INTERNATIONAL CONFERENCE OF AGRICULTURAL ECONOMISTS
ICAE
29th | Milan Italy 2015
UNIVERSITÀ DEGLI STUDI DI MILANO AUGUST 8 - 14
AGRICULTURE IN AN INTERCONNECTED WORLD

The effects of variability under farm land consolidation process: A perspective of cotton-growing farmers in Uzbekistan

Utkur Djanibekov[1] and Robert Finger[2]

[1]*Production Economics Group, Institute for Food and Resource Economics, University of Bonn, Meckenheimer Allee 174, 53115, Bonn, Germany. Email: u.djanibekov@ilr.uni-bonn.de*

[2]*Production Economics Group, Institute for Food and Resource Economics, University of Bonn, Meckenheimer Allee 174, 53115, Bonn, Germany. Email: r.finger@ilr.uni-bonn.de*

Abstract

In Uzbekistan cotton production substantially contributes to GDP. The cotton is produced based on the cotton procurement policy, according to which farmers have to allocate half of their land for cotton and produce certain amount of cotton. However, cotton yields are uncertain. Lower than expected cotton production by farms can be considered as inefficient farm. Because farmers lease land from the state, failure to deliver the cotton output lead to adjustment in its scale of operations – a process called farm optimization. Reduction in farm size of one farmer leads that the area of more efficient farmer that accomplished the cotton production increases. The study aims to develop policies that can improve cotton production and farm incomes. For this we developed a dynamic recursive model that considers variability and farm adjustments. We showed that variability influences farm sizes and due to farm size changes the income inequality may widen among farms.

IAAE

1. Introduction

State policies in agriculture are aimed to improve farm production and incomes (Anderson, 2007), which are usually accompanied with changes in the structure of agriculture (e.g., farm size) (Happe et al., 2011). Such state policies can be in the form of intervention. For example, in the post-Soviet countries the transition from a planned to a market economy is motivated by economic and political objectives. Since the independence of these countries in 1991 various reforms have been implemented to shift towards the market economy in agricultural production. However, in some countries the functioning of agricultural policies has remained similar as it was during the Soviet Union. For example, cotton production in Uzbekistan. Presently, the cotton production is of high importance in Uzbekistan and contributes about 13% to GDP through the foreign currency earnings (Rudenko et al., 2009). In the early years of independence, in contrast to many other former Soviet Union countries, Uzbekistan performed well in terms of aggregate output due to its cotton export revenues (Rosenberg et al., 1999). The main policy incentivizing the cotton production is the cotton procurement policy (also called cotton policy). The cotton is produced by farmers based on this policy. According to the cotton procurement policy, farmers have to fulfill several requirements to achieve the predetermined cotton output targets set by the state. This comprises, for example, the obligation for farmers to allocate half of their arable land to cotton cultivation (area-based target), and have to produce a certain cotton output (quantity-based target) (Djanibekov et al., 2010). The entire raw cotton harvest is purchased by the state and its price level is determined by the state.

In addition to agricultural policies, the institutions, infrastructure and farming practices are designed to facilitate high cotton output (Djanibekov et al., 2010). For instance, since independence in Uzbekistan have been implemented several farm restructurization processes (Lerman, 2008). The most recent farm restructuring process is the government program that is called the farm optimization/land consolidation that started in 2008 and is considering the farm size adjustments (Djanibekov et al., 2012a). The farm adjustments occur to optimize the agricultural production. During this process the area of inefficient farm is reduced and is given in favor for increasing the area of more efficient farms, which may result in economic gains and losses for farmers. Considering that the cotton production is the core of Uzbekistan’s agriculture and thus the primary policy interest, it can be inferred that the land consolidation process was mainly targeted for improving cotton output. The farm failing to deliver the cotton output is considered inefficient and these may lead to adjustment in farm scale. The magnitude of such changes can be substantial with some farmers driven out of the sector. While other farmers that meet cotton output target can be considered as efficient, and they receive additional opportunities by increase in land area and may further prosper. The farm size changes would be as a result of heterogeneity among farmers that can include diversity in terms of farm size, specialization, and resource endowments. Changes in agricultural policies can lead to the structural change of farms, where some farms may benefit whereas others may lose (e.g. Happe et al., 2008). Still, the assumed benefitting farmer that could increase farm size may have insufficient resources to manage the land, or such adjustments may increase his/her costs of operation (i.e., scale inefficient). Accordingly, in the situation of farm size changes it is important to consider resources available for agricultural production.

At the same time, the cotton production target is made prior sowing the cotton. However, uncertainties in farming activities cause problems on agricultural output and farm incomes (Bobojonov and Aw-Hassan, 2014) and effects would be different depending on the specific farm. For example, in the case of Germany, Troost and Berger (2015) showed that the uncertainty in climate would bring different incomes depending on the heterogeneity of farms. In our case, cotton production below performance goals can occur due to residual natural variability of cotton output, even though farmers may have adopted optimal management practices. The possibility that cotton yields will be lower than expected ones will necessitate changing farm structure by reducing the area of farmer that fails to deliver the predetermined cotton amount. To manage the risks of low cotton output the necessary management strategies needs to be developed. Djanibekov and Khamzina (in press) revealed that flexibility in cotton policy by removing the area-based policy and diversifying farming with new cropping practices would reduce the effects of risks.

To our knowledge few studies have addressed change in farm structure under situations of variability, caused by combinations of production and institutional risks, especially in the developing country settings. We aim to fill this gap by addressing uncertainties that affect cotton production and farm livelihoods in Uzbekistan. More specifically, we analyze different options to modify cotton policy and revealed opportunities for improving cotton production and farm incomes. Hence, the objective of this study is to: (1) analyze the effects of change in land possession due to the cotton policy, i.e., failure to deliver to the state the cotton output of one farmer leads to its land area reduction and the transfer of this land to another farmer, on farm incomes under revenue variability; and (2) identify policies that lead to the improvement of cotton production and increase in farm incomes. To this end, we develop a framework combining heterogeneous agents depicted with farm-level models which are combined via land-transfer mechanisms. This modeling framework allows addressing the land size adjustments to institutional, market and production risks and dynamics in farm interactions.

