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Land Acquisition in Africa for Agricultural Purposes

- The case of sugar cane plantation and sugar mill in Ethiopia

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Abstract

Land acquisition in Africa has dramatically increased recently and many land deals have been signed. A real option (RO) model is developed to examine the profitability of land investment in Africa for the agricultural purposes. In this model, the factors that can affect the willingness of private corporations abroad to lease land and then implement the agricultural projects are taken into account.

A land lease contract, signed between Hunan Dafengyuan Agriculture Co., LTD and the Ministry of Agriculture of the Federal Democratic Republic of Ethiopia, for sugar cane plantation and sugar processing in Ethiopia is chosen for the case study. This land investment project is evaluated as a series of compound real options using the binomial model and the project value is compared with the evaluation result under the net present value (NPV) approach.

In the empirical study, the project value under NPV approach is 1.832 billion 2008ETB, while the value under RO approach is 43.174 billion 2008ETB. The results indicate that this project is worth investing in and the real options embedded in this project are considerably valuable. Furthermore, the project value is subject to the value of some exogenous variables, including the current sugar price, the average yield of sugar cane, the volatility of sugar price, annual land rent and the discount rate. The sensitivity tests illustrate how the exogenous parameters affect the decision of investors.

Abbreviations

ADF	Augmented Dickey-Fuller
APV	Adjusted Present Value
DR	Democratic Republic
ETB	Ethiopian Birr
EU	European Union
FAO	Food and Agriculture Organization
GLP	Global Land Report
HDAC	Hunan Dafengyuan Agriculture Co., LTD
IFAD	International Fund for Agriculture Development
IFPRI	International Food Policy Research Institute
IIED	International Institute for Environment and Development
MAE	The Ministry of Agriculture of Ethiopia
NPV	Net Present Value
RO	Real Option
ROA	Real Option Approach
SMNE	Solidarity Movement for a New Ethiopia
UN	United Nations

List of Figures and Tables

Table of contents

1 Introduction

The first section of this chapter introduces the problem background of the thesis in general. The research problem is presented in the second section. Next, the objectives of this thesis are described. Finally, how this thesis is structured is shown.

1.1 Background

Land acquisition has dramatically increased since the agricultural commodity prices boomed in 2007-2008 (von Braun & Meinzen-Dick, 2009; Kachika, 2010; Arezki et al., 2011; Collier & Venables, 2011; Hall, 2011). As identified by the World Bank, 70% of the land under negotiation, nearly 32 million hectares, is in Africa (Deininger & Byerlee, 2010). Land transfers updated by Arezke et al. (2011) covered 4.0 million hectares in Sudan, 2.7 million hectares in Mozambique, 1.6 million hectares in Liberia and 1.2 million hectares in Ethiopia. The pace of land rush in Africa is still increasing. The fact that the demand for land in Africa in 2009 added up to 39.7 million hectares, compared with the annual land expansion of 1.8 million hectares in 1961-2007, indicates a significant increase in land demand in Africa recently (Arezki et al., 2011).

In many African countries, e.g. Ethiopia, Mozambique and Tanzania, land is nationalized; in other countries like Madagascar and Mali, the private land ownership is not widespread, even though it can be achieved via a land registration procedure (Vermeulen & Cotula, 2010). Deininger (2003) found that less than 10% of land, mainly urban land, in Africa is held under formal land tenure. More than 80% of undeveloped land in Ghana is held under customary tenure[1] (Kasanga & Kotey, 2001). On the basis of nationalized land and customary tenure in Africa, it is the government that formally owns the land in most circumstances and then allocates the land for large-scale land deals (Vermeulen & Cotula, 2010).

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[1] Customary tenure is "usually associated with indigenous communities and administered in accordance with their customs, as opposed to statutory tenure usually introduced during the colonial period" (FAO, 2002, p.44). The protection of customary tenure is often limited since it is subordinate to a state land title within the national law (Vermeulen & Cotula, 2010).

The acquisition of land can be achieved either through land purchases or leases. However, Cotula et al. (2009) pointed out that it is the land leases that predominate in African land deals. The major investors acquiring African land are the countries[2] which are capital-rich but short of agricultural land or water resource to meet the growing domestic food demand (Robertson & Pinstrup-Andersen, 2010). Furthermore, it is the private corporations rather than the government-owned companies that made most approved land investments (Cotula et al., 2009).

The duration of leases varies among countries, normally from 10 years to 99 years[3] (Vermeulen & Cotula, 2010). Annual land rent is often charged very low[4] or not charged at all (Cotula et al., 2009). Although no or little monetary transfers occur in land deals, some other commitments are required by host countries. In the GEM Biofuels PLC deal in Madagascar, local employment of 4,500 part-time workers was promised; in the Petrotech/AgroMali deal in Mali, the investor was required to develop and maintain irrigation infrastructures (Cotula et al., 2009). The implementation of projects and the fulfillment of additional promises are monitored in some countries like Mali, Sudan and Mozambique, and land lease contracts can be terminated as a result of non-compliance (Cotula et al., 2009).

A large amount of land deals have been signed in Africa; however, little land has been developed so far (Collier & Venables, 2011). Among 464 cultivation projects checked by Arezke et al. (2011, p. 11), "some 30% of projects were at an early exploratory stage, in 18% permission had been granted but no activity started, 30% were at initial level of development and only 21% had started production, often at a much lower level than envisaged."

1.2 Problem

As mentioned in section 1.1, land acquisition in Africa has dramatically increased recently;

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[2] Predominantly are "oil-rich but food-insecure Gulf states like Saudi Arabia, Qatar and the United Arab Emirates" and "populous but capital-strong countries in Asia like China, South Korea and India" (Friis & Reenberg, 2010, p.6).

[3] In Ethiopia, all leases are up to 50 years; in Mozambique, investors can only acquire 50-year, renewable leases; in Mali, 50-year renewable leases are the majority; in Ghana, all documented leases are above 50 years; in Tanzania, leases can be obtained up to 99 years (Vermeulen & Cotula, 2010).

[4] Often between $2 and $10 per hectare in countries like Sudan, Angola, Mali and Ethiopia (Cotula et al., 2009).

however, the number of implemented agricultural projects is relatively small. Therefore, whether African land is really worth investing in becomes an interesting question.

When companies decide on such an investment opportunity, present values of costs incurred for the land lease and expected profit from the designed agricultural project should be compared. If the expected profits overweigh the costs, the land deal can be made. Once the farmland has been leased, firms can choose when to carry out the agricultural project within time constraints set by host countries. The project can even be abandoned if the future production and market conditions are much poorer than expected. The decision of the investor can be influenced by exogenous variables like future food prices, potential productivity of land and discount rate, etc[5]. The variables of interest are factored into the project evaluation model.

1.3 Aim

The aim of this thesis is to examine the profitability of land leases in Africa for the agricultural purposes. In this study, the factors that can influence the willingness of private corporations abroad to lease land and then implement the agricultural projects are taken into account.

Three questions faced by foreign investors will be analyzed in this study:

i) Should they lease African land?

ii) Within time constraint for the implementation of the project, when should they develop the land they have leased?

iii) Should they abandon the project before the expiration of land lease contract?

The following question will also be answered in this study:

- How can the variables of interest, including food price, volatility of food price, potential productivity of land, costs of land lease (including land fees and cost of additional requirements) and the discount rate, affect investors' decision?

[5] For instance, high food prices in the future boost the agricultural revenue, then the value of agricultural project, and finally the value of land investment.

The real option approach is useful for the evaluation of land acquisition under uncertainty since it allows the corporations to properly account for the flexibility they may have when managing the operations of the agricultural projects. With the real option approach, the profitability of land acquisition in Africa can be studied and the optimal strategy for the implementation of the agricultural project can be illustrated.

1.4 Organization

This thesis is organized into six chapters. Chapter 1 presents the problem background, research problem and aim of this thesis. Chapter 2 describes the drivers of land acquisition in Africa for agricultural purposes. Chapter 3 introduces theoretical background of this dissertation and it covers the shortfalls of the net present value (NPV) approach, the advantages of the real option (RO) approach and the evaluation model chosen for this thesis. Chapter 4 focuses on the background of an empirical study. The project evaluation using both NPV approach and RO approach is provided in Chapter 5. Besides, the influences of some exogenous variables on the decision of investors are illustrated in Chapter 5 too. The last chapter gives the conclusions of this dissertation as well as suggestions for future research.

2 What drives the land acquisition in Africa

The bulk of total leased land (approximately three-quarters) in Africa is acquired by foreign investors (Cotula & Vermeulen, 2009). The motivations for both foreign investors and host countries are summarized in this chapter.

2.1 Why are foreign investors interested in African land?

With the joint action of food security, energy security and renewable energy consumption, profitability of land investment in agriculture and incentive policies, foreign corporations become interested in African land for agricultural purposes.

2.1.1 Food security

Food security is one significant driver of government-backed land acquisition in Africa (Arezki et al., 2011; von Braun & Meinzen-Dick, 2009; Collier & Venables, 2011; Friis & Reenberg, 2010; Robertson & Pinstrup-Andersen, 2010). The trade distortions like export restrictions established by major food-exporting countries in 2008 led to a dearth of food on the global market, which further drove up the world food prices and caused panic for countries relying on imported food (Robertson & Pinstrup-Andersen, 2010). The food crisis drew great attention to the volatility of food prices and the vulnerability of food supply, and brought grave concern regarding food security (Friis & Reenberg, 2010; Robertson & Pinstrup-Andersen, 2010). Net importers of food started to search for arable land to ensure their food supply.

The food security concern is becoming more serious due to the increasing global food demand. Since the world population continues to grow[6], more people need to be fed and the population pressure on land continues to intensify. Moreover, because of accelerating urbanization, the population depending on food purchases expands; due to the change in eating habit (growing preference for meat-based diets), more land is required to produce food (Friis &

[6] In 2050, the number of global citizens is expected to rise to approximately 9.1 billion, while world population is estimated to be 7.0 billion in 2012 (U.S. Census Bureau, 2002).

Reenberg, 2010; Cotula et al., 2009). Furthermore, the unequal distribution of population and population growth in the world, which results in distinct population pressures on land, boosts the cross-country land acquisitions (Friis & Reenberg, 2010). Africa has been a particular target for countries like China, India and Saudi Arabia because of its large amount of “underutilized” agricultural land (Collier & Venables, 2011).

2.1.2 Energy security and renewable energy consumption

Demand for bio-fuel is another key driver of land acquisition in Africa[7] (Cotula et al., 2009; Kachika, 2010; Vermeulen & Cotula, 2010; Robertson & Pinstrup-Andersen, 2010; Hall, 2011). As found by World Bank, 21% of land transfers in 2009 was for bio-fuel production; while the updated figure given by International Land Coalition was 44 percent (Hall, 2011). With high, fluctuating global oil price in 2007-2009, countries are searching for alternative energy resources in order to strengthen long-term energy security and reduce energy bills (Cotula et al., 2009). Some countries also tend to diversify their energy sources in anticipation of high oil prices and export restrictions enforced by major oil suppliers, and bio-fuel production is a crucial component of this diversifying strategy (Friis & Reenberg, 2010).

The awareness of climate change and increasing interest in renewable energy is also an important motivation. The EU’s Renewable Energy Directive established “a 10% binding minimum target for biofuels in transport to be achieved by each Member State” by 2020 (European Commission, 2008, p.2). Also, the European Commission stated that almost 60% bio-fuels would be imported to achieve the 10% target (Robertson & Pinstrup-Andersen, 2010). This bio-fuel target offers an incentive for the investment in bio-fuel since it ensures the demand for bio-fuels and creates a credible and profitable investment field (Friis & Reenberg, 2010; Robertson & Pinstrup-Andersen, 2010).

[7] Liquid bio-fuel is often produced from crop feedstocks, “either carbohydrate-rich crops for bioethanol (e.g. maize, sugarcane) or oil-rich crops for biodiesel (e.g. rapeseed, oil palm, jatropha)” (Vermeulen & Cotula, 2010, p. 2).

2.1.3 Profitability of land investment in Africa

The low rent of African land results in a low cost of leasing land and makes land acquisition in Africa a tempting option for both government-backed and private investments. Reasons for low land price are summarized as follows:

i) **Current low output of local land**. This is due to the limited technical and agronomic knowledge and the lack of irrigation systems and advanced machines (Collier & Venables, 2011). The acquired land usually is “underutilized” (von Braun & Meinzen-Dick, 2009). Some land is used for purposes such as “grazing animals and gathering fuelwood or medicinal plants” by the poor (von Braun & Meinzen-Dick, 2009, p. 2). These uses are not marketed and will eventually result in the undervaluation of land in the official assessment.

ii) **The shortage of necessary infrastructure in host countries** (Collier & Venables, 2011). Agriculture needs transport, electricity and irrigation. Lack of them will bring difficulties to the implementation of agricultural projects and increase the investment costs if investors need to solve these problems on their own. Hence, the shortage of necessary infrastructures inevitably dampens the enthusiasm of potential investors. Host countries have to lower the land rent in order to attract investors.

iii) **Weak negotiation position of host countries**. The bargaining power of the investor and the host is unequal in the negotiation, and stronger power is usually on the side of foreign firms rather than African countries (Cotula et al., 2009; von Braun & Meinzen-Dick, 2009). This also pushes down the price of African land.

iv) **Land property rights.** Most land holders in Africa have no formal title to the land (Vermeulen & Cotula, 2010; Deininger, 2003). Smallholders using land with customary tenure can hardly make any requests such as consultation or compensation (von Braun & Meinzen-Dick, 2009). In this way, the land rent is further diminished.

v) **Corruption problem.** Lack of transparency in land deals creates a breeding ground for corruption (Cotula et al., 2009). The local governments will not do their utmost to raise the land price or maximize public interest when they negotiate with the investors. In addition, in order to attract foreign investment, the local governments need to lower land price to differentiate themselves from the other land providers.

With the advanced agronomic knowledge, technology and equipments brought by the foreign investors, big improvements in the productivity of African land can be predicted (Collier & Venables, 2011). Rising food prices and increasing food demand make agricultural production an appealing option since a high rate of return can be expected (Cotula et al., 2009). In addition, the agricultural investment in Africa can be a strategy of some corporations to secure their input supplies, particularly when they suffer from future food price hikes or export restrictions enforced by their suppliers (Friis & Reenberg, 2010). Given the financial crisis and collapse in the housing and stock market in 2008, land investment in Africa for the agricultural purposes has become a good option for investors who are seeking new and profitable investment opportunities (Cotula et al., 2009; Friis & Reenberg, 2010).

