Ca' Foscari
University
of Venice

Master degree

in Global Development and Entrepreneurship

Final Thesis

Failing land deals in Ethiopia: a real options analysis

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Matriculation Number 861312

Academic Year
2020 / 2021

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Abstract

The last decade has been characterised by an increasing interest for large-scale land acquisitions (LSLAs) in Africa. The economic, energy and food crises started in 2007 encouraged the sealing of a relevant number of land contracts. However, only in a few cases, these contracts led to investment for the development of the agreed land project.

In this paper, we adopt a standard real options model to study the impact that commodity price volatility has on an investor's decision to develop a specific land project. The model is applied using, as a case study, a land lease agreement signed by Saudi Star Agricultural Development Plc and the Ministry of Agriculture and Rural Development of the Federal Democratic Republic of Ethiopia for the development of 10,000 hectares to be destined to the production and export of rice.

We show how failure, understood as a delay in the development of the contracted land, is justified by economic reasons. Indeed, foreign investors will decide to exercise the option when their returns are maximised.

Abbreviations

ADF	Augmented Dickey-Fuller
APV	Adjusted Present Value
AR	Autoregressive
ARMA	Autoregressive Moving Average
EIAR	Ethiopian Institute of Agricultural Research
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
HA	Hectare
IRRI	International Rice Research Institute
LSLA	Large Scale Land Acquisition
MAE	Ministry of Agriculture of Ethiopia
MT	Metric Ton
PPI	Producer Price Index
PV	Present Value
NPV	Net Present Value
R	Annual Revenue
RO	Real Option
ROA	Real Option Analysis
SSAD	Saudi Star Agricultural Development Plc
USD	U.S. Dollar
WB	World Bank

List of Figures and Tables

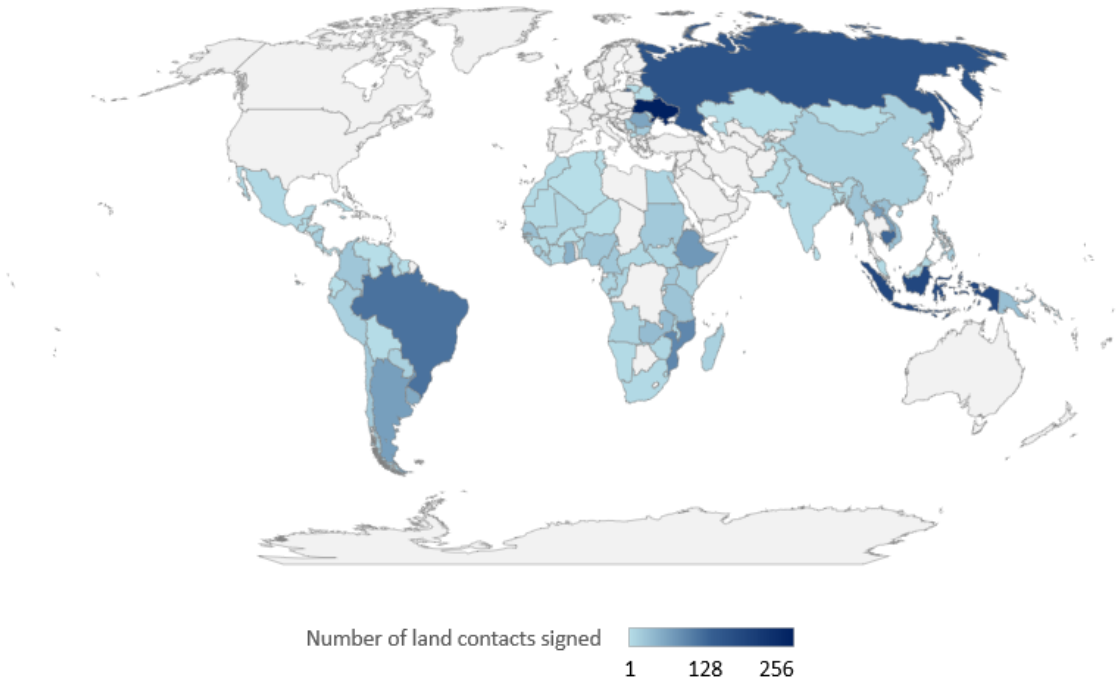
1. Introduction

In this introductory chapter, the background of the thesis is presented in the first section. In the second and third section, we discuss the problem and the project's purpose, respectively. Finally, in the fourth section, we briefly present the structure of the thesis.