2. Methods

2.1. Study area

The case study area is the Khorezm region and southern districts of the Autonomous Republic of Karakalpakstan, namely Beruniy, Turtkul and Ellikkala, located in the lowlands of the Amu Darya River, Uzbekistan. Irrigated agriculture accounts for about 35% of region's GDP. Cotton and winter wheat (hereafter referred to as wheat) are the major crops cultivated, and are also subject to a state procurement policy. To fulfill the cotton policy, farmers allocate 50% of the farmland for cotton cultivation, fulfill cotton output (i.e., 2.4 t/ha) and sell the entire cotton harvest to the state at the state determined prices. Half of the wheat output is purchased by the state (below the local market price), while the remainder can be traded in local markets (Djanibekov et al. 2012b). Farmers receive indirect subsidies from the state for cotton and wheat production, although subsidies are allocated to the agricultural sector rather than to farmers (Djanibekov et al., 2010). Crops such as rice and vegetables are vital to farmers for income generation and food diets, while maize is used as livestock feed. Rice or maize is usually cultivated on the fields following the wheat harvest. The main agricultural producers are farmers (about 89% of arable land), followed by small-scale semi-subsistence rural households (about 10% of arable land) and state and collective farms (about 1% of arable land). The main farm types are cotton-grain farms that occupy about 80% of arable land that is in possession of farms.

Since 1991 the *kolkhoz* and *sovkhoz* lands were distributed among private farms and the number of farms has been increasing. However, since 2008 the numbers of farms started to reduce significantly (e.g., in Figure 1 is shown the change in farm numbers and size between

1997 and 2010 in Uzbekistan). This development also holds for our study area where in 2012 the number of farms was almost one fifth than in 2008. The decrease of farm numbers led to an increase in the size of other farms, so released land resources were re-allocated. The reduction in farm numbers is mainly observed in relatively smaller in size farms (i.e., with area of up to 40 ha), while larger farms have experienced the increase in their land area. This decrease in farm numbers was triggered by the state's farm optimization policy (i.e., land consolidation process) that is aimed to increase agricultural productivity by reducing the area of inefficient farms while increasing the land area of efficient farms (Djanibekov et al., 2012a). In particular cotton-grain growing farms experienced increases in their farm size. Although, over the last years the number and size of farms has not changed substantially the farms may be subject to land consolidation again if fail to meet the required amount of cotton output.

In the study area, agricultural production is subject to various risks (Bobojonov and Aw-Hassan, 2014; Djanibekov and Khamzina, (in press)). For instance, yields are uncertain as a result of irrigation water variability, crop diseases and unfavorable weather conditions. Due to inherently low suitability for farming or degradation about 20–30% of arable lands are marginal (Dubovyk et al., 2013). Over the last decades irrigation supplies varied substantially and affected crop yields. Farmers are also facing price fluctuations, except the state procurement prices for cotton and half of wheat yields. Such uncertainties may lead that farms fail to produce sufficient amount of cotton to meet the state cotton procurement policy. Subsequently, it can be assumed that the area of farms failing to meet the cotton output may reduce, and as a result the area of those farms that are meeting targeted cotton production level is increasing. It was observed that the size of larger farms is not reducing during the land consolidation process. This might indicate that changes in farm sizes can be also influenced by other factors (e.g., networks). Furthermore, this might be caused by the fact that the variability of crop yields at larger farms is lower because a wider spatial allocation of production sites implies on-farm hedging effects where there is a non-perfect correlation of yield levels at individual fields. Thus, a larger area under of cotton is expected to imply lower yield variability at the farm-level (e.g., see Finger, 2012; Marra and Schurle, 1994)

<insert Figure 1 here>

2.2.The model

We developed and applied a model that includes heterogeneous farms to address the issues such as cotton policy, change in farm size (i.e., both decrease and increase in farmland), land use and farm income under conditions of revenue uncertainty. The land uses include cotton, wheat, rice, maize and vegetables. Each of these crops has main products (i.e., cotton, wheat and rice grain, and vegetables) and by-products except for vegetables (i.e., cotton stem, wheat and rice straw). Crop by-products are included as the ratio of crop main products. The risks in the model are related to production, market and institution. The production risk includes variability in yields of crop main products (hereafter crop yields) and irrigation water supply that were generated using the multivariate normal distribution. It was assumed that the distribution of simulated parameters on crop yields and irrigation water was not influenced by the model outcome in one period, and hence we have the same probability distribution every year. However, our approach accounts for interdependencies across random variables, i.e., yield-irrigation correlations. Market risk includes price variability of crop main products that was generated using the geometric Brownian motion that has independent increments and the change in the process in any period is normally distributed with a variance that increases with time (see Dixit and Pindyck, 1994). As the cotton price is set by the state it was assumed to be deterministic. Institutional risk may occur to farmers due to their failure to fulfil the cotton production amount set by the state and their land is taken away and transferred to another farm.

The model was programmed in GAMS[1]. In the model we assumed that farmers face the problem of selecting which crops to cultivate to achieve the highest annual present values from farm under revenue uncertainty. We selected the recursive programming model to address dynamics in farm planning to maximize incomes of farms under different states of nature in each period of analysis. The recursive programming model allows considering farmers' decisions for each year. Farmers' objective is to maximize present values over years from farming subject to different constraints under uncertainty and land size adjustments. The following is the objective function of the model:

[1] http://www.gams.com/

$$Max\ Obj = \sum_{t=1}^{T}\sum_{f=1}^{F}\sum_{s=1}^{S}\sum_{j=1}^{J}\sum_{l=1}^{L}\frac{\bar{p}_{jst}\bar{y}_{jslt}X_{jslft} - c_{jt}X_{jslft}}{(1+d)^{t}} \quad (1)$$

where Obj is the objective value of the model, index t is the period of analysis (1, 2, …, T) with T was assumed to be equal to 10 years, f is the number of farms with F being equal to farms 3 farm types (i.e., A, B, C), s is the states of nature, j is the annual crop types that can be cultivated, l is the soil productivity levels (i.e., marginal, average, good and high) that are constant over years, is the $\bar{p}$ is the varying crop output prices, $\bar{y}$ is the varying crop yields, X is the area allocated to certain crops by each farm under different states of nature where crop cultivation follows the seasonal calendar, c is the input costs of crop cultivation which is assumed to be deterministic, d is the discount rate which in our study was assumed to be 5, 10 and 14%, which are values close to the ones observed in other studies in the region (e.g., see Djanibekov et al. 2012b). For the simplicity of results interpretation we present the output with 10% discount rate.