2.1.4 Incentive policies

Land investments in Africa for agricultural purposes have been encouraged by both origin and host countries. For instance, China provides "information and connections, risk assessments, diplomatic support, help with work permits and immigration requirements, preferential tax and foreign exchange control policies, insurance, assistance with customs, and low-cost loans" for Chinese firms to seek for agribusiness in Africa (Bräutigam & Xiaoyang, 2009, p. 9). Investment promotion agencies were established in Mali, Mozambique and Ghana to facilitate land access and obtain all the necessary permits for foreign investors (Cotula et al., 2009). A land bank was set up in Tanzania to gather all available land for the potential investment (Cotula et al., 2009). Custom duties, tax on all capital items and profit tax in agriculture sector are exempted by the government in Sudan, and profit tax is exempted for 5 years in Ethiopia (Cotula et al., 2009).

2.2 Why are land investors welcomed by African countries?

Since land rent is often not charged or charged very low, the direct monetary transfer is not the main target of host countries. An officer of the Angolan government said that “the government is not interested in making money out of the land. The government is interested in stimulating the local economy, diversifying the primary economic base from past focus on mining and industry” (Cotula et al., 2009, p. 79). One official in Mali said that the aim of attracting agricultural investments is to “transform Mali into an agriculture powerhouse,” and another official stated that investors in agriculture can help Mali “diversify food production” (Oakland Institute, 2011a, p. 35).

The rural poor are likely to benefit from the foreign investments since they may create plenty of farm and off-farm jobs, develop the rural infrastructure, construct schools and health clinics, and also create spillovers like advanced agriculture technologies (von Braun & Meinzen-Dick, 2009). Investors from abroad can bring capital, advanced technology and agronomic knowledge, which can lead to productivity improvement, and also help African countries develop local market (Collier & Venables, 2011). According to Cotula et al. (2009), investment amounts, employment creation and infrastructure development, which may improve rural livelihood and stimulate local economies, are what host governments care about, and commitments to these factors are required as conditions of land lease contracts.

3 Theoretical perspective and methodology

This chapter aims at providing theoretical background of this thesis. The first section analyzes the characteristics of land investment in agriculture. The NPV approach and its shortfalls are presented in the second section. Subsequently, the ROA is introduced and the typical real options associated with project evaluation are explained. Next, the previous applications of ROA in investment evaluation are presented. The fifth section illustrates the binomial pricing model. The last two sections illustrate the statistical tests for the time series data elaboration.

3.1 Economic evaluation of land investment in agriculture

An enterprise leasing land for an agricultural project is an investor. The costs of land lease contain upfront fees, annual payments like rents and irrigation fees and the costs for additional commitments made in the contracts. The rewards are the expected profits, i.e. the sales of products net of expenditures including the construction cost of infrastructures, the cost of machinery and equipments and the operating costs such as costs of seeds, fertilizers and pesticides, labour and energy costs, transportation costs, taxation, etc.

The features of investments normally depend on the specific sector or industry. For the land investment in agriculture in Africa, the features can be summarized as:

- The uncertainty of future payoffs. The profitability of agricultural projects can be affected by the crop yield, the price of the agricultural product and all kinds of costs in the future. Furthermore, the crop yield is highly influenced by the weather, which, to some extent, is unpredictable and uncontrollable. Nowadays, the extreme weather becomes more frequent, and this leads agricultural investment to be more risky. In our particular case, the factors like the limited knowledge about local market and the uncertainty of land productivity in Africa add further uncertainties to the future pay-offs of agricultural project.

- The flexible choice of the investment. The investment can be postponed to collect more information about the future product price, land productivity and costs of cultivation, etc. In addition, the agricultural project can also be given up partially or completely to avoid future losses when the production or market condition turns out to be much poorer than expected. Hence, the implementation of agricultural project is flexible.

3.2 Traditional economic evaluation approach – NPV

This section will explain what the NPV approach is and why it is not suitable for land acquisition in Africa for agriculture under uncertainty.

3.2.1 What is NPV approach?

Traditional economic evaluation approaches like the NPV approach discount the cash flows in the future by the rate of return offered by equivalent investment alternatives in the capital market and then subtract the initial investment costs (Brealey et al., 2008). NPV is used to assess the profitability of a project and it can be calculated using the following formula:

$$NPV = C_0 + \sum_{t=1}^{\infty} \frac{C_t}{(1+r_t)^t} \qquad (3.2.1.1)$$

where C_0 is the cash flow at time 0, and it is negative if it is a cash outflow, i.e. investment cost, C_t is the cash flow at time t, and r_t is called discount rate, hurdle rate or opportunity cost at time t. When C_t is absolutely safe, r_t is the interest rate given by the safe securities; when C_t is uncertain, r_t is the expected rate of return offered by the equivalent-risk securities (Brealey et al., 2008). If a project has a positive NPV, it creates wealth for the firm. Under the same criterion, it is possible to compare one project with other alternatives. Theoretically, all the projects with positive NPV can be accepted, conversely, the ones with negative NPV should be rejected; but in capital rationing, the project which offers the highest NPV per dollar of initial expense will be chosen (Brealey et al., 2008).

3.2.2 The shortfalls of NPV analysis

It is straightforward to use NPV method to evaluate investment programs. However, there are several shortfalls involved in the application of NPV approach.

The determination of future cash flows of a project is one of the most challenging tasks for project managers using NPV approach (Tam & Velez-Pareja, 2004). Even though corporations can conduct market research, utilize their experience and hire specialized analysts to predict future cash flows, the estimations obtained are just predictions. The real future cash flows depend on the real future conditions, and they may change remarkably and even contrast sharply with predictions beforehand. The future pay-offs deriving from an investment actually can have a range of possible values with different probabilities.

Another difficult task is the choice of the discount factor (Tam & Velez-Pareja, 2004). The future cash flows deriving from an investment should be discounted by the expected rate of return offered by the equivalent-risk securities (Brealey et al., 2008). However, it is hard to estimate the risk of a project and then find the equivalent-risk securities. Furthermore, theoretically, it is possible to use different discount rates in different periods, while a constant discount factor is used to simplify the estimation process in many circumstances. With the acquisition of updated information, the estimated risk of the project may change, which will lead to the change of the discount factor and finally the value of project. In this way, it becomes difficult to determine a discount rate upfront for the entire project duration.

Besides, using NPV approach to evaluate a project, the decision maker should choose between "invest now" or "never" (Brealey et al., 2008). However, the value of a project is evaluated on the basis of the estimations of the future cash flows and the discount factor, which can be updated with extra information in the future. In the dynamic world, the profitability of a project can vary over time. The fact that a project has a positive NPV does not mean it should be undertaken right now, it might be more valuable if carried out later. A project with negative NPV today should not be given up immediately since it may turn out to be a profitable one tomorrow if the market flourishes.

All in all, the shortfalls mentioned above create difficulties and also set restrictions to the application of the NPV approach. For the land investment in agriculture in Africa,

3.3 Real option approach

A financial call (put) option is the right, but not the obligation, of its owner to buy (sell) a stock at a specified price on or before a specified date (Brealey et al., 2008). The real option approach is developed on the basis of financial option theory. This section aims at introducing the ROA and several typical real options associated with investment evaluation.

3.3.1 What is real option approach?

The real world is a dynamic world, which is full of uncertainties and changes. Projects that can be easily modified according to the dynamic conditions are of higher value than those that do not offer the flexibility (Brealey et al., 2008). The flexibility allows companies to collect information regarding the future market conditions and then act in response. The more uncertain the future condition, the more valuable the flexibility (Hull, 2009). Managers holding the real options can make decisions to capitalize on favorable market conditions or avoid losses. When a project is evaluated, the value of real options attached to it should be added into the conventional NPV (NPV of the project without flexibility) and the sum can be represented by the adjusted present value (APV) (Brealey et al., 2008). That is to say:

$$\text{APV} = \text{Conventional NPV} + \text{Value of real options} \qquad (3.3.1.1)$$

According to this definition, a project with a negative conventional NPV can also have a positive APV and be worth investing in as long as the value of real options is sufficient to offset the loss.

The real option evaluation, which pertains to the tangible assets such as land, capital and equipments rather than financial instruments, has developed based on the financial option theory. The real option approach regards the company as the owner of an option to invest

(Dixit & Pindyck, 1994). The company which is willing to invest in a new project is holding a call option – European call or American call, and it can exercise this option if it decides to invest. The European call can only be exercised on the specified exercise day, while American call can be exercised on or at any time before that date (Brealey et al., 2008). In most circumstances, the option to invest is similar to an American call, and the owner of this option can decide whether to exercise it and when to do so after evaluating the project.

The real option approach provides a new angle with respect to the role of uncertainty on investment opportunity. When the value of project increases, it is more likely to exercise the option to invest in order to gain profit. If the value of project drops, then the value of option to invest also drops, thus the owner of option may choose not to proceed with this project to avoid loss. Since the gain on the upside can be fully grasped while the loss on the downside is limited, the higher volatility of the project value will result in the higher investment benefits (Trigeorgis, 2005).

The enterprise holding the option to invest can choose the optimal timing to exercise it. The option can be exercised immediately if the project is profitable, or the enterprise can choose to wait to collect more information about the market and then exercise the option when the project has a bigger chance to be successful. Although Additional information is always valuable, the “wait and see” strategy may not be beneficial all the time. The enterprise faces a trade-off between the benefit of “wait and see” strategy and the benefit of an early bird (Trigeorgis, 2005). If the project is truly profitable, it would be the best that firm captures the cash flows deriving from the investment as soon as possible (Brealey et al., 2008).

3.3.2 The types of real options

When real option approach is used to evaluate a project, the real options attached to this project will contribute to the project value. Three main types of real options will be introduced next.

3.3.2.1 The option to defer

Firms can make a decision whether to invest or not within a determined period of time. The fact that a project has a positive NPV does not mean that the company should go ahead immediately. It may be better to wait and see how the market develops. Hence, the firm should not only decide whether to invest or not but also the optimal time for investment.

If the option to invest is exercised at time t, the initial investment and the expected following stream of cash flows can be used to calculate the NPV of project, which can be represented by V_t. If the option is kept open at time t, the project value may rise or drop in next period. The expected value of option at time t can be represented by OV_t. Thus, at time t, the option to invest is worth V_t if exercised, or OV_t if kept open.

That is to say, at time t,

If $\text{Max}(V_t, OV_t, 0) = V_t$, the project should be undertaken immediately;

If $\text{Max}(V_t, OV_t, 0) = OV_t$, the firm should better choose to wait；

If $\text{Max}(V_t, OV_t, 0) = 0$, the project should be rejected.

3.3.2.2 The option to expand

The option to expand creates a strategic opportunity for the company to make follow-on investments that could be considerably profitable (Brealey et al., 2008). An initial project with negative NPV (conventional NPV) can also be acceptable if it provides the possibility for profitable follow-on projects. By suffering from the loss of the project carried out upfront, the firm can obtain an option to expand when market turns out to be favorable in the future.

If present value of follow-up cost incurred is I_E, present value of cash flows stemmed from the follow-on project in case of favorable market condition is V_E, and probability of good market scenario in future is represented by p, thus the value of the option to expand is $p\text{Max}(V_E - I_E, 0)$. Assume the conventional NPV of base-scale project is denoted by V. The value of initial project is the value of base-scale project itself plus the value of option to expand: $APV = V + p\text{Max}(V_E - I_E, 0)$.

3.3.2.3 The option to abandon

Projects do not have to carry on until assets expire because of old age, and, generally, the decision to terminate a project is made by managers rather than nature (Brealey et al., 2008). In spite of professional evaluation from analysts and managers, the real cash flows may not turn out as expected. In the case of poor market situation, when cash flows are far below expectations, company can abandon the project temporarily or permanently.

Project does not have to be operated every period. If the revenue drops temporarily and is not sufficient to offset the variable operating cost, it might be better to shut down temporarily (Trigeorgis, 2005). The temporarily abandonment incurs expenses such as costs of mothballing and reactivating (Brealey et al., 2008). Hence, for temporarily abandonment, the costs are foregone revenues from operation plus the costs of mothballing and reactivating, while the benefits are the variable operating costs. When benefits exceed overall costs, the project will be shut down until market condition rebounds to a good level.

Once the project is no longer profitable, the manager may cut losses and abandon the project in exchange for its salvage value, i.e. the value obtained from selling capital, equipments and all other assets in the second-hand market (Trigeorgis, 2005). Tangible assets are easier to sell than intangible ones (Brealey et al., 2008) and more general-used capital assets have higher salvage values than specific-used ones (Trigeorgis, 2005). The option to abandon is similar to an American put option. Let S denote the salvage value and let V represent the value of project in the rest lifetime. The choice, whether to abandon or not, should be made by comparing S and V, and this kind of comparison should be kept in mind throughout the project's lifetime. When S exceeds V, the option will be exercised and the value of option is $S-V$, otherwise, the option value is 0.

3.3.3 The choice of real option approach

This thesis aims at studying the profitability of land investment in Africa for the agricultural purposes. As analyzed in section 3.1, there are two important characteristics of land investment in agriculture in Africa: one is the flexible investment choices and the other one is the uncertain future pay-offs.

The NPV approach is a traditional economic evaluation approach. However, under the NPV approach, investors have no opportunity to delay an investment or modify the project. In addition, the NPV approach requires the future cash flows deriving from an investment to be precisely forecasted. Therefore, the conventional NPV cannot properly reflect the value of a land lease in Africa for agricultural purposes.

The RO approach is useful for the evaluation of land acquisition for agricultural purposes in Africa. On one hand, the RO approach takes into account the variation of cash flows resulting from the uncertainty of market conditions. On the other hand, it allows the firms to account for the flexibility they may have when managing the operations of agricultural projects. Hence, the RO approach is chosen for the project evaluation in this study.

3.4 Synopsis of the applications of real option approach

Real option approach can lead to better investment decisions since it can incorporate the flexibility of a project into the project evaluation (Dixit & Pindyck, 1994). The theoretical advantages of real option approach have resulted in increased attention of real options, and further leaded to applications in a variety of categories. Real options have been identified and valued in “natural resource investments, land development, leasing, flexible manufacturing, government subsidies and regulation, R&D, new ventures and acquisitions, foreign investment and strategy and elsewhere” (Trigeorgis, 2005, p. 21).

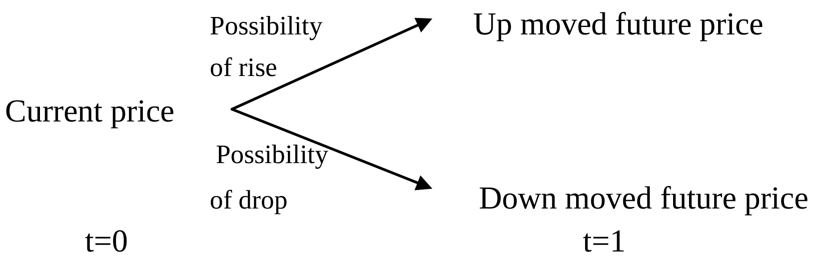
Titman (1985) showed that the value of the grossly underutilized land should not only reflect the value of its best immediate use, but also take the option value into account, i.e. defer the land investment, keep it vacant now but convert into the best use in the future. Two alternatives – valuing the land as a site for constructing a specific building right away or a potential site for constructing a building in the future – were considered, and a valuation equation for pricing the vacant lot was provided by Titman (1985). The pricing model of Titman (1985) can be adapted to the evaluations when it is rational to postpone the investment project until a future date.