1.1. Background

The phenomenon of the international land "acquisition" or land "grabbing" came into vogue again after the economic, energy and food crisis of 2007-2008 (von Braun & Meinzen-Dick, 2009; Kachika, 2010; Arezki et al., 2011; Collier & Venables, 2011; Hall, 2011). This "race" for land is a global phenomenon, present in almost every continent. As a matter of fact, from 2000 to 2021, 2,021 land contracts have been signed, covering a total area of 66,549,548 hectares[1]. The location of land contracts signed from 2000 to 2021 is presented in Figure 1.

Figure 1. *Number of land contracts signed from 2000 to 2021 by country (>200ha)*



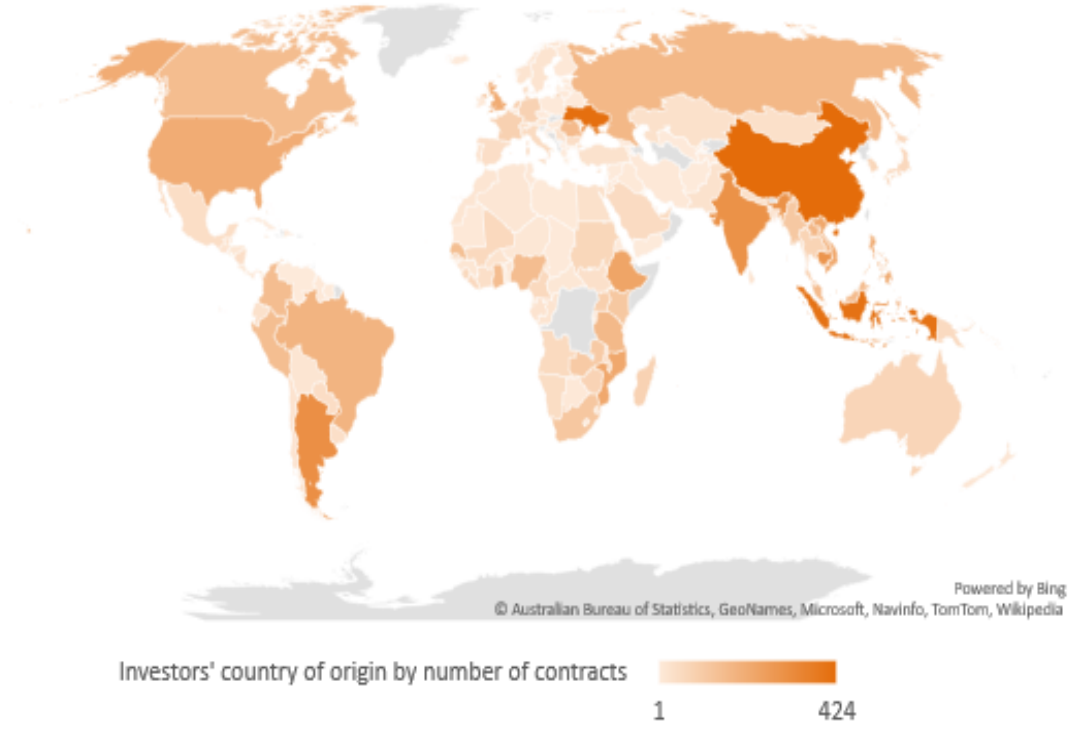
Source: own elaboration on Land Matrix data

Figure 2 presents the numbers of contracts concluded per investor's country of origin. As presented in literature (Vermeulen & Cotula, 2010; Robertson & Pinstrup-Andersen,

[1]The data were processed from landmatrix.org. The website's aim, launched in April 2012, is to make data on LSLAs transparent, traceable and visible (Anseeuw et al., 2013).