The farm land area is the constraint that restricts farmers' crop cultivation activities and changes every year depending on fulfillment of cotton procurement policy. For the first year of analysis we considered the initial state of farm sizes based on our observations (Equation 2). In subsequent periods the size of each farm can be adjusted as a result of cotton procurement policy (Equation 3).

$$a_{lft} \geq \sum_{j} X_{jslft} \qquad \text{where } t \text{ includes year one} \quad (2)$$

$$\bar{A}_{slft} \geq \sum_{j} X_{jslft} \qquad \text{where } t \text{ includes years after land size adjustment} \quad (3)$$

where a is the initial land size of farms, $\bar{A}$ is the possible size of farms under different states of nature after the land consolidation process.

The area of farms is determined every year through the fulfillment of cotton procurement policy. In this policy we assumed that farms have to allocate 50% of their land for cotton cultivation according to the area-based target (Equation 4). In addition, according to the quantity-based production target of cotton policy farms have to produce 2.4 t/ha on 50% of land allocated for cotton. However, cotton yields are uncertain, which may lead that farms fail to produce the required amount of cotton. In such case, we assumed that the reduction in farm area occur when the cotton output is lower than the expected cotton yields multiplied by the half of the farmland (i.e., 2.4 t ha^{-1} from half of farmland). Farms that did not produce the required cotton amount are inefficient and their area is reduced (Equation 5) and transferred to farm that is efficient and complied with the state policy. Produced cotton output affects the farm size in the next year. The following are equations for cotton area constraint (Equation 4), the area of farmland reduced (Equation 5) and the size of farm after the land transfer (Equation 6):

$$0.5\,\bar{A}_{slft} = \sum_{l} X_{jslft} \qquad \text{where } j \text{ includes cotton} \tag{4}$$

$$\frac{0.5\,\acute{y}_{jt}\,\bar{A}_{slft} - \sum_l \bar{y}_{jslt}\,X_{jslft}}{\frac{0.5}{\acute{y}_{jt}}} = R_{lsft} \qquad \text{where } j \text{ includes cotton} \tag{5}$$

$$\bar{A}_{slft} = \bar{A}_{slft-1} \pm R_{slft-1} \tag{6}$$

where $\bar{A}$ includes the size of farms in the initial (i.e., a) and subsequent years, $\acute{y}$ is the cotton yield required (i.e., 2.4 t/ha) from each farm, and R is the area of farm that is reduced as a result of lower than planned cotton output. R variable in Equation 6 can be subtracted from farms that lose land or added to the area of farms that are efficient and have increase in their size. In case only one of the farms has not produced required amount of cotton, part of his/her land is transferred to the farmer that produced the largest amount of cotton. In case when all modelled three farms do not produce the target level of cotton output their land is reduced and considered as residual farm land area.

Besides the cotton area constraint, we included in our model constraint on irrigation water availability. The irrigation water supply level to farmers is determined by the state, and depends on many conditions, especially climate and most importantly water use in upstream countries (i.e., Tajikistan). Hence irrigation water available for crop cultivation is varying and accordingly farmers adjust their land use activities. Irrigation available amount is homogeneously distributed per hectare for each farm. With respect to this constraint, farms allocate arable lands with crops at respective irrigation rates that should not exceed the variable irrigation water supply to the farms:

$$\sum_{l} k_j X_{jslft} \leq \sum_{l} w_s \overline{A}_{slft} \tag{7}$$

where k is irrigation rates for crops, and w is the varying irrigation water availability.

Another constraint is related to the machinery available at farm for crop management. To manage crops farms have to use machinery and for addressing this we considered that each crop has diesel requirement and assumed that each farm has certain amounts of machinery available (in diesel values):

$$\sum_{l} i_j X_{jslft} \leq m_f \tag{8}$$

where i is the diesel required for crops. We assumed that farms cannot purchase additional machinery and hence machinery (expressed in diesel values) available at farm is the constant amount over the period of analysis.

2.3.Heterogeneous farms

In our study we considered three types of cotton-grain farms (i.e., farms A, B and C), which differ in their size, soil productivity level (i.e., marginal, average, good, and high productive lands), machinery available at farm and variability of crop yields (Table 1). We assumed that farm C has advantage over farms A and B as it has larger land area, share of area of more productive soils, more machinery available and less varying crop yields. The yield variability and correlation was assumed to be lower by twice than of farm C the larger is farm size, i.e., farm C has lowest yield variability and correlation. The smallest farm type is farm A which is also the most disadvantaged farm in land area, productivity level, machinery available and higher varying crop yields. Heterogeneous farms are interlinked to each other through the land transfer arrangements initiated by the farm optimization process. This process implies that the land of farms that are inefficient in terms of cotton output amount is taken away and given to efficient farms. The change in farm size mainly occurs due to the different resource endowments of farms and variabilities simulated in the model. In addition to resource endowments, each individual farm is subject to policies that set the boundaries of crop production activities.

<insert Table 1 here>

2.4. Scenario settings

We assumed scenarios that modify cotton procurement policy and improve cotton output to observe the changes in farm sizes and incomes. In all scenarios, it was assumed that the entire cotton output is sold to the state at the state determined price (i.e., 227 USD/t). To evaluate effects of various cotton production options we simulated the following four scenarios in the model:

(1) A business-as-usual (BAU) scenario, in which farms has to follow the current cotton setting (i.e., quantity- and area-based targets) where they allocate half of their land for cotton and produce certain amount of cotton (i.e., 2.4 t/ha from land allocated for cotton). According to the cotton production amount the farm area is determined.