McConnell and Schallheim (1983) developed a model using compound option pricing framework to evaluate several types of leasing contracts and also illustrated the influences of the various elements of the leasing contract on the equilibrium rental payments. Trigeorgis (1996) evaluated the leasing contracts with many embedded operating options by using a numeric example, and recognized the importance of computational approaches to deal with the interactions among the options present in combination.

In this thesis, an attempt is made to frame the decision on land investment in agriculture under a real option approach. The thesis will focus on three options faced by the investors: if they should lease land, when they should carry out the agricultural projects and whether they should abandon the projects before lease contracts end.

3.5 Binomial pricing model

This study relies on the binomial pricing model. According to Brealey et al. (2008) and Hull (2009), the binomial method is based on the simplification that the price of the underlying asset can only move from the current value to two possible levels, one up and one down, over a period.



The amount of the upside change and the downside change can be calculated using the volatility of the price of the underlying asset and the time interval. Besides, the up move, the down move and the volatility of price are constant over time.

A step by step binomial pricing model is presented as follows (Brealey et al., 2008):

In the hypothetical risk-neutral world, the expected return on the underlying asset must be equal to the risk-free interest rate. Hence,

Expected return = [probability of rise × upside change]
+ [(1 − probability of rise) × downside change]

Therefore, the risk-neutral probability of a rise is

$$p = \frac{\text{expected return} - \text{downside change}}{\text{upside change} - \text{downside change}} \qquad (3.5.1)$$

The up and down moves can be calculated according to the standard deviation (volatility) of returns of underlying asset:

$$1 + \text{upside change} = u = e^{\sigma\sqrt{\Delta t}} \qquad (3.5.2)$$

$$1 + \text{downside change} = d = 1/u \qquad (3.5.3)$$

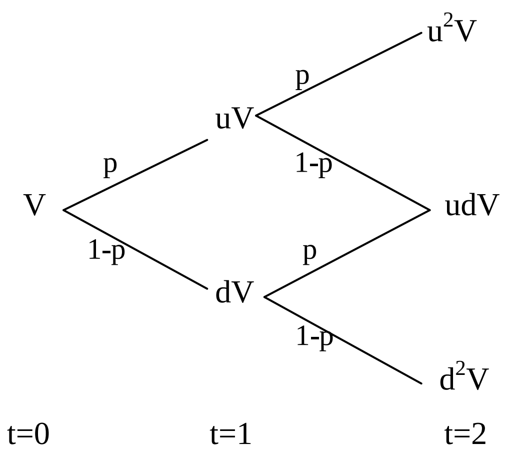
where

e = base for natural logarithms

σ = standard deviation of (continuously compounded) returns of underlying asset

Δt = time between each node, as fraction of a year

Figure 1 Binomial tree using binomial pricing model



V: current value of asset
u: 1+ upside move
d: 1+ downside move
p: probability of a rise

Then, the up move (u) and down move (d) can be used to build the value tree. At each node of the value tree, there are two possible future moves. The value can move up with the risk-neutral probability (p) and down with probability (1- p) respectively. Beginning with the current value of asset *V*, the price can either rise to *uV* with probability (p) or drop to *dV* with probability (1- p) at t=2. As d=1/u, the down move of the higher value and the up move of the lower value at t=2 will result in the same value at t=3. Therefore, there are three different values at the third node. Eventually, the value tree will be developed as the Figure 1.

At each node, the expected value of the option is

$$\frac{[\text{p} \times \text{option value if rise} + (1-\text{p}) \times \text{option value if drop}]}{1 + \text{interest rate}} \quad (3.5.4)$$

Using binomial method to calculate the option value is basically a process of solving a decision tree (Brealey et al., 2008). A tree of asset prices from present to the expiration time of the option can be developed, and the decision can be taken at each node. Start at the end nodes and work back through the decision tree to the starting node. In this way, the future pay-offs can be folded back to the present value which represents the value of the option.

The underlying asset can nearly have an unlimited number of future prices. Dividing the time interval into shorter periods does not change the fundamental method for the valuation (Brealey et al., 2008). The binomial pricing model will be more realistic and provide a more accurate evaluation of the option value if the time interval is chopped into more subperiods (Hull, 2009). The trinomial, quadranomial and multinomial trees are the extensions of binomial models and are also widely used to value options.

The binomial model is a fundamental option pricing model which allows for a wide range of applications, particularly projects with compound options. The binomial pricing model will be used in this thesis to deal with land investment in Africa in agricultural projects. Reasons behind the selection of this model refer to the time restriction and the mathematical capability of the author. Other real option pricing models are not considered in this study.

3.6 Time series data

Time series data is an important type of data used in the empirical analysis. An example of time series data can be a set of observations on the gross domestic product (GDP) which are represented by a set of data collected at discrete points in time. Time series data can be categorized into two types in terms of stationarity. A time series is said to be stationary if "its mean, variance, and autocovariance (at various lags) remain the same no matter at what point we measure them; that is, they are time invariant" (Gujarati, 2004, p. 798). On the contrary, the non-stationary time series is characterized by a varying mean or a varying variance or both over time. For a non-stationary time series, it is impossible to generalize its behavior to other time periods, i.e. it is of little value for forecasting (Gujarati, 2004).

A classic example of non-stationary time series is the random walk model. The stock prices and exchange rates are often said to follow a random walk. Two types of random walks should be distinguished: random walk without drift (i.e. no constant term) and random walk with drift (i.e. a constant term is present) (Gujarati, 2004).

The random walk without drift can be expressed as:

$$Y_t = Y_{t-1} + u_t \tag{3.6.1}$$

where u_t is called random shock, which is a error term with zero mean and constant variance σ^2. According to equation (3.6.1), the series Y_t is a random walk if the value of Y at period t is equal to its value at the previous period plus a random shock u_t.

From the equation (3.6.1), the value of Y at period t is equal to the initial value Y_0 plus the sum of random shocks at every previous period, which is to say,

$$Y_t = Y_0 + \sum u_t \tag{3.6.2}$$

Since the random shock u_t is zero mean and variance σ^2,

$$E(Y_t) = E(Y_0 + \sum u_t) = Y_0, \quad var(Y_t) = t\sigma^2 \tag{3.6.3}$$

The mean of Y is constant, however, the variance increases over time because of "the persistence of random shocks" (Gujarati, 2004, p.799). Since the conditions of stationarity are violated, the random walk without drift is a non-stationary stochastic process.

The random walk with drift can be schematized as follows:

$$Y_t = \delta + Y_{t-1} + u_t \qquad (3.6.4)$$

where δ denotes the drift. Y_t can have an upward drift with a positive δ, or a downward drift with a negative δ. In this case, the mean and variance are:

$$E(Y_t) = Y_0 + t\delta, \quad var(Y_t) = t\sigma^2 \qquad (3.6.5)$$

According to equation (3.6.5), both the mean and the variance are expected to change over time. Therefore, random walk with drift is a non-stationary stochastic process.

The random walk is also known as the unit root process in the literature. Write equation (3.6.1) in the following way:

$$Y_t = \rho Y_{t-1} + u_t \qquad -1 \leq \rho \leq 1 \qquad (3.6.6)$$

If $\rho=1$, the time series has a unit root and the above equation turns a random walk without drift (Gujarati, 2004). In the case of the unit root, time series Y_t is non-stationary. When the absolute value of ρ is smaller than one, the time series Y_t turns stationary.

3.7 The unit root test

Before the random walk process is chosen as the working model for the analysis, the non-stationarity of time series data should be tested. As mentioned in section 3.6, if the term ρ in equation (3.6.6) is equal to one, the time series is a random walk. Hence, the unit root test can be used to check whether a time series is stationary or not. The general idea behind the unit root test is to regress Y_t on Y_{t-1} and see whether the estimated ρ is statistically equal to one (Gujarati, 2004).

Manipulate equation (3.6.6) as follows:

$$Y_t - Y_{t-1} = \rho Y_{t-1} - Y_{t-1} + u_t = (\rho-1) Y_{t-1} + u_t \qquad (3.7.1)$$

Equivalently, if $\varphi = \rho - 1$, the formula above can be written as:

$$\Delta Y_t = \varphi Y_{t-1} + u_t \quad (3.7.2)$$

Instead of estimating equation (3.6.6), equation (3.7.2) is estimated and the null hypothesis becomes $\varphi = 0$. If $\varphi = 0$, then $\rho=1$. The presence of a unit root is confirmed, indicating the time series Y_t is non-stantionary.

Dickey and Fuller (1979) found out that under the null hypothesis $\varphi = 0$, the estimated *t* value of the coefficient of Y_{t-1} in equation (3.7.2) follows the τ (tau) statistics. The τ (tau) test is also known as Dickey-Fuller test. The Dickey-Fuller test is done in three forms (Gujarati, 2004):

random walk without drift: $$\Delta Y_t = \varphi Y_{t-1} + u_t \quad (3.7.3)$$

random walk with drift: $$\Delta Y_t = \beta_1 + \varphi Y_{t-1} + u_t \quad (3.7.4)$$

random walk with drift and time trend: $$\Delta Y_t = \beta_1 + \beta_2 t + \varphi Y_{t-1} + u_t \quad (3.7.5)$$

In all three cases, the null hypothesis is the same: $\varphi = 0$. If the null hypothesis is rejected, the time series Y_t is stationary.

In the Dickey-Fuller test, the error term u_t is assumed to be uncorrelated. The augmented Dickey-Fuller (ADF) test is then developed to deal with the case of correlated error terms. The ADF test is conducted by adding the lagged values ΔY_t to the above three equations. It can be formalized as:

$$\Delta Y_t = \beta_1 + \beta_2 t + \varphi Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t \quad (3.7.6)$$

where ε_t represents a white noise error term and $\Delta Y_{t-i} = Y_{t-i} - Y_{t-(i-1)}$. In ADF test, the null hypothesis H_0 is the same with Dickey-Fuller test: $\varphi = 0$.

4 Empirical study with the binomial method

This chapter is intended to provide the background and necessary description for the empirical study which could be an evaluation example for private companies to lease African land for agricultural projects.

4.1 Background of empirical study

A land lease contract, signed between a Chinese company named Hunan Dafengyuan Agriculture Co., LTD and the Ministry of Agriculture of the Federal Democratic Republic of Ethiopia, for sugar cane plantation and sugar processing in Ethiopia is chosen for the empirical study. This section aims to provide the background of empirical study in this dissertation.

4.1.1 Land lease contract in case of HDAC

The Ethiopian Ministry of Agriculture and Rural Development released the Land Rent Contractual Agreements between Ethiopia and twenty-four companies or individuals in May, 2011[8]. Among those twenty-four companies, there is only one Chinese company – Hunan Dafengyuan Agriculture Co., LTD (herein after referred to as "HDAC"). The land lease contract between the Ethiopian Ministry of Agriculture (EMA) and HDAC was executed on November 25th, 2010 (HDAC agreement, 2010). Details of the HDAC agreement (2010) is reviewed below.

The contract covers rural land of 25,000 hectares, located in Dima District in the Agnuwa Zone of Gambela Reginal State, and the land is allocated to HDAC for the purposes of Sugar Cane farming and sugar processing (article 1)[9]. This area of land is leased for 40 years but can be renewed if the renewal is agreed by both parties (article 2). This land lease contract is

[8] All contracts are now available for downloading on the website of Ministry of Agriculture, Federal Democratic Republic of Ethiopia, under the link of "Land Leased" (Internet, Ethiopian Agricultural Portal 1, 2011).

[9] Article 1 of the HDAC agreement (2010) can be referred to if needed. In section 4.1.1 of this dissertation, parenthesis in the same form represents the corresponding article of the HDAC agreement (2010).

effective from November 25th, 2010 to November 24th, 2050 (article 19).

The annual lease rate for 25,000 hectares set by the agreement in 2010 is 3,950,000 Ethiopian Birr (ETB) (article 2), which is equal to 3,376,242 ETB deflated in 2008 according to the consumer price index of Ethiopia (Internet, World Bank 3, 2012). However, EMA reserves the right to adjust the lease payment rate in consultation with HDAC (article 2).

One year down payment for the leased land should be made within 30 days in order to take over the leased land (article 4). Besides, there is a grace period of 4 years for the land rent and the rent during this period will be prorated over the remaining 35 years (article 2). Once the grace period is completed, i.e. at the beginning of the 6th year, the adjusted annual land rent which includes the prorated amount should be paid before June each year (article 4). Furthermore, EMA should "provide or cause to provide special investment privileges such as exemptions from taxation and import duties of capital goods and repatriation of capital and profits granted under the investment laws of Ethiopia" (article 6, p.5).

HDAC is expected to start the development of the leased land within six months (article 4). One-tenth of leased land should be developed within the first year, and the entire leased land should be developed within five years (article 4). The EMA has the right to restore the undeveloped land at the end of the first year, if HDAC does not complete the development of 1/10 of total area and it is given six months prior notice by EMA but still does not fulfill the requirement (article 5).

The land lease agreement can be terminated subject to written notice with "justified good cause" provided at least six months in advance (article 3, p.3). Once the land lease contract is terminated, EMA has the priority right to purchase properties over the land in negotiation with HDAC, and if this priority right is given up, HDAC can sell the properties to any third party with the written permit from the Ethiopian Ministry of Agriculture (article 10).

4.1.2 Sugar cane plantation and sugar mill in Ethiopia

The Embassy of Ethiopia provides project profiles for 100 kinds of investment opportunities on its official website[10], including the project profile on the establishment of sugar cane plantation and sugar mill[11]. This subsection is based on the financial analysis of the project profile provided by Ethiopian Embassy (2008). All the costs in this section are expressed in real 2008 ETB.

The envisaged plant in the profile is set to produce 16,000 tons of sugar per annum (3.2)[12]. The average yield of sugar cane per hectare per cropping cycle in Ethiopia is 80 tons and sugar cane cultivation has a 3-year cropping cycle (6.3). One ton of sugar cane can produce 0.1 ton of sugar (6.1). Therefore, the land requirement to provide the raw material, i.e. sugar cane, for the sugar mill is 6,000 hectares (6.3), and additional 600 hectares are needed for the seed bed of sugar cane (6.1). In addition, the site area for the envisaged plant is estimated to be 1.5 hectares including the area for production, storage and office facilities (6.3).

Table 1 Total initial investment

Items	Cost (2008 ETB)
Building and civil works	10,000,000
Office equipment	250,000
Vehicles	1,800,000
Machinery and equipment	22,500,000
Total fixed investment cost	34,550,000
Pre-production capital expenditure[13]	1,751,506
Total initial investment	36,301,506

Source: Ethiopian Embassy (2008)

The sugar mill plant is designed to work 250 days in one year in one shift (3.3). The construction period for this project is two years (8.1). Based on the assumptions that the

[10] Http://www.ethiopianembassy.org/AboutEthiopia/AboutEthiopia.php?Page=InvestmentProject.htm

[11] This profile presents the market study, sugar production program, raw materials and utilities, technology and engineering, human resource and training requirement and eventually the financial evaluation of the establishment of sugar cane plantation and sugar mill.