2010) the operating companies interested in acquiring land come from the countries most affected by this phenomenon. Many of these companies were established to facilitate transactions and negotiations between host countries and foreign investors.

Figure 2 *Number of land contracts signed from 2000 to 2021 by investors' origin country (>200ha)*



Source: own elaboration on Land Matrix data

Table 1 presents the number of concluded, failed and intended land contracts by geographic region from 2000 to 2020. In 2010, the World Bank identified Africa as the continent with the highest number of signed contracts (Deininger & Byerlee, 2010). After a decade, the continent continues to hold the primacy, nearing 26 million hectares of land under negotiation and 636 land contracts signed, as shown in Table 1. Land transfers covered 1.8 million hectares in Mozambique, 1.2 million hectares in Liberia, 917,000 hectares in Ethiopia, and 440,000 hectares in Sudan[2]. Although demand for land in Africa has recently lowered, foreign investors continue to find it very attractive.

[2]The data presented on Land Matrix are different from those published by Arezke et al. (2011).

Table 1. *Negotiation land status by continent from 2000 to 2020*

Continent	N. Contracts Concluded	N. Contracts Failed	N. Contracts Intended
Africa	636	139	91
Asia	477	23	56
Est Europe	519	3	19
Latin America and the Caribbean	357	5	6
Oceania	32	4	4

Source: own elaboration on Land Matrix data

The uncertainty of land ownership of many African indigenous communities has facilitated foreign investors' acquisition of African land. In many African countries, such as Ethiopia, Mozambique, and Tanzania, the land is nationalised; in others, such as Madagascar and Mali, private land ownership is not widespread, although it can be achieved through a land registration procedure (Vermeulen & Cotula, 2010; Henrÿ, 1984). In Africa, much of the land is held under customary tenure[3] (Udry, 2009), which is "usually associated with indigenous communities and administered according to their customs" (FAO, 2002, p.44). Hence, it is the government that formally owns the land[4], which can decide when negotiating with investors where to allocate LSLAs (Vermeulen & Cotula, 2010).

The relevant buyers of African land are capital-rich but land and water-poor countries, which are unable to meet the growing domestic demand for food and energy[5] (Robertson & Pinstrup-Andersen, 2010). Analysing the origin of private companies[6], a distinction can be made between those from oil-rich but highly food-insecure Gulf States such as Saudi Arabia, Qatar, and the United Arab Emirates (Friis & Reenberg, 2010) and, on the other hand, those from populous and capital-rich countries such as China, India, and Brazil (Havnevik et al, 2011).

[3]The protection of customary property is often limited due to its subordination to state title within national law (Vermeulen & Cotula, 2010).
[4]Actually, less than 10% of the land is held under a formal land tenure (Deininger, 2003).
[5]Karp and Richter (2011) state that the world population will reach 9 billion by 2050 and that the challenge of the future will be how to meet the increasing demand for food and energy. There is an increasing trade-off between land use for crops for bioenergy or biofuel and food production
[6]In most cases, it is private rather than government-owned companies that have initiated investments (Cotula et al., 2009).

There are two ways of acquiring land, that is, i) by direct purchase or ii) by long-term leasing. According to Cotula et al. (2009) and Land Matrix data, the latter predominates in Africa[7]. The duration of the lease, varying in any case from country to country, normally ranges between 10 and 99 years[8].

African countries promote foreign investment through both low prices and *tax holidays*. Although the tax relief and the usually very convenient land rents make the investment attractive to foreign investors, host countries require specific commitments. Non-compliance with the obligations presented on the land contract may lead to its cancellation. Such obligations may be related, for instance, to the construction of infrastructure (as in the Petrotech/AgroMali land deal), soil conservation (as in the Saudi Star Agricultural Plc land deal in Ethiopia), and the hiring of local workers[9] (as in the GEM Biofuels PLC land deal in Madagascar).