(2) Flexible area-based target scenario (Flexible) assumes a slight modification of the first scenario: the area-based target of cotton cultivation is abolished and farmers are flexible in deciding how much area to allocate for cotton cultivation. However, farms still have to meet the quantity-based production target of cotton policy. Accordingly, the area in possession of farms is determined based on the cotton output.

(3) Secure tenure rights scenario (Tenure), which reflects that farmers still have to allocate a specified area of their land for cotton (area-based target) and produce a certain level of cotton (quantity-based target). However, land possession of farmers is fixed and does not change depending on crop output. Thus, the area of farms is constant over years.

(4) Innovative cotton growing technologies scenario (Innovation) assumes a situation where farmers start to grow cotton using the conservation agriculture approach such as permanent bed with residue (i.e., crop by-product) retention and reduced tillage practice. Currently, such cotton cultivation practice is not implemented by farmers. We assumed

that cultivation of cotton with permanent bed practice leads to higher cotton yields (20% higher) and lower diesel requirements (75% lower) than in other scenarios. When growing cotton under the permanent bed practice the crop by-products are remained on the field and not included in gross margin calculations of cotton. In this scenario, farmers have to follow both area- and quantity-based targets of cotton policy, and their land is adjusted according to the fulfillment of cotton output.

2.5. Data sources

160 farms were surveyed in the study area during June 2010 and March 2011 to obtain information on their cropping pattern, crop input and output prices, and crop production technologies. Information on farm sizes was obtained from the official statistical departments (State Statistical Committee of Uzbekistan, 2010). Prices of commodities were also monitored through weekly market surveys and obtained from the statistical committees. In addition, to address variability information on crop output prices and yields and irrigation water availability were collected from official statistical departments (State Statistical Committee of Uzbekistan 2010; MAWR 2010). Yields of crops were estimated based on water-yield response functions using official irrigation rate recommendations for four classes of land productivity, i.e., marginal, average, good, and high (MAWR 2001; Land Resources 2002). In these norms, yield of rice changes with respect to irrigation level and is the same for all land productivity classes. For detailed information on input and output prices, and crop yield functions see Djanibekov et al. (2012b) and Djanibekov and Khamzina (in press).

3. Results

3.1. Farm size and cotton production

The model results show that the all three farm types experience change in their size. The main productivity land use that was taken away from farms and transferred to another farms are marginal (not shown here). On this type of lands the cotton output is low and insufficient to meet the target amount of cotton procurement. After marginal lands the average productive lands were mainly subject to the land transfer. When taking into the account the average values of farm size changes, farm C, which is the largest farm and has advantages in resources and lower yield variability in contrast to other farms, experiences the slight increase in its size in the BAU scenario (Figure 2a). Farms A and B in average terms experienced reduction in their size. This would be caused be their possession of large areas of low productive lands and high uncertainty in farm revenues. When all modelled farms are not able to meet the production target, the land is assumed to be transferred to other farmers or agricultural producers (e.g., rural households and/or state and collective farms) is expressed as 'Residue'. In the secure land tenure scenario, the area of farms was assumed not to change. The meager farm size change is in the Innovation scenario where the small plots of land are reallocated from farm A to C. In contrast, the Flexible scenario leads to drastic changes in farm sizes (Figure 2b). This policy option brings the substantial share for other agricultural producers that are not considered in this study. This is due to the fact that under yield uncertainty and when the area for cotton is not fixed, farmers are more likely not to be able to predict and produce the sufficient amounts of cotton to meet the state cotton production target. Also, in such case it might be that to maximize incomes farmers utilize well productive lands and omit cultivating the low productive lands.

When considering the variability, the most cases where the area of farm size is reduced is in the Flexible scenario, followed by the BAU. The least case with the land reduction is in the Innovation scenario, when cultivating cotton under permanent bed practice brings higher cotton yields than conventional practices (Figure 2c). When growing cotton using the permanent bed practice only the size of farm C increased but not substantially. In this scenario, there are some cases when farms A and B were not able to fulfill the cotton production target and the reductions in their area are lower than in other scenarios and only small parcels of land are distributed to farm C, i.e., no residual land. In many states all farms managed to produce the targeted amount of cotton. Thus, introducing new technologies that can increase cotton yields leads that even the less resource endowed farms might be able to meet the state procurement policy. The model also shows that in BAU and Flexible scenarios the area of all modelled farms might increase, except in Innovation scenario the land size augments solely in farm C (e.g., see the 'Max line'). The effects of variability with both largest farm increase and decrease are prevailed for farm C.

<insert Figure 2 here>

The change in land use is triggered by cotton production amount. In BAU scenario, in average values cotton production values, farm C increases the cotton output as a result of increase in its land area (Table 2). In contrast, farms A and B are not able to meet the cotton target level due to high variability of yields from their fields and more area of low productive lands. Introducing new cotton cultivation practice such as permanent bed retention leads to highest cotton production and shows that in average the farms B and C are able to meet the cotton targets and farm A only is not able to produce small amount of cotton in comparison to other scenarios. Accounting for flexibility in land use decision making of farmers (i.e., Flexible scenario) substantially reduced farmers' resource allocation to cotton production. In terms of farm production variability, implementing conservation agriculture practice leads not only to higher mean output but also to higher variability. This is due to the fact that along the increase of cotton yields by 20% their standard deviations also increase.

<insert Table 2 here>

3.2. Land use

The farm size adjustments changed the land use of farmers over years. When analzying separately each farm then the land use is declining slightly for farms A and B, whereas increasing for farm C. In Figure 3 is given land use share of combined three farms. The land use share of cotton is slightly declining as a result of increase in wheat cultivation that is rotated with rice and maize. In the initial years vegetables occupy substantial farmland, and over time its area is reduced by more than two fold. In the model, farmers reduce the area of vegetables in favor of increase of wheat, rice and maize cultivation. Such land use change is the result of farm size changes and price fluctuations. In all four scenarios the trend in land use share is similar. The substantial difference among scenarios in the area cultivated is observed in the Flexible scenario, where the farm areas are mostly reduced (not shown here). In addition, in this scenario it is also observed the highest variability in crop cultivation which is due to the high variability in farm size changes.