[12] Section 3.2 of the financial analysis provided by Ethiopian Embassy (2008) can be referred to if needed. In section 4.1.2 of this thesis, number in the parenthesis in the same form represents the corresponding section of the project profile given by Ethiopian Embassy (2008).

[13] Pre-production capital expenditure: all expenses for pre-investment studies, consultancy fee, administration expenses, commission expenses, marketing expenses during construction.

"logistics barriers would be eliminated gradually within the first three years of operation", the sugar mill plant will operate at 40% capacity in the first year, 60% in the second year, 80% in the third year and then 100% starting from the fourth year (3.3, p.4).

The total initial investment cost of this project except rents of the required land is estimated to be 36,301,506 ETB as detailed in Table 1. This amount of money should be paid at the first year in the construction period.

The production cost per annum at full capacity operation is estimated to be 4,209,921 ETB as detailed in Table 2. Based on the prediction that the plant will operate at 40% capacity in the first year, 60% in the second year and 80% in the third year (3.3), for simplicity, the corresponding production cost will be valued at 40%, 60% and 80% of total production cost for the 1st, 2nd and 3rd year, respectively.

Table 2 Annual production cost

Items	Cost (2008 ETB)
Raw materials	1,812,500
Utilities	772,000
Wages and salaries	1,275,120
Spares and maintenance	350,301
Production cost	4,209,921

Source: Ethiopian Embassy (2008)

Furthermore, the discount rate for the future cash flow is estimated to be 18% by Ethiopian Embassy (8.1). The depreciation rate of each item is given in Table 3.

Table 3 Depreciation rate

Items	Depreciation rate
Building and civil works	5%
Office equipment	10%
Machinery and equipment	10%
Vehicles	20%

Source: Ethiopian Embassy (2008)

4.1.3 Annual world sugar price

The yearly revenue is given from the sale of sugar produced by the establishment of sugar cane plantation and sugar mill. In theory, the annual net revenue can be affected by the yield of sugar cane per annum, the price of sugar and all kinds of costs. In this study, only the price of sugar is deemed to be stochastic through the process of evaluation and the average annual yield of sugar cane and operation cost given by Ethiopian Embassy are used. Therefore, the uncertainty of annual cash flow just comes from the sugar price.

The historical data of annual world sugar price – in real 2005 US Cents per KG – in the past three decades, i.e. from 1982 to 2011, are presented in Table A.1 in Appendix A. To test if the time series data is stationary or not, a unit root test could be conducted through the augmented Dickey-Fuller (ADF) test embedded in Eviews[14]. The ADF test checks the stationarity of the time series by testing the existence of a unit root. If the computed τ (tau) statistic exceeds the critical tau value, the null hypothesis of the presence of a unit root cannot be rejected (Gujarati, 2004).

Table 4 Dickey-Fuller test τ-statistics and critical values

	τ-statistic	test critical values		
		1%	5%	10%
without constant and trend	0.4430	-2.6471	-1.9529	-1.6100
with constant	-0.9195	-3.6793	-2.9678	-2.6230
with constant and trend	-1.5117	-4.3098	-3.5742	-3.2217

The time series data, i.e. annual world sugar prices from 1982 to 2011, passed the Durbin-Waston Test for autocorrelation. Therefore, the Dickey-Fuller test can be conducted and three types of regressions can be run. The tau values and p-values of Dickey-Fuller test conducted by Eviews are presented in Table 4 and the full results are shown in Table A.2 in Appendix A. The computed value of τ-statistic under every type of regression is well above the corresponding critical value at 1%, 5% and 10% level. It is quite clear that the null

[14] Eviews (Econometirc Views) is statistical software which offers solutions for econometric analysis, forecasting and simulation.

hypothesis of the presence of a unit root cannot be rejected, which is to say, the time series data is non-stationary. This means the application of the random walk model is justified.

According to Hull (2009), the formula to estimate the volatility of the expected return on an asset using historical data can be expressed as:

$$\sigma=\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\mu_i-\bar{\mu})^2} \quad where: \mu_i=\ln\left(\frac{S_i}{S_{i-1}}\right) \tag{4.1.3.1}$$

σ is the volatility of the asset price, μ_i is the expected return on the asset in period i, $\bar{\mu}$ is the average return on the asset, S_i is the asset price at the end of period i and n is the number of total observations.

The expected growth rate (drift) of annual sugar price can be calculated using the volatility (σ) and the mean of logarithmic return ($\bar{\mu}$) (Jarrow & Rudd, 1983):

$$g=\bar{\mu}+\frac{\sigma^2}{2} \tag{4.1.3.2}$$

Using the above two equations and the historical data of annual world sugar price from 1982 to 2011, the average growth rate (g) and volatility of annual sugar price (σ) is estimated at 5.03% and 24.06% respectively as shown in Table A.1. The positive average growth rate shows a general upward tendency of the annual world sugar price. Since the uncertainty refers to the volatility of annual sugar price, it will have a great impact on the decision of HDAC to lease Ethiopian land for the sugar cane plantation and sugar processing.

The land lease contract came into force in 2010. In this way, the starting value of the development of annual world sugar price in the project evaluation is the sugar price in 2010. The nominal price in 2010 is $0.4693 per kg (Internet, World Bank 1, 2012), which is equal to 5.7649 ETB deflated in 2008 according to the official exchange rate (Internet, World Bank 2, 2012) and the Consumer Price Index of Ethiopia (Internet, World Bank 3, 2012). From now on, all the values in this thesis will be expressed in real 2008 Ethiopian Birr.

4.2 Determination of input variables

The application of the theoretical framework concentrates on the variables influencing the decision of investors on the land lease for agriculture. There are several factors needed to be considered through the process of the evaluation of the HDAC investment project.

- The cost incurred in the land lease contract. In the case of HDAC, one year down payment (L_0), i.e 3,367,242 ETB, should be made once the lease contract is signed, and from the start of the sixth year, the revised annual rent (L) which includes the prorated amount of the land rent in the grace period, i.e. 3,752,070 ETB, should be paid at the beginning of each year.
- Land lease contract of HDAC case is valid for 40 years. The extension of the initial contract is not considered in this study.
- Time to maturity of given option refers to the time left until the option expired. By the end of first year, 1/10 of the total leased area should be developed and the entire land area should be developed within 5 years (HDAC agreement, 2010). If HDAC does not fulfill its obligation even with the 6 months prior written notice given by EMA, the contract will be terminated.
- The annual revenue (R) is given by the sales of sugar per annum. For the sake of simplicity, in this study, only the price of sugar is deemed to be stochastic. Therefore, the uncertainty of annual cash flow comes from the price of sugar.
- The annual volatility of sugar price (σ), risk-free discount rate (r_f) and the change in time interval (Δt) determine the probability of a rise (p), the upside move (u) and downside move (d). Using the historical data of annual sugar price from 1982 to 2011, the annual volatility and expected growth rate of sugar price is estimated to be 24.06% and 5.03% respectively in section 4.1.3.
- The land area required to prepare the sugar cane for the envisaged sugar mill is 6,000

hectares (Ethiopian Embassy, 2008). In the case of HDAC, the area of leased land is 25,000 hectares, which means the project can be four times the capacity of envisaged project given by Ethiopian Embassy. The rest of the land is assumed to be enough for the seed bed of sugar cane and the building site of the sugar mill. In this way, all the costs and revenues shall be four times the numbers provided by Ethiopian Embassy (2008), assuming constant cost and return to scale.

- The lifetime of envisaged project in the profile offered by Ethiopian Embassy is 10 years. However, the duration of land lease contract in the case of HDAC is 40 years. Therefore, this project needs to be renewed every ten years if HDAC wants to continue. Assume that the renewal of this project requires new equipment and machinery, office equipment and vehicles. Since the sugar mill works 250 days per annum (Ethiopian Embassy, 2008), the renewal can be assumed to finish within the remaining 115 days, i.e. the renewal does not affect the operation of sugar mill subsequent year.
- The salvage value is the sum of value of every item in the fixed initial investment depreciated by the corresponding depreciation rate as shown in Table 4.
- The risk-adjusted discount rate of future cash flow (r_r) is 18%, as stated in project profile (Ethiopian Embassy, 2008).
- The risk-free discount rate (r_f) is assumed to be 6% in the base case. In the chapter 5, a sensitivity test regarding a change in r_f will be done in order to show the influence of the discount rate on the decision of HDAC.
- Change in time interval (Δt) in the empirical study is chosen to be one year.
- No tax effects are considered in this study.

All the figures of input variables for the empirical study are summarized in Table 5.

Table 5 Input figures of empirical study - case of HDAC

Initial investment (2008 ETB)		**Land lease contract**	
Building and civil works	40,000,000	Lease duration (year)	40
Office equipment	1,000,000	Area (hectare)	25,000
Vehicles	7,200,000	Upfront payment (2008 ETB)	3,367,242
Machinery and equipment	90,000,000	Revised rent (2008 ETB/year)	3,752,070
Total fixed investment cost	138,200,000	Rent grace period (year)	4
Pre-production expenditure	7,006,024	**Operation scale**	
Total initial investment	145,206,024	1st operation year	40%
Production cost (2008 ETB)		2nd operation year	60%
Raw materials	7,250,000	3rd operation year	80%
Utilities	3,088,000	since 4th operation year	100%
Wages and salaries	5,100,480	**Depreciation rate**	
Spares and maintenance	1,401,204	Building and civil works	5%
Annual production cost	16,839,684	Office equipment	10%
Renewal cost (2008 ETB)		Machinery and equipment	10%
Office equipment	1,000,000	Vehicles	20%
Vehicles	7,200,000	**Others**	
Machinery and equipment	90,000,000	Annual yield of sugar (ton)	64,000
Total renewal cost	98,200,000	Construction period (year)	2
World sugar price		lifetime without renewal (year)	10
annual volatility	24.06%	Risk-adjusted discount rate	18%
Annual expected growth rate	5.03%	Risk-free discount rate	6%
current price (2008ETB/kg)	5.7649		

Source: HDAC agreement (2010), Ethiopian Embassy (2008), World Bank (Internet, 2012)

4.3 Empirical study description

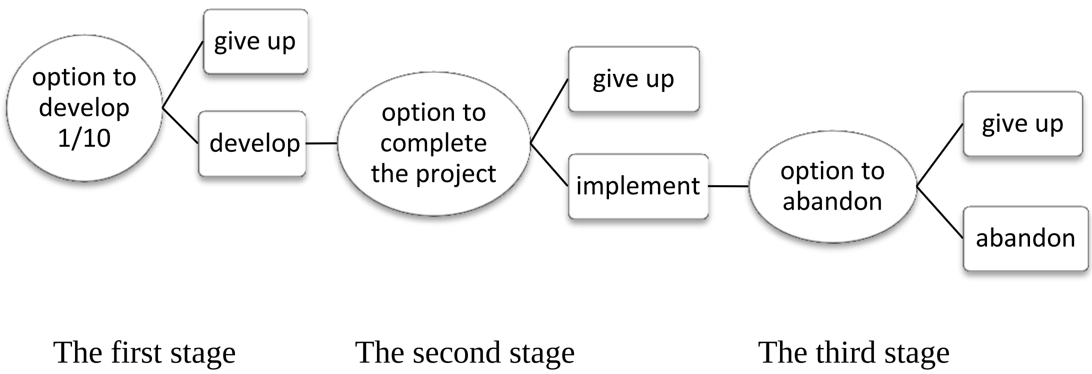
This section aims at illustrating how to estimate an investment on land acquisition for agricultural project using the binomial model.

According to the land lease contract, HDAC should develop 1/10 of the total leased area within one year. Since one year down payment has been made when the lease contract was signed, if HDAC give up development, the loss incurred will be given by the one year down payment. The entire plot of the leased land should be developed within five years, while the construction period of the whole project is two years. That is to say, the enterprise has three years indeed to determine whether to implement the whole project. Therefore, the deadline for decision should be at the beginning of the fourth year. Due to the fixed duration of land lease contract, the “wait and see” strategy shortens the lifetime of this project.

The project will operate at 40%, 60% and 80% capacity in the 1st, 2nd and 3rd operating year respectively. From the 4th operating year, the project can operate at full capacity. The reason for this prediction is “logistics barriers would be eliminated gradually” because of the accumulation of experience during the first three operating years (Ethiopian Embassy, 2008, p.6). In this way, the project can be assumed to operate at 100% capacity after renewal. Since the lifetime of this project given by Ethiopian Embassy (2008) is ten years, HDAC should consider whether to renew the project every ten years. In addition, it is assumed that the abandonment can be made in exchange of salvage value throughout the lifetime of this project.

Evaluation of this investment can be done by splitting it into three stages, and there is one option embedded in every stage, which is showed in Figure 2.

Figure 2 Illustration of options embedded in case of HDAC



- The first stage gives HDAC the right, but not the obligation, to develop the 1/10 of total leased land within the first year. This right can be treated as a call option with the required investment cost as the exercise price. The call option will expire after one year.
- The second stage gives HDAC the right, but not the obligation, to complete the project.

This right can be viewed as a call option and exercise price is the total initial investment less the expenses made in the first stage. The call option allows the enterprise to decide whether or not to complete the project within three years.

- The third stage gives HDAC the right, but not the obligation, to abandon the whole project. This right is actually a put option with the salvage value as the exercise price. This put option can be exercised at the cost of the expected value of continuing the project. Abandonment can be made throughout the lifetime of the agricultural project.

However, whether to exercise the first option depends upon the value of the second option and whether to exercise the second option depends on the future cash flows, which are further related to the decisions on abandonment. Therefore, the project evaluation requires that the value of the third stage option should be first determined and then the value of the second stage and finally the value of first stage option.

- The abandonment of the project can be considered every year throughout the lifetime of the project and the decision should be made according to the comparison between salvage value and continuation value at that node. The continuation value is calculated using equation (3.5.4). When the continuing value of the project does not exceed the salvage value, it would be better to give up.

- The exercise of the option to complete the project is determined on the basis of the project value tree in the third stage. Since the option is valid until the beginning of the fourth year (i.e. at node t=3 in the decision tree), the decision maker can choose to invest immediately, wait or abandon at the beginning of the first, second and third year (i.e. at node t=0, t=1, t=2 respectively) and to invest immediately or abandon at the beginning of the fourth year (i.e. at node t=3).

- The option to develop the required 1/10 of leased land is decided based on the decision tree in the second stage. Right after obtaining the option to develop the 1/10 of leased land (i.e. at node t=0), investor can choose to develop immediately, wait or abandon. If the option is kept alive at node t=0 in the decision tree, the investor can choose to develop or abandon at node t=1.

