institutions in transition: land ownership, property rights, and social conflict in China*, Oxford University Press.

[16] Holden, S. and H. Ghebru (2005), "Kinship, transaction costs and land rental market participation", Discussion paper, Department of Economics and Management, Norwegian University of Life Sciences, [On-line]Avaliable at ttp://www.umb.no/statisk/dreprojects/data/discussion_paper_files/kinship_and_land_rental_market_participation3.pdf.

[17] Holden, S. and H. Yohannes (2002), "Land redistribution, tenure insecurity, and intensity of production: A study of farm households in Southern Ethiopia", *Land Economics*, 78(4): 573.

[18] Jacoby, H. G., G. Li and S. Rozelle (2002), "Hazards of expropriation: Tenure insecurity and investment in rural China", *American Economic Review*, 92(5): 1420-1447.

[19] Kabubo-Mariara, J., V. Linderhof, G. Kruseman, R. Atieno and G. Mwabu (2007), "Household welfare, investment in soil and water conservation and tenure security: Evidence from Kenya", Working Paper, No. 06-6, Poverty Education and Environmental Management .

[20] Kassie, M., M. Jaleta, B. A. Shiferaw, F. Mmbando and M. Mekuria (2012), Interdependence in Farmer Technology Adoption Decisions in Smallholder Systems: Joint Estimation of Investments in Sustainable Agricultural Practices in Rural Tanzania. 2012 Annual Meeting, August 12-14, 2012, Seattle, Washington, Agricultural and Applied Economics Association.

[21] Kung, J. K.-s. (2000), "Common Property Rights and Land Reallocation in Rural China: Evidence from a Village Survey", *World Development*, 28(4): 701-719.

[22] Lin, J. Y. (1992), "Rural reforms and agricultural growth in China", *The American Economic Review*, 82(1): 34-51.

[23] Lohmar, B. (2003), *Land Tenure Policy and Farm Household Labor Allocation in China*, University of California at Davis, Ph.D. Dissertation.

[24] Maart-Noelck, S. C. and O. Musshoff (2013), "Investing today or tomorrow? An experimental approach to farmers' decision behaviour", *Journal of Agricultural Economics*, 64(2): 295-318.

[25] Mbah, M. L. N., G. A. Forster, J. H. Wesseler and C. A. Gilligan (2010), "Economically optimal timing for crop disease control under uncertainty: an options approach", *Journal of the Royal Society Interface*, 7(51): 1421-1428.

[26] McDonald, R. L. and D. Siegel (1986), "The value of waiting to invest", *Quarterly Journal of Economics*, 101(4): 707–727.

[27] McMillan, J., J. Whalley and L. Zhu (1989), "The impact of China's economic reforms on agricultural productivity growth", *Journal of Political Economy*, 97(4): 781–807.

[28] Piotrowski, S. (2009), *Land property rights and natural resource use: An analysis of household behavior in rural China*, Peter Lang GmbH.

[29] Qu, F., N. Heerink and W. Wang (1995), "Land administration reform in China: Its impact on land allocation and economic development", *Land Use Policy*, 12(3): 193-203.

[30] Rahim, A., E. Ierland and J. Wesseler (2007), "Economic incentives for entry and exit in gum arabic agroforestry system in Sudan", *Forest Policy and Economics*, 10(1): 36-47.

[31] Sarkar, S. (2000), "On the investment–uncertainty relationship in a real options model", *Journal of Economic Dynamics and Control*, 24(2): 219-225.

[32] Shreve, S. E. (2004), *Stochastic Calculus for Finance II: Continuous-Time Models*. New York: Springer Press.

[33] Tan, R., F. Qu, N. Heerink and E. Mettepenningen (2011), "Rural to urban land conversion in China—How large is the over-conversion and what are its welfare implications?" *China Economic Review*, 22(4): 474-484.

[34] Tan, S. (2006), *Fragmentation and Rice Production: A Case Study of Small Farms in Jiangxi Province, P.R. China*. The Netherlands, Wageningen University, Ph.D. Disertation.

[35] Towe, C. A., C. J. Nickerson and N. Bockstael (2008), "An empirical examination of the timing of land conversions in the presence of farmland preservation programs", *American Journal of Agricultural Economics*, 90(3): 613-626.

[36] Trigeorgis, L. (1998), *Real Options*, Cambridge: MIT-Press.

[37] Vendryes, T. (2010), "Land Rights in Rural China since 1978: Reforms, Successes, and Shortcomings", *China Perpectives*, [On-line] Available at http://chinaperspectives.revues.org/5345.

[38] Wang, H., J. Tong, F. Su, G. Wei and R. Tao (2011), "To reallocate or not: Reconsidering the dilemma in China's agricultural land tenure policy", *Land Use Policy*, 28(4): 805-814.

[39] Weaver, R. D. and J. Wesseler (2004), "Monopolistic pricing power for transgenic crops when technology adopters face irreversible benefits and costs", *Applied Economics Letters*, 11(15): 969-973.

[40] Wesseler, J. (2009), "The santaniello theorem of irreversible benefits", *AgBioForum*, 12(1): 8-13.

[41] Wesseler, J., S. Scatasta and E. Nillesen (2007), "The maximum incremental social tolerable irreversible costs (MISTICs) and other benefits and costs of introducing transgenic maize in the EU-15", *Pedobiologia*, 51(3): 261-269.

[42] Whalley, J. and S. Zhang (2007), "A numerical simulation analysis of (Hukou) labour mobility restrictions in China", *Journal of Development Economics*, 83(2): 392-410.

[43] Wong, K. P. (2007), "The effect of uncertainty on investment timing in a real options model", *Journal of Economic Dynamics & Control*, 31(7): 2152-2167.

[44] Zhang, Q. F., M. Qingguo and X. Xu (2004), "Development of land rental markets in rural Zhejiang: Growth of off-farm jobs and institution building", *The China Quarterly*, 180(1): 1050-1072.