1.2. Problem

Although the number of land deals has recently declined (Bongiorni, 2021), Africa continues to attract the interest of foreign investors. Still, the number of farming projects implemented has remained relatively small[10]. The situation presented by Arezke et al. (p.11) has remained almost unchanged since 2011: of the 464 agricultural projects analysed in Africa, "some 30% of projects were at an early exploratory stage, in 18% permission had been granted but no activity started, 30% were at an initial level of development, and only 21% had started production, often at a much lower level than envisaged."

As discussed above, Africa is trapped in a paradox, on the one hand, the increasing foreign interest in land acquisitions; on the other hand, the poor implementation of land projects. Therefore, understanding why land contracts fail to induce the actual development of the associated land project becomes a key issue for the development of African countries[11].

[7]Land leases account for 75.5% of African land deals, between 2000 and 2021.
[8]Many countries, such as, for instance, Mozambique, Mali and Ethiopia allow for contract renewal (Vermeulen & Cotula, 2010).
[9]Local employment for 4500 part-time workers was foreseen in the contract (Cotula et al., 2009).
[10]Only 10% of this land has been developed so far.
[11]A vast literature defines LSLAs as "neo-colonialism" aimed at grabbing the richest land to ensure food and energy security (Robertson, 2010). At the same time, others have outlined

The companies invest only if the expected profit from the farming project is positive. Once the contract has been signed by both parties and the land has been made available, foreign investors have the right, but not the obligation, to carry out the project within the limits set by the host country in the contract. This means that the foreign investor holds a real option. Suppose market and production conditions are no longer favourable or are not in line with the investor's expectations, in that case, the investor may then decide to postpone the development of the project or, in extreme cases, even abandon it. The future prices for the commodity, the discount rate, the potential productivity, the soil type, and so on, may affect the project profitability and consequently the decision to exercise the option to invest (Liu, 2012).

1.3. Aim

This dissertation aims to investigate why agricultural projects fail in Ethiopia. The term failure refers to the non-development of the contracted land by foreign investors. This may be due to a rational delay in exercising the option to invest due to the presence of market uncertainty. The commodity price is the only stochastic variable considered in the case study, while yield and production costs are assumed constant.

This thesis will attempt to enrich the literature on the topic of land project failure by examining whether the delay in land development is motivated by market uncertainty.

In contrast to the standard net present value (NPV) analysis, taking a real option approach (ROA) to the investment analysis allows including the value associated with temporal flexibility in the exercise of the option to invest.

1.4. Organisation

This thesis consists of six chapters. Chapter 1 is intended to give a general presentation of the background, the research problem and the aims of this dissertation. Chapter 2 focuses on the motivations for land acquisition in Africa and on the concept of failure. Chapter 3 introduces the theoretical background of this thesis. In particular, it covers the shortcomings of the net present value (NPV) approach, the advantages of the real option (RO) approach, the valuation model chosen for this thesis and the data analysis. Chapter 4 focuses on the empirical study. In Chapter 5, the project is analysed using both NPV

foreign investment as an engine for the host country's economic, infrastructural, and social development (Makki & Geisler, 2011).

and ROA. Further, the motivations for the delayed land development are presented and discussed. The final chapter presents the conclusions and limitations of this dissertation.

2. The interest in African land and the failure of land deals

Although Africa is the continent that has attracted the most interest from foreign investors over the last 20 years[12], it is also the continent that has experienced the most land failures, both in terms of project abandonment and undeveloped projects. In this chapter, we analyse the motivations for foreign initiatives and failures, and then the idea of failure that will apply in this thesis is characterized.