Using the annual volatility of world sugar price (σ), the expected growth rate of sugar price per year (g), the risk-free interest rate (r_f) and also the change in time interval (Δt), the up move (u), down move (d) as well as the risk-neutral probability of rise (p) can be calculated. The binomial tree of annual revenues given by the sales of sugar can be built. Subsequently, the value of options can be determined. Eventually, the optimal strategy of HDAC can be obtained. The detailed evaluation process under RO approach will be presented in section 5.1.2.

5 Analysis and discussion

This chapter aims at developing a decision-making model to investigate the effects of some external factors on the decision of private companies to lease African land for agricultural projects. The case of HDAC in Ethiopia is analyzed and the evaluation results of NPV approach and ROA are compared. Additionally, sensitivity studies will be presented to illustrate the effects of variables of interest on the decision of HDAC.

5.1 Evaluation of the HDAC case

This section aims at evaluating the project value under NPV approach and ROA. The binomial pricing model is used for ROA. Eventually, the value of options embedded in this project can be estimated.

5.1.1 NPV approach

Based on the input variables listed in section 4.2, it is straightforward to get the NPV of this potential project. All the necessary figures of input variables for this evaluation are summarized in Table 5.

Table 6 shows how the spreadsheet is set up to evaluate the value of the project. The cost of initial investment should be paid at t=0 and the cost of renewal should be paid every ten operating years, i.e. at t=11, 21 and 31. According to the gradually increasing operating scale, the production cost and the quantity of sugar produced during the first three operating years are reduced proportionally. Furthermore, the annual sugar price is expected to grow at the rate of 5.03%. In addition, the annual revenue generated by the sales of sugar is discounted by the risk-adjusted discount rate, while the risk-free discount rate is used to discount the annual land rent, the production cost and the salvage value.

As shown in Table 6, the conventional NPV of this project is estimated at 1,831.560 million 2008ETB. According to the conventional NPV criterion, the land lease of HDAC in Ethiopia for sugar cane plantation and sugar mill is worth investing in.

Table 6 HDAC project evaluation using NPV approach (million 2008ETB)

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
annual rent	3.367					3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752
initial investment	145.206											98.200									
production cost			6.736	10.104	13.472	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840
annual sales			162.802	256.486	359.183	471.562	495.281	520.194	546.360	573.842	602.706	633.022	664.863	698.306	733.430	770.322	809.069	849.765	892.508	937.402	984.553
salvage value												32.503									
PV*	-148.573	0.000	110.927	147.622	174.591	190.737	168.951	149.607	132.433	117.188	103.657	57.042	80.999	71.550	63.171	55.742	49.157	43.322	38.152	33.574	29.521
NPV	**1,831.560**																				

Table 6 HDAC project evaluation using NPV approach (million 2008ETB) : continued

year	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
annual rent	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752	3.752
initial investment	98.200										98.200								
production cost	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840	16.840
annual sales	1034.076	1086.090	1140.720	1198.099	1258.363	1321.659	1388.138	1457.961	1531.297	1608.321	1689.220	1774.187	1863.429	1957.159	2055.604	2159.001	2267.599	2381.659	2501.457
salvage value	32.503										32.503								
PV*	6.609	22.761	19.954	17.474	15.282	13.346	11.638	10.131	8.803	7.633	-4.188	5.697	4.900	4.201	3.588	3.051	2.581	2.170	6.560
NPV																			

5.1.2 RO approach

5.1.2.1 Value tree of annual sugar sales

To develop the value tree of this project, the annual volatility of world sugar price (σ), the risk-free interest rate (r_f) and the change in time interval (Δt) should be substituted in to equation (3.5.2), (3.5.3) and (3.5.1) respectively to obtain the up move (u), down move (d) as well as the risk-neutral probability of rise (p).

$$u = e^{\sigma\sqrt{\Delta t}} = e^{0.2406\sqrt{1}} = 1.272;\ d = e^{-\sigma\sqrt{\Delta t}} = e^{-0.2406\sqrt{1}} = 0.786$$

$$p = \frac{e^{r_f\sqrt{\Delta t}} - e^{-\sigma\sqrt{\Delta t}}}{e^{\sigma\sqrt{\Delta t}} - e^{-\sigma\sqrt{\Delta t}}} = \frac{e^{0.06\sqrt{1}} - d}{u-d} = 0.567;\ 1-p = 0.433$$

Then, the up move (u), down move (d) and expected growth rate of sugar price per year (g) are then used to build the value tree of yearly revenue. At each node of the value tree, there are two possible future moves. The annual revenue (R) at present can move up to u(1+g)R with risk-neutral probability (p) or down to d(1+g)R with probability (1－p). Beginning with the annual revenue at t=0, which is $3.690*10^8$ ETB, the revenue can either rise to $4.929*10^8$ ETB with probability of 0.567 or drop to $3.046*10^8$ ETB with probability of 0.433 at t=1. Each of these values will either move up or down over the next period with probability of (p) or (1-p) respectively. As d=1/u, the down move of $4.929*10^8$ ETB and the up move of $3.046*10^8$ ETB at t=1 will result in the same value at t=2. Eventually, the value tree of the annual sales will be developed as the Table B.1 in Appendix B.

5.1.2.2 Seven scenarios of project implementation

Having determined of the value tree of annual sugar sales, the future payoffs at each node in every possible circumstance can be calculated. As the duration of lease contract is fixed, the time to complete the development of this project determines the maximal lifetime of this project. With reference to section 4.3, HDAC should decide whether to develop the 1/10 of leased land by the end of first year and the rest of land by the end of the third year. In this way, seven distinct scenarios can be created with regard to the different combinations of the time to develop the 1/10 and the remaining 9/10 of the total leased land area:

a. To develop the entire area at t=0.
b. To develop 1/10 of land at t=0, the rest at t=1.
c. To develop 1/10 of land at t=0, the rest at t=2.
d. To develop 1/10 of land at t=0, the rest at t=3.
e. To develop the entire area at t=1.
f. To develop 1/10 of land at t=1, the rest at t=2.
g. To develop 1/10 of land at t=1, the rest at t=3.

The scenarios above imply that HDAC actually has seven specific choices. The project value in every possible scenario will be estimated and then compared in order to choose the optimal implementation strategy.

5.1.2.3 Steps of project evaluation

The calculation of the project value should start with the payoffs at the end node (t=39) and then work back through the decision tree to the beginning point (t=0). The terminal cash flows at the end nodes are the sum of net revenue and the salvage value of this project at that time, i.e. the terminal payoff V= (R–P–L)+S, where *R* denotes the annual sales, *P* represents the annual production cost, *L* denotes the adjusted annual rent and *S* is the salvage value. The salvage value (S) in million 2008ETB can be expressed as: $S= 40*(1–5\%)^{t1} +1*(1–10\%)^{t2} +7.2*(1–20\%)^{t2} +90*(1–10\%)^{t2}$, where t_1 denotes the years that building and civil works have been utilized and t_2 is the years that office equipments, vehicles and machinery have been used. As the duration of land lease contract is fixed, the starting date of the entire project directly affects salvage value. For instance, if the entire project is carried out immediately like scenario (a), the maximal lifetime of the project would be 38 years; if the project is completed as specified in scenario (d) and (g), the maximal lifetime of the project is shorten to 35 years. The different lifetime of this project leads to different salvage values at the end node and then results in different terminal payoffs.

Subsequently, HDAC should decide whether to continue or not at the other nodes where the project is operated. Besides the net agricultural revenue (R–P–L) at the specific node, if the option to abandon is exercised, the following payoff is given by the salvage value at that moment; otherwise, it will be the value of continuing project. That is to say, the accumulated payoffs from the terminal node to the current node are determined by the formula below:

$$R-P-L+\mathrm{Max}\left[S,\left(pV_u+\left(1-p\right)V_d\right)e^{-r_f\sqrt{\Delta t}}\right] \tag{5.1.2.3.1}$$

where V_u, V_d is the up moved and down moved project value in the next period respectively; p is the risk-neutral probability of a rise and r_f is the risk-free discount rate. Whether to continue this agricultural project depends on the comparison between the salvage value and continuation value. When the continuation value, i.e. $(pV_u + (1-p)V_d)\,e^{-r_f\sqrt{\Delta t}}$, overweighs the salvage value, the enterprise will choose to continue; otherwise, it is better to bail out.

The option to renew should be considered every ten operating years. If the enterprise chooses to continue with the project, then office equipments, vehicles and machinery should be renewed. However, if the renewal is given up, the project is then abandoned. The payoff in the last year of every ten-year period can be expressed as:

$$R-P-L+\mathrm{Max}\left[S,\ (pV_u+(1-p)V_d)e^{-r_f\sqrt{\Delta t}}-I_R+S_R\right] \tag{5.1.2.3.2}$$

where I_R denotes the cost of renewal; S denotes the salvage value of entire project at this specific node; S_R denotes salvage value of the items renewed in the last year of every ten-year period, and $S_R = 1*(1-10\%)^{10} + 7.2*(1-20\%)^{10} + 90*(1-10\%)^{10} = 32.503$ million 2008ETB. If the renewal is decided, the expected value shall be $S_R - I_R + \left(pV_u+\left(1-p\right)V_d\right)e^{-r_f\sqrt{\Delta t}}$.

Furthermore, the annual revenues and production costs in the first three production years will be reduced proportionally according to the corresponding operation scale. In addition, the grace period of land rent is 4 years, from t=1 to t=4. The annual adjusted land rent (L) will be paid starting from t=5.

After the determination of the option to abandon in the third stage, the option in the second stage can be determined. Since the option to complete the project should be exercised at the cost of 9/10 of total initial investment cost, the return can be estimated using the following formula:

$$\text{Max}\left[\left(pV_u + (1-p)V_d\right)e^{-r_f\sqrt{\Delta t}} - I_2,\ 0\right] \qquad (5.1.2.3.3)$$

where I_2 represents investment required to complete the project, which is 9/10 of total initial investment cost. Since the construction period is still in the grace period of land rent, no annual land rent occurs here. If current accumulated project value is bigger than the investment cost (I_2), it is optimal to carry out the rest of the project; otherwise, it is better to bail out.

In the first stage, the option to develop the required 1/10 of leased land can be exercised at the cost of necessary investment (I_1), or left unexercised. If the decisions of first-stage option and second-stage option are made in separated period, value of this first-stage option can be calculated as follows:

$$\text{Max}\left[\left(pV_u + (1-p)V_d\right)e^{-r_f\sqrt{\Delta t}} - I_1,\ 0\right] \qquad (5.1.2.3.4)$$

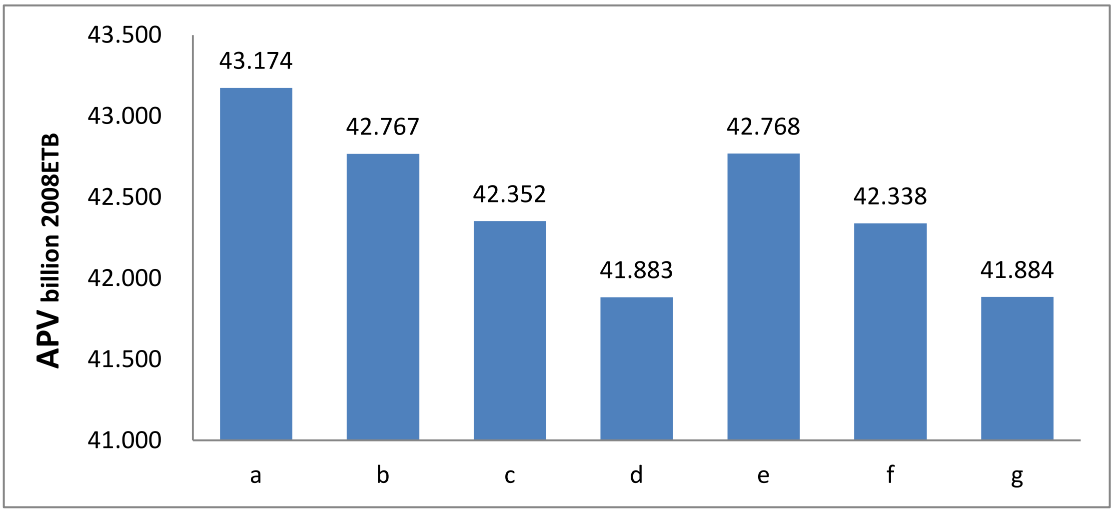
With the positive value, HDAC will decide to develop the 1/10 of project to keep the sequential options alive. Otherwise, the first stage option will be given up. Moreover, if the second-stage option is exercised right after the exercise of the first-stage option, i.e. the 1/10 and 9/10 of project is decided to be undertaken at the same node, just as scenario (a) and (e), the cost to exercise these two options will be the total cost of initial investment (I). The decision criterion is the same, i.e. go ahead with positive payoff and reject with zero.

According to the step-by-step calculation, the project value at t=0 in every scenario can be evaluated. At t=0, the land lease contract can be signed and the one year down payment should be made immediately. The expected value of this project less the one year down payment will be the APV of this land investment opportunity of HDAC. If the APV is positive, this project is worth investing in.

5.1.2.4 Evaluation results

As mentioned in section 5.1.2.2, in this empirical study, there are seven scenarios with regard to the time of the 1/10 development and the time to carry out the rest of the project. The project value at t=0 in each scenario is evaluated and the results are presented in Figure 3. The results in different scenarios can be compared to figure out the optimal investment strategy. Clearly, the maximal value is 43.174 billion 2008ETB given by scenario (a). Since the APV is positive, this project is worth investing in. The optimal strategy for HDAC is obtained: HDAC should sign the contract and start the development of the entire land and implementation of the whole project at t=0. The value tree of HDAC project in scenario (a) is presented in Table B.2 in Appendix B.

Figure 3 APV of HDAC project in seven scenarios



This result is straightforward. Since the duration of the contract is fixed, adopting the "wait and see" strategy actually shortens the maximal lifetime of the project. Hence, HDAC is facing a trade-off between the benefit of "wait and see" strategy and the benefit of an early investment. In this case study, the current sugar price results in the annual sales of 368.954 million 2008ETB, which is sufficient to cover the total cost of the initial investment of 145.206 million, the annual rent of 3.367 million and the production cost of 16.840 million. Since the project is truly profitable, "wait" means "loss". Therefore, it makes sense to exercise the option to develop the entire leased land right away.

5.1.3 Evaluation results: NPV vs. APV

The value of the project invested by HDAC in Ethiopia under NPV approach is 1.832 billion 2008ETB, which means this project is worth investing in and should be accepted according to the conventional NPV criterion. However, the APV of this project under RO approach is 43.174 billion 2008ETB, which is 23 times greater than the conventional NPV of this project, indicating a much more profitable investment opportunity that shouldn't be missed. Furthermore, the optimal investment strategy given by RO approach is to develop the entire area of leased land and undertake the whole project immediately.

According to the equation (3.3.1.1), the real options embedded in this project are worth 41.342 billion 2008ETB. That is to say, the managerial flexibility, which allows HDAC to collect information regarding the future sugar price and then act in response, is of great value since the gain in the future can be fully grasped while the loss can be avoided.