<insert Figure 3 here>

3.3.Farm incomes

The livelihoods of farmers differ as a result of farm size change. The increase of farm area leads to increase in net present value of such farm (Table 3). However, this trend would reduce the profits of farms that are giving away the land. For example, our model showed that under the BAU scenario farm C generates higher profits than in the Flexible and Tenure scenarios. However, an increase in incomes of farms whose area increased is not substantially contributing to their income levels. This is as a result of that mainly the low productive lands are transferred to these farms and insufficient machinery to manage the larger farm. In the BAU scenario, when the size of farms A and B is reduced their income also becomes lower than in case of secure land tenure arrangement. Such income difference in BAU and Tenure scenarios show that the total net present value of all three farms (i.e., modelled rural farm welfare) are lower in the BAU scenario than in the Tenure. Even though the low procurement price of cotton leads that secure land tenure did not substantially increase farm incomes, providing secure land tenure for farms allows increasing overall farm incomes and may address possible widening of farm income disparity. Under the presence of land consolidation and variabilities the flexibility in land use of farmers leads that their incomes substantially lower in comparison to the BAU. Farmers generate the largest income when the new cotton cultivation technique is introduced, and all farms experience higher profits than in other scenarios. If we look at the farm income variability then it depends on each farm type and scenario. For instance, the highest net present value variability for farm A is in Tenure scenario, for farm B is in Innovation scenario, and for farm C is in BAU scenario.

<insert Table 3 here>

4. Discussion and Conclusions

The transition from planning to market economies in post-Soviet countries leads to changes in agricultural structure. In Uzbekistan some of the features of Soviet economy have remained. The most important one is the cotton production policy. After the break-up of the Soviet Union, cotton production is still a potential sector to generate export revenues (Zettelmeyer, 1999), and policies, institutions, infrastructure and farms are designed to fulfill the cotton production. In this paper we show how the farm restructuring process occurs due to uncertainties surrounding agriculture and especially cotton production. During the farm restructuring, farms receive the production targets, procedures and spatial boundaries with the aim to increase cotton production and revenues from cotton export (Müller, 2006). According to our model results, variability in cotton yields leads to substantial changes in size of farms due to land transfer from one farmer to another. Particularly, the large scale farms had increase in size in contrast to smaller farms. We also showed that due to yield variability some farms become inefficient and their lands are reduced. Although, it is considered important to distribute the land among rural people to alleviate the rural poverty (Lerman, 2005), in the study area infrastructure and institutions are designed to support the large-scale farms for cotton production and such design may hamper agricultural innovation and efficiency of small-scale farms (Djanibekov et al., 2012a). However, this leads that the land consolidation may further increase the incomes of well-endowed farms (but not substantially) and reduce the incomes of poorer farms. Due to farm number reduction in favor of augmenting the area of other efficient cotton producing farms and low off-farm opportunities the rural population will become more income polarized.

Several studies showed that the cotton production may not be beneficial for farmers. For example, Guadagni et al. (2005) identified that the low state cotton procurement price creates disincentives for farmers to grow cotton. In support of that argument, Pomfret (2000) concluded that the cotton procurement policy prevents the output growth, diversification and adoption of new practices and technologies by farmers. In developing country settings the state agricultural policies with the aim of land consolidation need to consider possible increase of incomes of some groups or rural people while the incomes of less economically endowed rural population may reduce. Thus, policies need to contribute to the population welfare that includes heterogeneous rural population groups. Besides increasing the cotton output through the farm size changes several other potential options are present to modify the cotton production. We showed that among promising policies are the secure tenure rights and introduction of innovative crop management practices are increasing overall farm incomes while meeting the cotton target levels. Abolishing the cotton production targets and liberalization of marketing cotton may also increase farm incomes (Guadagni et al., 2005; Chertovitsky et al., 2007; Djanibekov et al., 2013a). While further analyzing along the cotton processing chain alternative the liberalized marketing channels for raw cotton can improve revenues for farmers (Rudenko et al., 2009). However, when farmers have more flexibility in land use decision making and considering the transition agrarian policies and agricultural uncertainties, farmers may fail to deliver the required level of cotton production. Consequently, these farms may be subject to land optimization process and their land size may decrease. In the presence of possible farm optimization process and agricultural production uncertainties the efficient way to supply the targeted cotton amount is when both the area- and quantity-based cotton policies are functioning and innovative cotton cultivation practices are disseminated to farmers.

It should be noted that the impacts of policies targeted towards farms can affect not only these farms but also have indirect effects on other groups of rural population, e.g., rural households, through the rural interdependencies such as contractual arrangements between farmers and rural households (Djanibekov et al., 2013b; Djanibekov et al., 2015). In this case, during the transitional pathways, it is vital to take into the account the uncertainty in effects of policies not only on the rural actors for whom these policies are specifically developed, but also possible other groups of population. Besides the contractual relationship that influences agricultural production, there might be other types of networks among population that may be difficult to capture with our model. In addition, it is important to further elaborate the model. As can be seen from some scenarios the land transfer is substantial in the last period of analysis. Such model behavior can be explained because we did not consider the terminal periods (i.e., years that go beyond the modelling periods). Another one of the main disadvantages of the model is that we did not include all farms in the region. We showed that in some situations when cotton production is lower than certain amount of land is taken away from all modelled farm types, and subsequently this may lead to formation of new farms. It might be also the case that the land distribution will be among already established farms where land distribution occurs not only through the cotton fulfillment but also through other processes that are not addressed in this study. Accordingly, in future research it is important to consider spillover effects and various rural networks to address the farm optimization process and cotton production targets under agricultural revenue variability in the transitional country settings.

References

Anderson, K., 2007. Agricultural trade liberalisation and the environment: a global perspective. World Econ. 15, 153–172.

Bobojonov, I., Aw-Hassan, A., 2014. Impacts of climate change on farm income security in Central Asia: An integrated modeling approach. Agric. Ecosyst. Environ. 188, 245–255.