2.1. Land in Africa

Access to land has always been a crucial issue in Africa. Land provides food, security, and livelihoods for millions of people. In the continent, around 60% of the population depends on agriculture in order to survive (Kugelman & Levenstein, 2009). According to a World Bank (WB) study, in 2019, agriculture accounted for about 14% of Sub-Saharan Africa's GDP value-added, reaching 62.7% in Somalia, 54.3% in Sierra Leone, 33.5% in Ethiopia[13]. Besides being a source of income, the land is considered a social, cultural, and ontological resource. Indeed, in African culture, the ancestral land remains the cornerstone for the formation of social identity, the creation and transmission of culture, and it marks religious life[14] (Union, 2009). Whereas the world moves towards the "Green Deal", as oil reserves are depleted, and energy demand increases, land use is becoming increasingly conflictual.

2.2. Why are foreign investors interested in African lands?

Food security concerns drive the majority of land acquisitions. Soaring food prices (especially cereals) in 2008 caused a crisis in more than thirty developing countries. It is in the interest of food-importing countries - such as Saudi Arabia and South Korea - to secure access to crops. Rising oil prices have prompted many countries to acquire land in order to establish energy security by considering the use of energy crops as alternative energy sources. In addition, incentive policies and extremely convenient land deals make foreign private companies interested in this type of investment project. The motivations driving the LSLAs are summarised in Table 2.

[12]International buyers account for about three-quarters of all land purchases in Africa (Cotula & Vermeulen, 2009).
[13]https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=ZG (accessed:25/09/2021)
[14]Union, 2009, p.8 "Indeed land is fully embodied in the very spirituality of society".

Table 2. *Core aspects driving land acquisition from a review of literature*

Drivers of land acquisition	Key concepts	Author
Food security	Rising food prices and volatility	Arezki et al., 2011; Friis & Reenberg, 2010; Robertson & Pinstrup-Andersen, 2010; von Braun & Meinzen-Dick, 2009
	Reduction in exports of agricultural products after the 2008 crisis	Friis & Reenberg, 2010
	Vulnerability of supply and the search for autonomy	Carroccio et al., 2016; Perrone & Hornberger, 2014; Tscharntke et al., 2012
	Increased demand for food due to population growth and urbanisation	Carroccio et al., 2016; Nally, 2015; Perrone & Hornberger, 2014; Tscharntke et al., 2012
	Change in eating habits	Friis & Reenberg, 2010; Cotula et al., 2009
Energy security and renewable energy consumption	Increased demand for biofuels to marginalize fluctuations of world oil prices	Giovannetti & Ticci, 2016; Scholvien, 2016; Perrone & Hornberger, 2014; Boamah, 2014; Hall, 2011; Kachika, 2010; Vermeulen & Cotula, 2010; Robertson & Pinstrup-Andersen, 2010; Cotula et al., 2009;
	Diversifying the energy source	Carroccio et al., 2016; Friis & Reenberg, 2010; Cotula et al., 2009
	Importance of environmental and climate change issues	Friis & Reenberg, 2010; Robertson & Pinstrup-Andersen, 2010
Profitability of land investment and incentive policies	Current low output of local land	Collier & Venables, 2011; Borras et al., 2011; von Braun & Meinzen-Dick, 2009
	Lack of infrastructure in host countries	Collier & Venables, 2011
	Weak negotiating power of the host country	Fuentes-Nieva & Nicholls, 2013; Cotula et al., 2009; von Braun & Meinzen-Dick, 2009

	Informal land property right	Borras & Franco, 2012; Vermeulen & Cotula, 2010; von Braun & Meinzen-Dick, 2009; Deininger, 2003
	Corruption problem	Bujko et al., 2016; Cotula et al., 2009
	Tax Holiday and investment support	Arezki et al., 2015; Cotula et al., 2009; Bräutigam & Xiaoyang, 2009

Source: own elaboration

2.2.1. Food security

The food shortage on the global market and the consequent rise in global food prices, especially cereals, have been exacerbated by trade distortions such as export restrictions imposed by major food-exporting countries in 2008 (Semerari, 2011). These restrictions both panicked countries that based their food security on food imports and led to a loss of confidence in international markets[15]. The relatively weak WTO discipline has also fostered this mistrust of export restrictions (Zupi, 2018). Food security is one of the main concerns justifying foreign investment in Africa. This situation[16] reflects the fear that dependence on world markets for food supplies has become riskier. In countries with limited resources - such as land and water - and growing populations and urbanisation, the food crisis has drawn attention to the volatility of food prices, prompting a severe reassessment of their food security strategies. These countries have identified African lands as the possible and cheap solution to their problems.