5.2 Sensitivity study to changes in the input variables

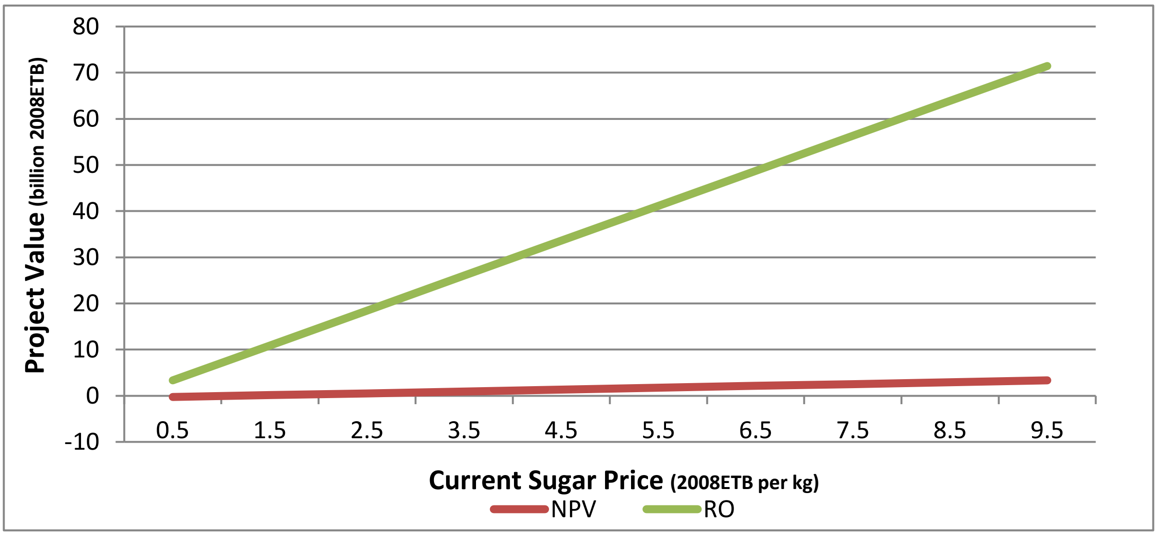
This section examines how the evaluation results of NPV approach and ROA respond to changes in some input variables in the case of HDAC.

5.2.1 A change in the current sugar price

The sugar price which is the price of final product of this sugar cane plantation and sugar processing project can serve as an indicator for the future annual cash inflow. The different cases elaborated in this sensitivity test use the current sugar price varying from 0.5 ETB per kg to 9.5 ETB per kg, while the other input variables remain constant. The results of this simulation are illustrated in Figure 4 as well as Table C.1 in Appendix C.

As shown in Figure 4, a positive relationship between current sugar price and the project value is observed, no matter which evaluation approach is used. An increase in the current sugar price will boost the annual revenue generated by the sale of sugar and then lead to an increase in the project value. Furthermore, the breakeven point under NPV approach is calculated to be 1.178 2008ETB per kg. In this way, the project is still profitable under the NPV criterion even if the current sugar price reduces to 1.781 2008ETB per kg (i.e. the lowest sugar price in the collected historical data). In addition, the APV of project evaluated using RO approach is still positive even when the current sugar price is only 0.5 2008ETB per kg, i.e. the APV still implies a good opportunity to invest.

Figure 4 A change in the current sugar price

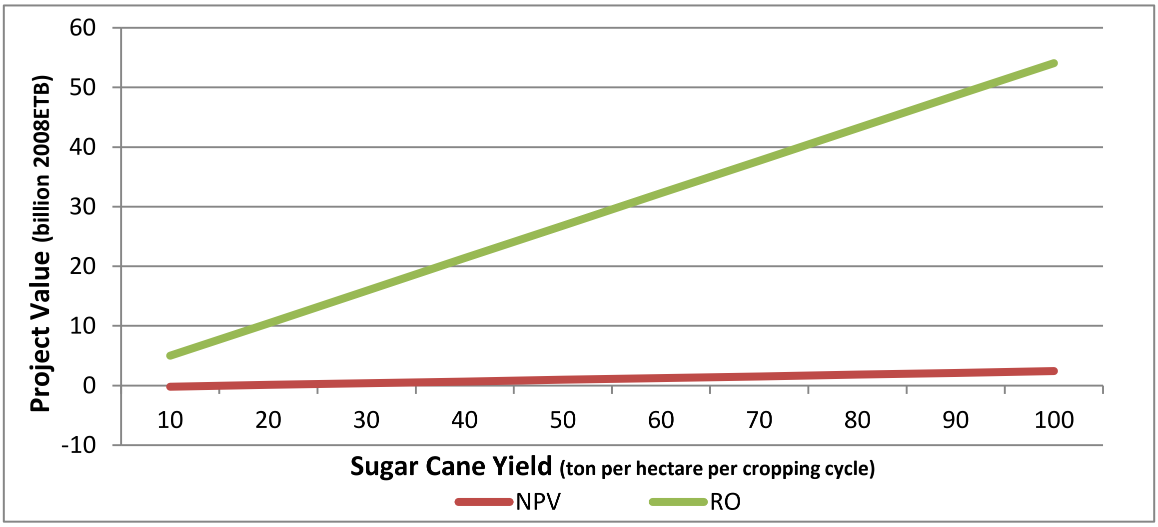


5.2.2 A change in the average yield of sugar cane

Since sugar cane is the key input of sugar processing, the yield of sugar cane is strongly linked to the agricultural revenue in that year. This sensitivity analysis in this section is done by varying the average yield of sugar cane from 10 to 100 tons per hectare per cropping cycle. The other input variables are kept constant. The effect of the average yield of sugar cane on the project value is demonstrated in Figure 5 as well as Table C.2 in Appendix C.

The results show that there exist a positive relationship between the average yield of sugar cane and the project value. The average yield of sugar cane given by Ethiopian Embassy is 80 tons per hectare per cropping cycle. If the real annual yield decreases from the value in the base case, the project value also decreases. The breakeven point under the NPV approach is 16.342 tons per hectare per cropping cycle. As long as the annual yield is above this value, the project is worth investing in. Under the RO approach, the APV of the project is positive even if the annual yield of sugar cane is 1/8 of the value given by Ethiopian Embassy, i.e. the APV still implies a good opportunity to invest when the average yield of sugar cane is only 10 tons per hectare per cropping cycle.

Figure 5 A change in the average yield of sugar cane

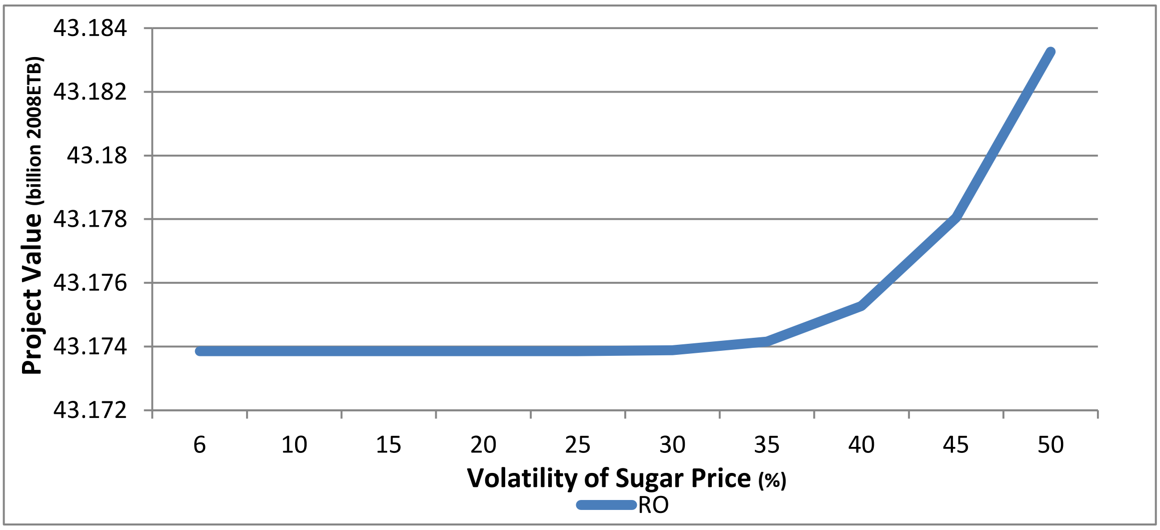


5.2.3 A change in the volatility of sugar price

Since the uncertainty of annual cash flow comes from the price of sugar, the volatility of sugar price reflects the volatility of annual revenue. The analysis in this section is done by varying price volatility from 6% to 50% and the other inputs are kept constant. The evaluation results are presented in Figure 6 and Table C.3 in Appendix C (Table C.3 also includes the calculated parameters *p*, *1-p*, *u* and *d*).

Overall, the results show that the volatility of sugar price is positively related to the APV of this project. Increasing the volatility of current sugar price from 6% to 50% produces a rise in the project value by of 9.410 million 2008ETB. This conclusion accords with the real option theory that, higher volatility will lead to higher benefits since the gain on the upside can be grasped while the loss on the downside is limited (Trigeorgis, 2005).

Figure 6 A change in the volatility of sugar price



The fact that project value is not very sensitive to the volatility (σ) over the range of 6% to 25% can be explained as follows. There are twofold effects of σ on the decision model. On one hand, the up move (u) increases and the down move (d) decreases due to the increase of σ. On the other hand, the risk-neutral probability of price rising (p) decreases when σ grows. However, as the hypothetical risk-neutral world is assumed, the expected return on the underlying asset must be equal to the risk-free interest rate. If no option to abandon is exercised, the expected return will be the same, i.e. the two impacts cancel out. Therefore, the project value will remain the same when no option to abandon is exercised in the decision tree. When σ = 12%, the option to abandon is exercised in the worst case at t=38, and this is the only case where option to abandon is exercised. For a 40-year project, the effect of one exercised abandonment option at t=38 on the whole project value is negligible. When σ increases to a much higher value, the number of exercised options to abandon becomes larger. In this way, the downside changes are well-protected by abandonment while the upside change can be fully utilized. This will lead to a higher value of project evaluated using ROA.

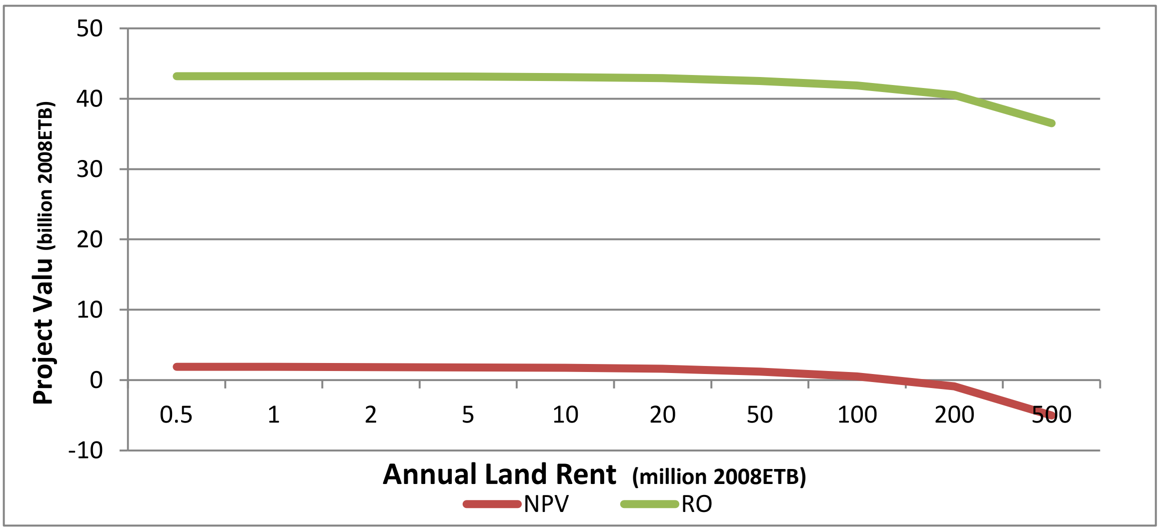
5.2.4 A change in the annual land rent

In the empirical study, the right to adjust the rent in consultation with HDAC is reserved by MAE. This section is aiming at studying the effect of total annual land rent on the decision of HDAC. The sensitivity analysis is done by varying the yearly land rent from 0.5 million

2008ETB to 500 million 2008ETB for leased 25,000 hectares and all the other input variables are kept constant. The results are presented in Figure 7 as well as Table C.4 in Appendix B.

In general, the value of project decreases with an increase in the annual land rent, regardless of the evaluation method. Since the annual sales of sugar calculated using current sugar price is 368.954 million ETB, when the land rent is much smaller than the sales, the effect of the changes in land rent on decision making of HDAC is negligible. The breakeven point under NPV approach is 136.123 million 2008ETB, which is 40 times higher than the rent set in the land lease contract. As long as the land rent is below 136.123 million 2008ETB, the project can be accepted according to the conventional NPV criterion. However, the APV is still positive even with annual land rent of 500 million 2008ETB. Therefore, the project of sugar cane plantation and sugar procession is still profitable under the RO assessment.

Figure 7 A change in the annual land rent



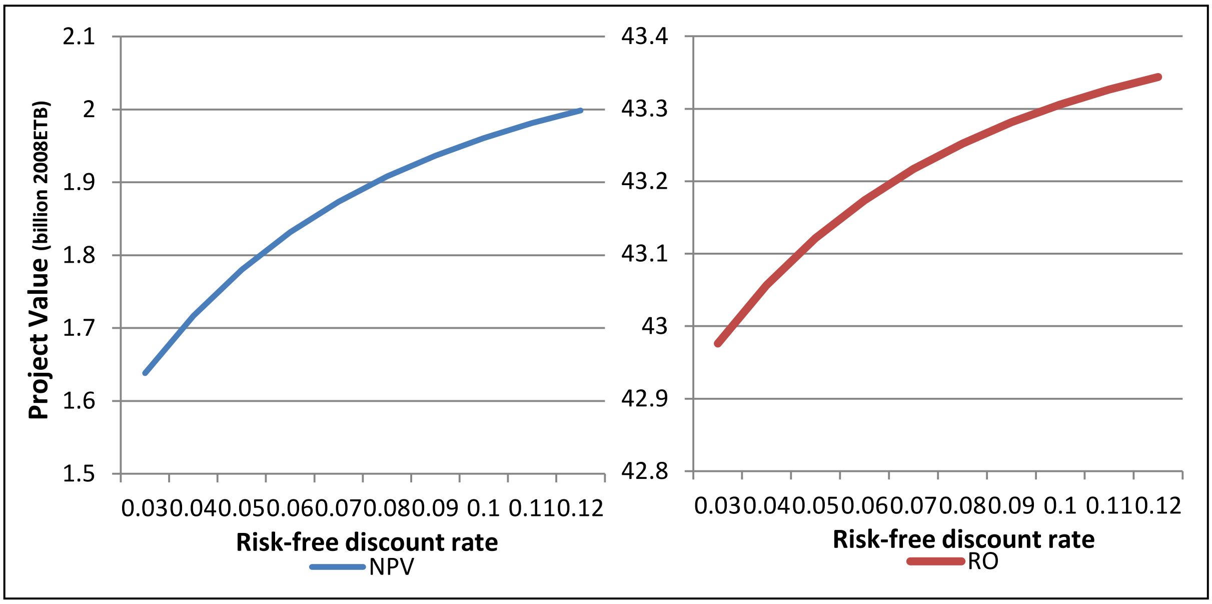
5.2.5 A change in the risk-free discount rate

This section aims at the sensitivity study of changes in risk-free discount rate (r_f). The sensitivity analysis is done by varying the risk-free discount rate from 3% to 12% and all other variables are kept constant. The evaluation results are illustrated in Figure 8. All calculation results can be found in Table C.5 in Appendix C.