Chertovitsky, A., Akbarov, O., Yahshilikov, Y., 2007. Relaxing control over the cropping structure: the next step for land reform in Uzbekistan. In Paper Presented at the Joint IAAE-104th EAAE Seminar 'Agricultural Economics and Transition: What was expected, what we observed, the lessons learned' Budapest, Hungary, 6-8 September 2007.

Dixit, A. K., Pindyck, R. S., 1994. Investment under uncertainty. New Jersey: Princeton University Press.

Djanibekov, N., Rudenko, I., Lamers, J. P. A., Bobojonov, I., 2010. Pros and Cons of Cotton Production in Uzbekistan. In P. Pinstrup-Andersen and F. Cheng, eds., Food Policy for Developing Countries: Food Production and Supply Policies (Ithaca, NY, Cornell University Press).

Djanibekov, N., Van Assche, K., Bobojonov, I., Lamers, J. P. A., 2012a. Farm Restructuring and Land Consolidation in Uzbekistan: New Farms with Old Barriers. Eur. Asia Stud. 64, 1101–1126.

Djanibekov, N., Sommer, R., Djanibekov, U., 2013a. Evaluation of effects of cotton policy changes on land and water use in Uzbekistan: Application of a bio-economic farm model at the level of a water users association. Agric. Syst. 118, 1–13.

Djanibekov, U., Khamzina, A., Djanibekov, N., Lamers, J. P. A., 2012b. How attractive are short-term CDM forestations in arid regions? The case of irrigated croplands in Uzbekistan. For. Policy Econ. 21, 108–117.

Djanibekov, U., Van Assche, K., Boezeman, D., Djanibekov, N., 2013b. Understanding contracts in evolving agro-economies: Fermers, dekhqans and networks in Khorezm, Uzbekistan. J. Rural Stud. 32, 137–147.

Djanibekov, U., Van Assche, K., Boezemann, D., Villamor, G. B., Djanibekov, N., 2015. Revealing the role of agricultural contracts in rural livelihoods in Uzbekistan. In: A. Kimhi and

Z. Lerman, eds., Agricultural transition in Post-Soviet Europe and Central Asia after 25 years. IAMO, Halle/Saale, 141–158.

Djanibekov, U., Khamzina, A., (in press). Stochastic economic assessment of afforestation on marginal land in irrigated farming system. Environ Resour. Econ. DOI: 10.1007/s10640-014-9843-3

Dubovyk, O., Menz, G., Conrad, C., Lamers, J. P. A., Lee, A., Khamzina, A., 2013. Spatial targeting of land rehabilitation: a relational analysis of cropland productivity decline in arid Uzbekistan. Erdkunde, 67, 167–181.

Finger, R., 2012. Biases in farm-level yield risk analysis due to data aggregation. German J. Agric. Econ. 61(1), 30–43

Guadagni M., Raiser, M., Crole-Rees, A., Khidirov, D., 2005. Cotton taxation in Uzbekistan: Opportunities for reform. ECSSD Working Paper No 41. Europe and Central Asia Region, World Bank, Washington DC.

Happe, K., Hutchings, N. J., Dalgaard, T., Kellerman, K., 2011. Modelling the interactions between regional farming structure, nitrogen losses and environmental regulation. Agric. Syst. 104, 281–291.

Happe, K., Balman, A., Kellerman, K., Sahrbacher, C., 2008. Does structure matter? The impact of switching the agricultural policy regime on farm structures. J. Econ. Behav. Organ. 67 (2), 431–444.

Land Resources, 2002. Workbook on bonitet measurement of irrigated areas of the Republic of Uzbekistan (in Russian). State Committee on Land Resources of the Republic of Uzbekistan, pp. 1–12.

Lerman, Z., 2005. The impact of land reform on rural household incomes in Transcaucasia and Central Asia. Discussion Paper 9.05, Hebrew University of Jerusalem, Jerusalem, Israel.

Lerman, Z., 2008. Agricultural development in Central Asia: A survey of Uzbekistan, 2007–2008. Eurasian Geogr. Econ. 49(4), 481–505.

Marra, M. C., Schurle, B. W.. 1994. Kansas wheat yield risk measures and aggregation: a meta-analysis approach. J.. Agric. Resour. Econ. 69-77.

Ministry of Agriculture and Water Resources of Uzbekistan (MAWR), 2001. Guide for water engineers in shirkats and WUAs. Scientific production association Mirob-A, Tashkent.

Ministry of Agriculture and Water Resources of Uzbekistan (MAWR), 2010. Land and water use values for Uzbekistan for 1992-2009.

Müller, M., 2006. A general equilibrium approach to modeling water and land use reforms in Uzbekistan. PhD dissertation, Center for Development Research, University of Bonn, Bonn, Germany.

Rosenberg, C., Ruocco, A., Wiegard, W., 1999. Explicit and implicit taxation in Uzbekistan. Regensburger Diskussions-beiträge Nr. 325. University of Regensburg, Regensburg, Germany.

Rudenko, I., Lamers, J.P.A., Grote, U., 2009. Can Uzbek farmers get more for their cotton? Eur. J. Dev. Res. 21 (2), 283–96.

State Statistical Committee of Uzbekistan, 2010. Statistical Yearbook, Tashkent.

State Statistical Committee of Uzbekistan, 2012. Statistical Yearbook, Tashkent.

Troost, C., Berger, T., 2015. Dealing with uncertainty in agent-based simulation: farm-level modeling of adaptation to climate change in Southwest Germany. Am. J. Agric. Econ. 97 (3), 833–854.

Zettelmeyer, J., 1999. The Uzbek growth puzzle. IMF Staff Papers 46 (3), 274–92.

Table 1. Farm size, soil structure and crop main product yield variability.