2.2.2. Energy security and renewable energy consumption

Although most land contracts have food security as their purpose[17], about a quarter of land deals are sealed in order to cultivate energy crops (Timilsina & Shrestha, 2010) for producing renewable energy to supply domestic and foreign markets. The high uncertainty surrounding non-renewable energy sources and the public relevance of climate change mitigation encourage the acquisition of African land for renewable

[15]"The choice to buy them protects them from future price volatility and, more importantly, ensures security of food supply in a world where the threat of export bans by producing countries has become much more concrete" (Firstbrook C, 2010).
[16]Which is the result of higher food prices and supply-side shocks. In particular, a direct effect of export control policies.
[17]The production of food crops accounts for more than 50% of intended investment initiatives.

energy production and energy security. However, as pointed out by Donald (2018), the pursuit of energy security has promoted the use of land to produce agro-fuels, reducing the area for growing food. This trade-off, which has led to a reduction in the quantity of food produced, has fostered an increase in its price.

2.2.3. Land property right and incentive policies

In many African regions, land prices are very low compared to international levels. The combined effect of low prices and the potential future increase in land value makes land acquisitions, at least potentially, very profitable. Thus, African land acquisition can be intended as "a speculative option on higher future prices or productivity" (Venables & Collier, 2011, p.1). Land acquisition provides an option for future use, thus much of the demand for land is speculative. In fact, the possibility of developing land when the economic conjuncture will secure high revenues, leads foreign investors to purchase/rent land as a way to acquire this option (Venables & Collier, 2011). The reasons that can justify these low prices may be found in the geography of the territory and in the economic, legal, and cultural setup of African countries.

The leased land is usually "under-utilised"[18] (Hall, 2011), and, due to the limited agronomic and technological, not highly productive. The lack of infrastructure and capital, typical of African countries, together with the strong bargaining power of foreign investors further reduces the price of land. In addition, the lack of transparency and the strong persistence of corrupt behaviour, the interest of elites in maximising their profit at the expense of society's (Hvid, 2014), and African land law lead to a reduction in the price of contracted land.

Land deals are not only encouraged by host countries through *tax holidays*[19] but also by investors' home countries. The former offers tax-free periods on customs duties, capitals and profits in the agricultural sectors (EIA, 2008; MoFA, 2018), and assistance[20]. At the same time, home countries offer support and advice to national companies interested in entering into a land contract in Africa[21].

[18]State actors in the host country claim that the land leased to foreign investors is 'marginal', 'uncultivated', 'infertile', 'unused', without explicitly stating the criteria used to assess these land parcels (Nalepa et al., 2017).
[19]The duration can vary between 2 and 7 years.
[20]The host countries have set up investment promotion agencies (Cotula et al., 2009).
[21]For example, in China, the state provides information, risk assessment, visa and residence permit support, fiscal and exchange control policies, insurance, and so on (Bräutigam & Xiaoyang, 2009).

2.3. What are the benefits of foreign investment for the host country?

There is extensive literature on why land investors are welcome in African countries. When discussing land contracts, the key aspects to be taken into account are the benefits on the labour market and the infrastructural and economic development of the host country. Last and less relevant, the direct monetary transactions that the country of origin receives (Cotula et al., 2009). Thanks to the inflow of capital and the bilateral nature of investments, the governments of "land-abundant" countries rent (or sell) land to secure the construction of infrastructure (roads, dams, irrigation systems) that would otherwise be beyond their own budget.