The results show a positive relationship between the risk-free interest rate and the project value, no matter which evaluation approach is used. Higher risk-free discount rate boosts the project value. Since both the NPV and APV are positive, this project is worth investing in and can be accepted by HDAC.

The effect of the risk-free discount rate (r_f) on the project value evaluated using the NPV approach is easy to understand. The risk-free discount rate is used to discount the costs and salvage value in the NPV approach. The higher the r_f is, the lower the present values of costs and salvage value will be. Compared with costs, the salvage value is relatively small. In this way, the effect of r_f on the PV of costs will overweigh the effect of r_f on the PV of the salvage value. Therefore, an increase of r_f will lead to a decrease of the PV of costs, and finally an increase in the project value.

Figure 8 A change in the risk-free discount rate



The effect of risk-free discount rate on the decision model using ROA is twofold. On one side, the value of project is discounted at a higher rate when r_f grows. On the other hand, the higher r_f means higher expected rate of return, which results in a higher risk-neutral probability of a rise (p). The second effect overweighs the first effect, so the increase of risk-free discount rate can boost the value of project. The discount factor (e^{-rf}), risk-neutral probability of a rise (p) and risk-neutral probability of a drop (1-p) can be found in Table C.5.

6 Conclusions and suggestions for future researches

The aim of this thesis is to examine the profitability of land leases in Africa for agricultural purposes. The factors that can influence the willingness of private corporations to lease African land and then implement the land development projects are taken into account.

In this thesis, a land lease contract, signed between a Chinese company named Hunan Dafnegyuan Agriculture Co., LTD and the Ministry of Agriculture of the Federal Democratic Republic of Ethiopia, for sugar cane plantation and sugar processing in Ethiopia is chosen for the empirical study. Both the net present value approach and the real option approach are used for the project evaluation. The effects of variables on the decision making of the investor are also analyzed in this study.

According to the evaluation results, the project value under NPV approach is 1.832 billion 2008ETB, while the project value under RO approach is 43.174 billion ETB. No matter which approach is used for evaluation, the project of HDAC is worth investing in. Furthermore, the fact that the APV is 23 times greater than the conventional NPV implies that the real options embedded in this project are considerably valuable. Therefore, this project is much more profitable under ROA since the value of managerial flexibility is added into the project value. Besides, the optimal strategy for HDAC is to develop the entire area of land and undertake the whole project immediately.

In addition, the project value is subject to the value of some exogenous variables. The sensitivity tests illustrate how the exogenous parameters affect the decision of HDAC. An increase in the current sugar price, the average yield of sugar cane, the volatility of sugar price or the risk-free discount rate can boost the project value. However, the rising annual land rent has negative impact on the project value. The estimated project value is very sensitive to the changes in the current sugar price and the average yield of sugar cane. In the case of HDAC in Ethiopia, compared with the annual agricultural revenue, the land rent per annum is so small that the effect of a relatively small change on the project value is negligible.

The availability of empirical data and time factor put some limitations on the research. In order to enrich current research, there are several aspects that can be considered in future studies.

Land investment in Africa for the agricultural purposes is encouraged by origin countries as well as host countries. The profitability of agricultural projects can also be influenced by incentive policies such as low-cost loans, subsidies and tax deductions. For the future studies, the incentive policies can be taken into account.

Moreover, in this thesis, the average yield of sugar cane is used and the costs of investment and operation are deemed to be fixed through the process of project evaluation. Uncertainty of annual cash flow only comes from the sugar price. Since the yield of sugar cane also fluctuates randomly over time due to the changeable weather, it can be considered as another source of uncertainty of future agricultural revenues in future researches.

Expropriation risk, which can be defined as "the forced divestment of equity ownership of a foreign direct investor, including nationalization and confiscation", is a threat for foreign direct investment (Clark, 2003, p.1). Clark (2003) examined the investor's cost of expropriation risk and linked it to the value of government's option to expropriate. Based on the pricing model developed by Clark (2003), the cost of expropriation risk of the investor can be factored into the project evaluation model in future studies.

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Appendix A

Table A. 1 Annual world sugar price and the time series analysis

Year	Nominal Price (US cents per kg)	Real Price (2005 US cents per kg)	$Ln(RP_t / RP_{t-1})$*
1982	18.56	25.08	
1983	18.67	25.91	0.032695
1984	11.47	16.27	-0.465354
1985	8.95	12.83	-0.237680
1986	13.34	16.63	0.259392
1987	14.90	16.95	0.018980
1988	22.47	24.00	0.348064
1989	28.21	30.31	0.233506
1990	27.67	28.61	-0.057703
1991	19.76	20.50	-0.333653
1992	19.96	20.44	-0.002587
1993	22.10	22.42	0.092395
1994	26.70	27.06	0.188115
1995	29.28	27.17	0.004033
1996	26.36	25.24	-0.073622
1997	25.07	25.60	0.014206
1998	19.67	21.13	-0.191906
1999	13.81	15.16	-0.331900
2000	18.04	20.19	0.286217
2001	19.04	22.44	0.105850
2002	15.18	18.01	-0.220153
2003	15.63	17.33	-0.038385
2004	15.80	16.27	-0.063378
2005	21.79	21.79	0.292494
2006	32.59	31.90	0.380979
2007	22.22	20.46	-0.443948
2008	28.21	24.10	0.163759
2009	40.00	36.59	0.417534
2010	46.93	41.56	0.127305
2011	57.32	46.62	0.114921
The standard deviation of the logarithmic return (σ)			0.240596
The mean of the logarithmic return ($\bar{\mu}$)			0.021385
The mean of the geometric return (g)			0.050329

* $Ln(RP_t / RP_{t-1})$ is the μ_i in equation (4.1.3.1) and RP_t denotes the real price in period *t*.

Source: The nominal and real sugar prices are provided by World Bank (Internet, 2012). The calculations of standard deviation and mean are done by the author.

Table A. 2 The results of Dickey-Fuller tests

Exogenous: None			Lag length: 0 (Fixed)	
	Coefficient	Std. Error	t-Statistic	Prob.
sugar price(-1)	0.019318	0.043609	0.442995	0.6612
R-squared	-0.011067	Mean dependent var		0.743017
Adjusted R-squared	-0.011067	S.D. dependent var		5.612322
S.E. of regression	5.643292	Akaike info criterion		6.332686
Sum squared resid	891.7087	Schwarz criterion		6.379834
Log likelihood	-90.82395	Hannan-Quinn criter.		6.347452
Durbin-Watson stat	1.799021			

Exogenous: Constant			Lag length: 0 (Fixed)	
	Coefficient	Std. Error	t-Statistic	Prob.
sugar price(-1)	-0.149465	0.164161	-0.910478	0.3706
C	4.206312	3.944852	1.066279	0.2957
R-squared	0.029788	Mean dependent var		0.743017
Adjusted R-squared	-0.006146	S.D. dependent var		5.612322
S.E. of regression	5.629541	Akaike info criterion		6.360405
Sum squared resid	855.6768	Schwarz criterion		6.454701
Log likelihood	-90.22587	Hannan-Quinn criter.		6.389937
F-statistic	0.828971	Durbin-Watson stat		1.591623
Prob(F-statistic)	0.370627			

Exogenous: Constant, Linear Trend			Lag length: 0 (Fixed)	
	Coefficient	Std. Error	t-Statistic	Prob.
Sugar price(-1)	-0.250791	0.165903	-1.511673	0.1427
C	2.987962	3.826240	0.780913	0.4419
Trend(1)	0.237746	0.126272	1.882804	0.0710
R-squared	0.146199	Mean dependent var		0.743017
Adjusted R-squared	0.080522	S.D. dependent var		5.612322
S.E. of regression	5.381623	Akaike info criterion		6.301554
Sum squared resid	753.0084	Schwarz criterion		6.442999
Log likelihood	-88.37254	Hannan-Quinn criter.		6.345853
F-statistic	2.226029	Durbin-Watson stat		1.643998
Prob(F-statistic)	0.128126			

Appendix B

Table B. 1 Value tree of annual sales of sugar (10^8 ETB deflated in 2008)

t	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
R	3.690	4.929	6.585	8.798	11.754	15.703	20.980	28.029	37.446	50.028	66.837	89.294	119.296	159.379	212.930	284.473	380.054	507.750	678.352	906.274	1210.777	1617.591
		3.046	4.070	5.438	7.265	9.705	12.966	17.323	23.143	30.919	41.308	55.187	73.730	98.503	131.599	175.816	234.889	313.811	419.249	560.115	748.310	999.738
			2.515	3.361	4.490	5.998	8.014	10.706	14.304	19.109	25.530	34.108	45.568	60.879	81.334	108.662	145.171	193.948	259.113	346.174	462.487	617.879
				2.077	2.775	3.707	4.953	6.617	8.840	11.810	15.779	21.080	28.163	37.626	50.268	67.157	89.722	119.868	160.143	213.950	285.836	381.875
					1.715	2.291	3.061	4.090	5.464	7.299	9.752	13.028	17.406	23.254	31.068	41.506	55.452	74.083	98.975	132.230	176.658	236.015
						1.416	1.892	2.528	3.377	4.511	6.027	8.052	10.758	14.372	19.201	25.652	34.272	45.787	61.171	81.724	109.182	145.867
							1.169	1.562	2.087	2.788	3.725	4.977	6.649	8.883	11.867	15.854	21.181	28.298	37.806	50.509	67.479	90.152
								0.965	1.290	1.723	2.302	3.076	4.109	5.490	7.334	9.799	13.091	17.489	23.366	31.216	41.705	55.717
									0.797	1.065	1.423	1.901	2.540	3.393	4.533	6.056	8.091	10.809	14.441	19.293	25.775	34.436
										0.658	0.879	1.175	1.570	2.097	2.802	3.743	5.000	6.680	8.925	11.924	15.930	21.283
											0.543	0.726	0.970	1.296	1.731	2.313	3.090	4.129	5.516	7.369	9.846	13.154
												0.449	0.600	0.801	1.070	1.430	1.910	2.552	3.409	4.555	6.085	8.129
													0.371	0.495	0.661	0.884	1.180	1.577	2.107	2.815	3.761	5.024
														0.306	0.409	0.546	0.730	0.975	1.302	1.740	2.324	3.105
															0.253	0.338	0.451	0.602	0.805	1.075	1.437	1.919
																0.209	0.279	0.372	0.497	0.665	0.888	1.186
																	0.172	0.230	0.307	0.411	0.549	0.733
																		0.142	0.190	0.254	0.339	0.453
																			0.117	0.157	0.210	0.280
																				0.097	0.130	0.173
																					0.080	0.107
																						0.066

Table B.1 Value tree of annual sales of sugar (10^8 ETB deflated in 2008) : continued

t	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
R	2161.092	2887.207	3857.293	5153.321	6884.808	9198.064	12288.562	16417.449	21933.619	29303.191	39148.897	52302.705	69876.118	93354.098	124720.546	166625.944	222611.318	297407.460
	1335.644	1784.413	2383.966	3184.965	4255.096	5684.784	7594.839	10146.662	13555.882	18110.582	24195.635	32325.232	43186.327	57696.688	77082.448	102981.714	137582.988	183810.092
	825.483	1102.841	1473.390	1968.440	2629.825	3513.431	4693.924	6271.056	8378.095	11193.088	14953.902	19978.328	26690.933	35658.936	47640.136	63646.952	85031.968	113602.228
	510.183	681.601	910.616	1216.577	1625.340	2171.445	2901.039	3875.772	5178.009	6917.790	9242.129	12347.432	16496.099	22038.695	29443.572	39336.445	52553.268	70210.868
	315.314	421.258	562.798	751.895	1004.527	1342.043	1792.962	2395.387	3200.223	4275.480	5712.017	7631.223	10195.270	13620.824	18197.343	24311.547	32480.090	43393.216
	194.877	260.355	347.832	464.702	620.839	829.438	1108.124	1480.448	1977.870	2642.423	3530.263	4716.411	6301.098	8418.231	11246.710	15025.540	20074.037	26818.800
	120.442	160.910	214.975	287.205	383.704	512.627	684.867	914.978	1222.405	1633.127	2181.848	2914.937	3894.339	5202.815	6950.931	9286.404	12406.584	16575.126
	74.438	99.449	132.863	177.505	237.145	316.825	423.276	565.494	755.497	1009.340	1348.472	1801.551	2406.862	3215.554	4295.962	5739.381	7667.781	10244.112
	46.006	61.464	82.115	109.705	146.566	195.811	261.602	349.499	466.928	623.814	833.412	1113.433	1487.540	1987.345	2655.082	3547.175	4739.005	6331.284
	28.434	37.987	50.750	67.802	90.584	121.019	161.681	216.005	288.581	385.543	515.083	688.148	919.361	1228.262	1640.950	2192.300	2928.901	3912.995
	17.573	23.478	31.366	41.905	55.984	74.795	99.925	133.500	178.355	238.281	318.342	425.304	568.203	759.116	1014.175	1354.932	1810.182	2418.393
	10.861	14.510	19.385	25.899	34.601	46.226	61.758	82.508	110.231	147.268	196.749	262.855	351.173	469.165	626.802	837.404	1118.767	1494.667
	6.712	8.968	11.981	16.007	21.385	28.570	38.169	50.994	68.127	91.017	121.599	162.455	217.039	289.963	387.390	517.550	691.444	923.766
	4.149	5.542	7.405	9.893	13.217	17.657	23.590	31.516	42.105	56.253	75.153	100.404	134.139	179.209	239.423	319.867	427.341	570.925
	2.564	3.425	4.576	6.114	8.168	10.913	14.580	19.478	26.023	34.766	46.448	62.054	82.904	110.759	147.973	197.691	264.114	352.855
	1.585	2.117	2.828	3.779	5.048	6.745	9.011	12.038	16.083	21.487	28.707	38.352	51.238	68.454	91.454	122.181	163.234	218.079
	0.979	1.308	1.748	2.335	3.120	4.168	5.569	7.440	9.940	13.280	17.742	23.703	31.667	42.307	56.522	75.513	100.885	134.782
	0.605	0.809	1.080	1.443	1.928	2.576	3.442	4.598	6.143	8.208	10.965	14.649	19.572	26.148	34.933	46.670	62.351	83.301
	0.374	0.500	0.668	0.892	1.192	1.592	2.127	2.842	3.797	5.073	6.777	9.054	12.096	16.160	21.590	28.844	38.536	51.483
	0.231	0.309	0.413	0.551	0.737	0.984	1.315	1.756	2.347	3.135	4.188	5.596	7.476	9.988	13.344	17.827	23.817	31.819
	0.143	0.191	0.255	0.341	0.455	0.608	0.813	1.086	1.450	1.938	2.589	3.458	4.620	6.173	8.247	11.018	14.720	19.665
	0.088	0.118	0.158	0.211	0.281	0.376	0.502	0.671	0.896	1.198	1.600	2.137	2.856	3.815	5.097	6.809	9.097	12.154
	0.055	0.073	0.097	0.130	0.174	0.232	0.310	0.415	0.554	0.740	0.989	1.321	1.765	2.358	3.150	4.209	5.623	7.512
		0.045	0.060	0.080	0.107	0.144	0.192	0.256	0.342	0.457	0.611	0.816	1.091	1.457	1.947	2.601	3.475	4.643