Attributes	Farm types		
	A	B	C
Farm size, ha	15	40	87
Area of land by productivity type, ha			
Marginal	5	8	10
Average	5	16	35
Good	5	15	40
High	0	1	2
Machinery available, in thous diesel l	6	12	30
Crop yield coefficient variation			
Cotton	0.16	0.12	0.08
Wheat	0.15	0.11	0.08
Rice	0.22	0.17	0.11
Maize	0.16	0.12	0.08
Vegetables	0.11	0,08	0,06

Source: coefficient of variation of crop yields are adapted from MAWR (2010) and Statistical Committee of Uzbekistan (2010).

Table 2. Average and standard deviation (SD) of cotton production over years in the business-as-usual (BAU), Flexible, Tenure and Innovation scenarios, in tons per farm.

Years	Scenarios							
	BAU		Flexible		Tenure		Innovation	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Farm A								
1	13	2	18	0	13	2	16	2
2	13	2	17	2	13	2	16	2
3	13	2	17	2	13	2	16	2
4	13	2	17	2	13	2	16	3
5	13	2	16	2	13	2	16	3
6	13	3	16	3	13	2	16	3
7	13	3	16	3	14	3	16	3
8	12	2	16	3	13	2	15	3
9	12	3	14	3	13	2	16	3
10	12	3	11	3	14	3	16	4
Farm B								
1	43	6	48	0	43	6	51	7
2	42	6	47	2	42	6	51	7
3	42	5	46	3	43	5	51	7
4	42	6	46	3	43	6	51	9
5	42	7	45	3	43	6	50	9
6	42	7	44	4	43	6	52	9
7	42	6	44	5	44	6	51	9
8	41	6	44	5	42	6	50	8
9	42	6	42	5	43	6	51	9
10	42	8	34	7	44	8	52	10
Farm C								
1	102	13	104	0	102	13	123	17
2	101	11	104	1	101	11	121	13
3	102	13	104	1	101	13	123	16
4	101	16	104	2	101	16	122	20
5	101	15	103	6	101	15	122	19
6	103	17	103	7	102	16	123	20
7	104	16	102	7	102	14	124	18
8	102	14	101	7	101	13	121	17
9	103	16	99	9	101	15	122	18
10	106	22	86	18	104	20	126	25

Table 3. Expected and standard deviation (SD) of farm net present values in the business-as-usual (BAU), Flexible, Tenure and Innovation scenarios under the 10% discount rate, in 1,000 USD per farm.

Scenarios	Farm A		Farm B		Farm C	
	Mean	SD	Mean	SD	Mean	SD
BAU	156.4	65.6	448.4	186.1	1076.9	430.8
Flexible	133.7	54.7	426.8	174.0	1063.7	417.5
Tenure	163.3	68.4	450.3	187.5	1070.4	426.5
Innovation	170.8	67.2	478.9	187.6	1116.6	419.5

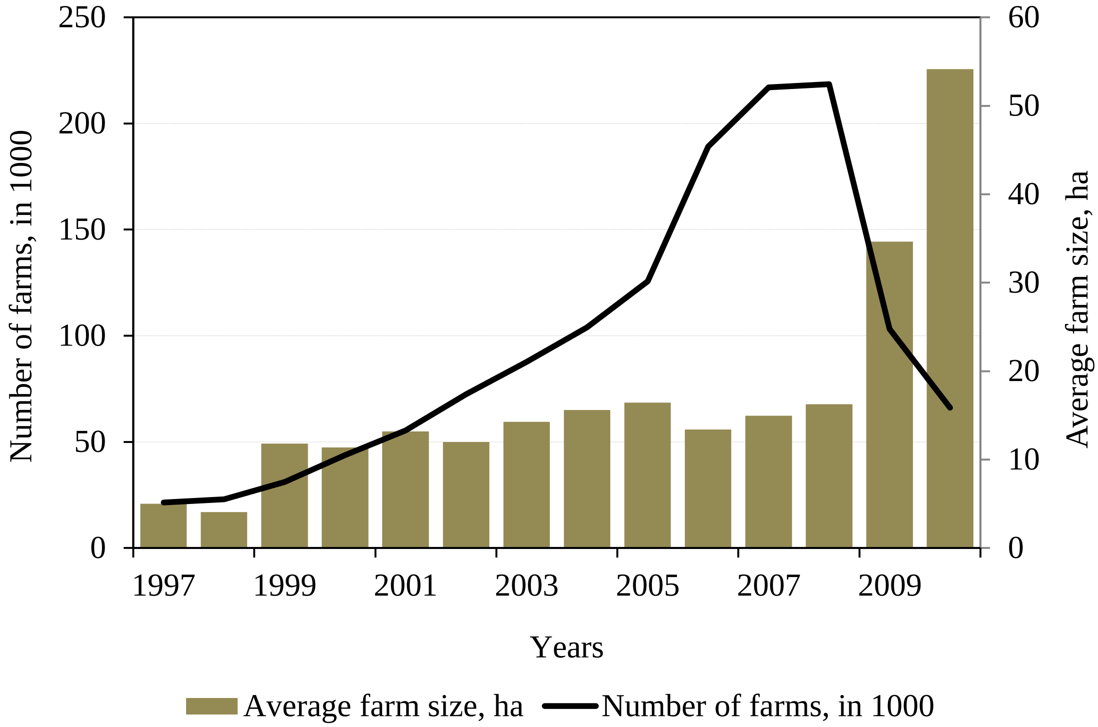

Figure 1. Dynamics in number and average size of farms in Uzbekistan.

Modified from Djanibekov et al. (2015).

Source: State Statistical Committee of Uzbekistan (2012).

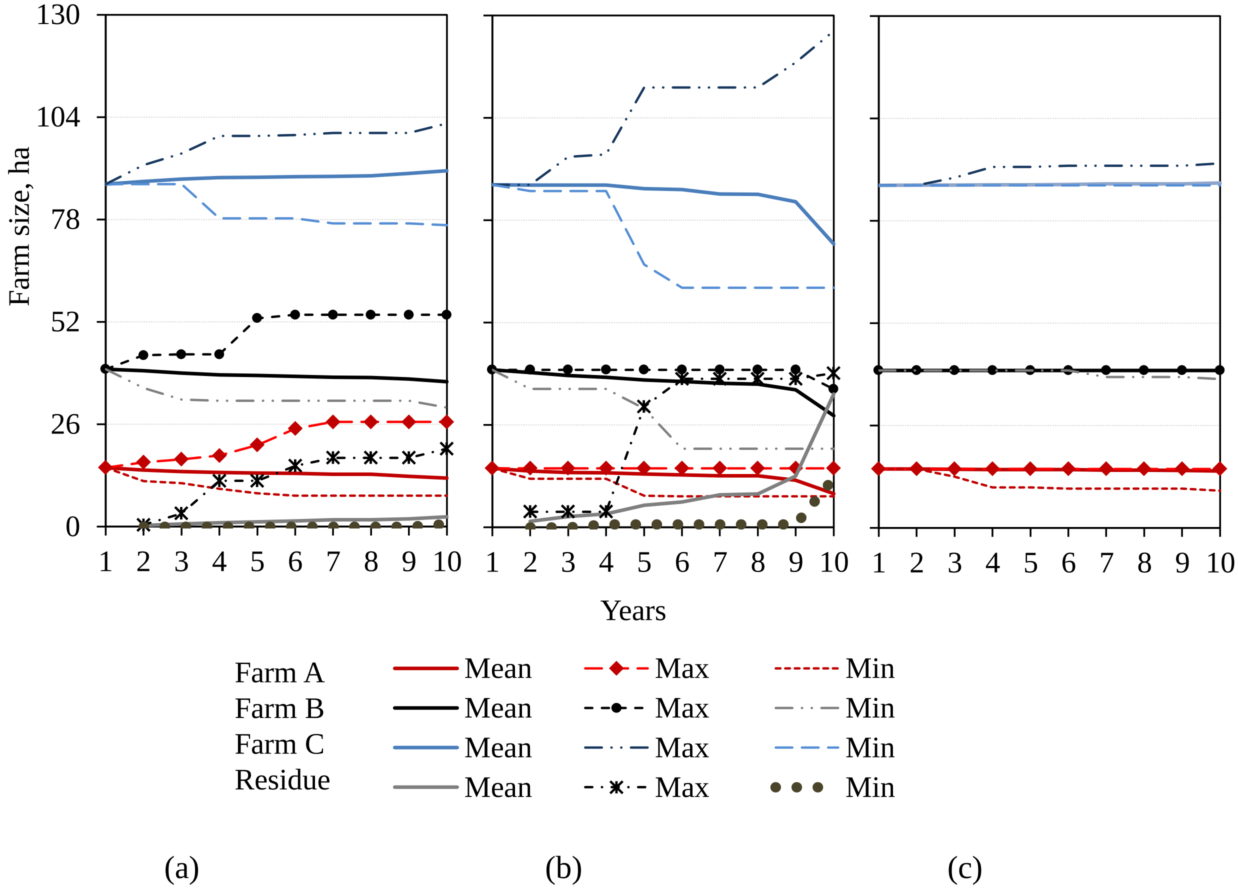

Figure 2. Mean, maximum (max) and minimum (min) simulated size of farms and residue of land in the business-as-usual (a), Flexible (b) and Innovation scenarios (c).

Note: Residue refers to land not transferred to any modelled farm.

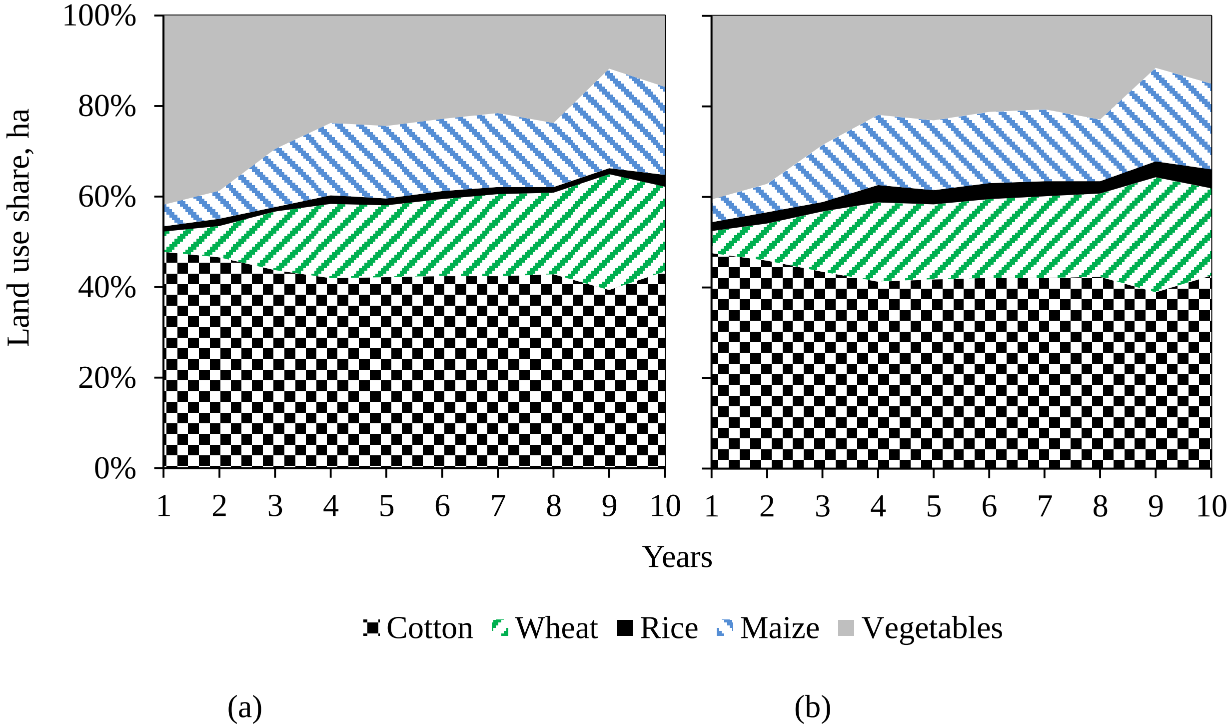

Figure 3. Combined land use shares of farms A, B and C in the business-as-usual (a) and Innovation scenarios.