0.037	0.050	0.066	0.089	0.119	0.158	0.212	0.283	0.378	0.505	0.674	0.901	1.203	1.608	2.148	2.869
	0.031	0.041	0.055	0.073	0.098	0.131	0.175	0.233	0.312	0.417	0.557	0.744	0.994	1.327	1.773
		0.025	0.034	0.045	0.061	0.081	0.108	0.144	0.193	0.258	0.344	0.460	0.614	0.820	1.096
			0.021	0.028	0.037	0.050	0.067	0.089	0.119	0.159	0.213	0.284	0.380	0.507	0.677
				0.017	0.023	0.031	0.041	0.055	0.074	0.098	0.131	0.176	0.235	0.313	0.419
					0.014	0.019	0.025	0.034	0.046	0.061	0.081	0.109	0.145	0.194	0.259
						0.012	0.016	0.021	0.028	0.038	0.050	0.067	0.090	0.120	0.160
							0.010	0.013	0.017	0.023	0.031	0.041	0.055	0.074	0.099
								0.008	0.011	0.014	0.019	0.026	0.034	0.046	0.061
									0.007	0.009	0.012	0.016	0.021	0.028	0.038
										0.005	0.007	0.010	0.013	0.017	0.023
											0.005	0.006	0.008	0.011	0.014
												0.004	0.005	0.007	0.009
													0.003	0.004	0.006
														0.003	0.003
															0.002

Table B. 2 Binomial value tree for HDAC project in scenario (a) (billion 2008ETB)

t	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
S			0.126	0.114	0.104	0.095	0.087	0.080	0.073	0.067	0.061	0.056	0.110	0.100	0.091	0.082	0.075	0.068	0.062	0.056	0.051	0.047
V	43.174	55.172	70.250	89.105	112.759	142.329	179.151	225.318	283.146	355.507	445.951	558.860	699.695	874.939	1092.752	1363.001	1697.661	2111.194	2620.970	3247.710	4015.938	4954.401
		33.972	43.282	54.930	69.545	87.817	110.573	139.105	174.845	219.566	275.463	345.244	432.311	540.620	675.238	842.263	1049.097	1304.678	1619.741	2007.093	2481.890	3061.899
			26.615	33.809	42.836	54.126	68.189	85.822	107.910	135.548	170.094	213.221	267.057	333.997	417.196	520.426	648.258	806.218	1000.940	1240.340	1533.785	1892.256
				20.755	26.330	33.303	41.994	52.891	66.541	83.622	104.972	131.625	164.923	206.295	257.716	321.517	400.523	498.149	618.496	766.456	947.817	1169.367
					16.128	20.434	25.805	32.539	40.974	51.530	64.724	81.195	101.800	127.370	159.151	198.583	247.412	307.750	382.130	473.575	585.665	722.593
						12.481	15.799	19.960	25.172	31.695	39.848	50.027	62.788	78.591	98.234	122.604	152.784	190.075	236.045	292.563	361.840	446.467
							9.615	12.186	15.406	19.437	24.475	30.764	38.676	48.444	60.584	75.647	94.299	117.347	145.759	180.690	223.507	275.810
								7.381	9.370	11.860	14.973	18.859	23.775	29.812	37.315	46.625	58.153	72.399	89.959	111.548	138.011	170.338
									5.640	7.178	9.101	11.501	14.565	18.296	22.934	28.688	35.814	44.618	55.472	68.815	85.171	105.151
										4.284	5.471	6.954	8.872	11.179	14.046	17.603	22.007	27.449	34.157	42.405	52.514	64.863
											3.228	4.143	5.355	6.780	8.553	10.751	13.474	16.838	20.984	26.082	32.330	39.963
												2.407	3.180	4.062	5.158	6.517	8.200	10.279	12.843	15.994	19.856	24.574
													1.837	2.382	3.059	3.900	4.940	6.226	7.811	9.759	12.147	15.063
														1.345	1.763	2.283	2.926	3.721	4.701	5.906	7.382	9.185
															0.964	1.284	1.682	2.173	2.779	3.524	4.437	5.552
																0.670	0.914	1.217	1.592	2.052	2.617	3.307
																	0.445	0.629	0.859	1.143	1.492	1.919
																		0.276	0.412	0.584	0.798	1.062
																			0.154	0.248	0.374	0.534
																				0.074	0.130	0.217
																					0.039	0.053
																						0.033

Table B.2 Binomial value tree for HDAC project in scenario (a) (billion 2008ETB) : continued

t	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
S	0.101	0.091	0.082	0.074	0.067	0.061	0.055	0.050	0.045	0.041	0.096	0.086	0.077	0.070	0.063	0.057	0.051	0.046
V	6096.458	7479.951	9147.406	11145.032	13521.179	16323.418	19593.649	23360.305	27626.337	32351.115	37423.740	42623.708	47564.946	51614.899	53780.057	52544.309	45642.002	29740.772
	3767.766	4622.823	5653.382	6888.000	8356.560	10088.462	12109.603	14437.555	17074.143	19994.255	23129.377	26343.178	29397.073	31900.118	33238.282	32474.546	28208.643	18381.035
	2328.537	2857.001	3493.931	4256.979	5164.612	6235.002	7484.153	8922.928	10552.451	12357.205	14294.870	16281.138	18168.578	19715.569	20542.617	20070.604	17434.108	11360.248
	1439.035	1765.649	2159.301	2630.898	3191.856	3853.404	4625.435	5514.660	6521.776	7637.192	8834.780	10062.381	11228.903	12185.015	12696.171	12404.456	10775.000	7021.112
	889.285	1091.149	1334.444	1625.914	1972.612	2381.479	2858.628	3408.210	4030.653	4720.030	5460.219	6218.933	6939.898	7530.821	7846.744	7666.459	6659.396	4339.347
	549.518	674.280	824.649	1004.792	1219.068	1471.768	1766.669	2106.337	2491.036	2917.103	3374.601	3843.524	4289.116	4654.337	4849.598	4738.182	4115.783	2681.905
	339.527	416.638	509.575	620.913	753.347	909.529	1091.793	1301.725	1539.489	1802.819	2085.603	2375.422	2650.823	2876.552	2997.238	2928.385	2543.725	1657.538
	209.744	257.404	314.845	383.660	465.512	562.042	674.692	804.442	951.393	1114.146	1288.949	1468.075	1638.290	1777.806	1852.402	1809.856	1572.129	1024.437
	129.533	158.991	194.495	237.027	287.619	347.281	416.906	497.101	587.926	688.518	796.584	907.297	1012.503	1098.737	1144.847	1118.559	971.642	633.154
	79.959	98.168	120.113	146.403	177.673	214.550	257.584	307.151	363.288	425.462	492.282	560.713	625.741	679.043	707.549	691.309	600.516	391.325
	49.321	60.577	74.142	90.393	109.722	132.516	159.117	189.754	224.453	262.882	304.210	346.510	386.706	419.656	437.280	427.251	371.145	241.865
	30.385	37.344	45.730	55.776	67.725	81.816	98.259	117.198	138.647	162.402	187.975	214.123	238.972	259.343	270.243	264.052	229.384	149.492
	18.682	22.985	28.171	34.382	41.770	50.481	60.647	72.355	85.615	100.300	116.136	132.303	147.667	160.264	167.007	163.188	141.770	92.402
	11.449	14.110	17.318	21.160	25.728	31.115	37.401	44.641	52.839	61.919	71.737	81.735	91.237	99.028	103.203	100.851	87.621	57.118
	6.978	8.626	10.610	12.987	15.814	19.146	23.034	27.512	32.583	38.198	44.297	50.481	56.360	61.183	63.770	62.323	54.155	35.311
	4.215	5.236	6.465	7.937	9.686	11.749	14.155	16.926	20.063	23.537	27.337	31.166	34.805	37.792	39.398	38.512	33.471	21.833
	2.508	3.141	3.903	4.815	5.899	7.177	8.667	10.383	12.325	14.477	16.856	19.228	21.483	23.336	24.336	23.795	20.688	13.504
	1.453	1.846	2.320	2.886	3.559	4.351	5.276	6.339	7.543	8.877	10.378	11.849	13.250	14.401	15.026	14.700	12.787	8.356
	0.802	1.046	1.341	1.694	2.112	2.605	3.179	3.840	4.588	5.416	6.374	7.289	8.161	8.880	9.273	9.078	7.904	5.174
	0.403	0.554	0.737	0.957	1.218	1.526	1.884	2.295	2.761	3.276	3.899	4.471	5.016	5.467	5.717	5.604	4.887	3.207
	0.173	0.258	0.368	0.503	0.666	0.859	1.083	1.341	1.632	1.954	2.370	2.729	3.072	3.358	3.519	3.457	3.021	1.992
	0.090	0.102	0.154	0.230	0.328	0.448	0.589	0.751	0.934	1.137	1.425	1.653	1.871	2.054	2.161	2.130	1.869	1.241
	0.086	0.078	0.071	0.087	0.133	0.200	0.285	0.387	0.503	0.632	0.841	0.987	1.129	1.248	1.321	1.310	1.156	0.777
		0.075	0.068	0.062	0.057	0.072	0.111	0.167	0.238	0.321	0.480	0.576	0.670	0.750	0.803	0.803	0.716	0.490

	0.065	0.059	0.053	0.049	0.046	0.057	0.086	0.131	0.257	0.322	0.386	0.443	0.482	0.490	0.444	0.312
		0.057	0.051	0.046	0.042	0.039	0.038	0.038	0.127	0.167	0.211	0.252	0.284	0.296	0.276	0.203
			0.049	0.044	0.039	0.035	0.033	0.031	0.090	0.085	0.107	0.135	0.161	0.176	0.172	0.135
				0.042	0.037	0.033	0.030	0.027	0.084	0.077	0.073	0.071	0.087	0.102	0.107	0.093
					0.036	0.032	0.028	0.025	0.081	0.073	0.067	0.062	0.060	0.059	0.068	0.067
						0.031	0.027	0.023	0.079	0.070	0.063	0.057	0.053	0.050	0.050	0.051
							0.026	0.022	0.077	0.068	0.061	0.054	0.049	0.045	0.042	0.041
								0.021	0.077	0.067	0.059	0.052	0.046	0.042	0.038	0.035
									0.076	0.067	0.058	0.051	0.045	0.039	0.035	0.032
										0.066	0.058	0.050	0.044	0.038	0.033	0.029
											0.057	0.050	0.043	0.037	0.032	0.028
												0.050	0.043	0.037	0.032	0.027
													0.043	0.036	0.031	0.026
														0.036	0.031	0.026
															0.031	0.026
																0.026

Appendix C

Table C. 1 Sensitivity test – a change in the current sugar price

sugar price[a]	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5
NPV[b]	-0.271	0.129	0.528	0.927	1.327	1.726	2.125	2.524	2.924	3.323
RO[b]	3.323	10.892	18.461	26.030	33.600	41.169	48.738	56.307	63.876	71.446

[a] sugar price: ETB per kg deflated in 2008

[b] project value evaluated using NPV or RO approach: billion 2008ETB

Table C. 2 Sensitivity test – a change in the average yield of sugar cane

sugar cane yield[a]	10	20	30	40	50	60	70	80	90	100
sugar yield[b]	8000	16000	24000	32000	40000	48000	56000	64000	72000	80000
NPV[c]	-0.182	0.105	0.393	0.681	0.968	1.256	1.544	1.832	2.119	2.407
RO[c]	4.993	10.447	15.902	21.356	26.810	32.265	37.719	43.174	48.628	54.083

[a] sugar cane yield: ton per hectare per cropping cycle

[b] sugar yield: ton per annum

[c] project value evaluated using NPV or RO approach: billion 2008ETB

Table C. 3 Sensitivity test – a change in the volatility of sugar price

volatility[a]	6	10	15	20	25	30	35	40	45	50
RO[b]	43.174	43.174	43.174	43.174	43.174	43.174	43.174	43.175	43.178	43.183
u	1.062	1.105	1.162	1.221	1.284	1.350	1.419	1.492	1.568	1.649
d	0.942	0.905	0.861	0.819	0.779	0.741	0.705	0.670	0.638	0.607
p	1.000	0.784	0.668	0.604	0.560	0.527	0.500	0.477	0.456	0.437
1-p	0.000	0.216	0.332	0.396	0.440	0.473	0.500	0.523	0.544	0.563

[a] volatility of annual world sugar price: %

[b] project value evaluated using RO approach: billion 2008ETB

Table C. 4 Sensitivity test – a change in the annual land rent

annual rent[a]	0.5	1	2	5	10	20	50	100	200	500
NPV[b]	1.871	1.864	1.850	1.809	1.740	1.602	1.188	0.498	-0.881	-5.020
ROA[b]	43.212	43.206	43.192	43.152	43.085	42.950	42.547	41.875	40.533	36.526

[a] annual land rent for leased 25,000 hectares: million 2008ETB

[b] project value evaluated using NPV or RO approach: billion 2008ETB

Table C. 5 Sensitivity test – a change in the risk-free discount rate

r_f[a]	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1	0.11	0.12
NPV[b]	1.638	1.717	1.780	1.832	1.874	1.908	1.937	1.961	1.981	1.999
ROA[b]	42.976	43.057	43.121	43.174	43.217	43.252	43.281	43.306	43.326	43.344
p	0.503	0.524	0.546	0.567	0.589	0.612	0.634	0.657	0.679	0.703
1-p	0.497	0.476	0.454	0.433	0.411	0.388	0.366	0.343	0.321	0.297
e^{-rf} [c]	0.970	0.961	0.951	0.942	0.932	0.923	0.914	0.905	0.896	0.887

[a] risk-free discount rate (r_f)

[b] project value using NPV or RO approach: billion 2008ETB

[c] discount factor (e^{-rf})