Employment and other economic benefits are linked to the positive spill-over effect of foreign investment. These positive externalities are able to spread to the domestic agricultural sector by encouraging harmonisation that includes both small producers and input suppliers. The prerequisite for achieving this synergy is the absorption capacity of the national agrarian sector (Mingyong et al., 2006). If the precondition is fulfilled, the proximity of a big commercial farm (usually owned by a foreign investor) to a small local one should foster capital inflows, technology transfer for productivity and innovation enhancement, quality, and domestic production[22] (Deininger & Xia, 2016). Multiplier effects on the labour market and increased local supply of agricultural goods for domestic and export are also expected (Collier & Venables, 2011). As noted by Deininger & Xia (2016), using the case study of Mozambique, positive spillovers are present in the short term and these are heterogeneously distributed[23].

However, suppose that the investment is limited to creating an enclave of advanced agriculture in a country with a primary sector composed of small farmers, where traditional agriculture is still used as the only production model. In this case, Foreign Direct Investments (FDIs) slows down or inhibits possible positive spill-over effects to the detriment of the poor population in particular. As a matter of fact, it should be the rural communities that benefit most from foreign investment in agriculture, such as off-farm jobs, empowerment, learning and so on (von Braun & Meinzen-Dick, 2009).

[22]In this case, we can use the term external economies of scale.
[23]Heterogeneity is fostered by variables such as land quality and access to infrastructure, trading patterns and the nature of the investment (Deininger & Xia, 2016).

2.4. The failure

The term failure can have three meanings. First, it can be defined as "the fact of someone or something not succeeding" (Dictionary, 2008), where the failure of the entrepreneur or the business project is the focus. Second, postponement and insolvency of obligations shape and define failure as "the fact of not doing something that you must do or are expected to do" (Dictionary, 2008). Third, the dictionary refers to "the fact of something not working as it should" (Dictionary, 2008), where the key is the inability to work and fulfil certain obligations. Concerning the land deals in Africa, these three definitions of failure overlap and make it complex to identify the exact causes of the non-development of a farming project.

2.4.1. Three levels of failure in Ethiopia

The issue of the failure of farming projects has not received so far the due attention in the literature. In particular, scholars have addressed the problem by focusing on project abandonment[24] and rarely on the developmental delay of the contracted land.

One of the African countries most affected by failed land deals is Ethiopia[25]. Analysing the data published in Land Matrix, we can identify three levels of failure:

- Contact. The reasons for contract failure can be divided into two categories: cancelled contract or negotiations failed.
    - Cancelled contracts account for about 33%. The reasons for this failure lie on the side of both foreign investors and the Ethiopian government. The structure of contracts always follows the same line: one section devoted to the seller's obligations and one to the buyer's obligations. If either party does not respect these, the contract may be terminated and cancelled. The Ethiopian government cancels about 80% of the contracts due to lack of land development and non-compliance with contractual obligations. In contrast but less frequently, investors withdraw from the contract[26] due to low productivity and unfavourable soil condition.

[24]Some of the scholars who have addressed this issue are Shete, 2020; Chandran & Tom 2017; Schoneveld, 2017; Keeley, 2014; Vidal, 2013; Poulton et al., 2008.
[25]Together with Mozambique and Ghana.
[26]The preparation of the land and its conformation is part of the seller's obligations, who must sell a parcel of land suitable for agricultural production.

- With regards to failed negotiations, the causes are not always associated with a non-fulfilment of obligations - non-payment, the land is not made available, investment permits are not granted - but can be exogenous. For example, during the negotiation period, the foreign company may declare bankruptcy and this leads to the negotiation failure. Although it does not happen often, misunderstandings and differences related to the investment objectives may occur during the negotiation phase, causing a failure of the agreement between the parties.

- Investment. This level of failure focuses on contracts that have been successfully concluded but are stuck, where neither the buyer nor the seller has terminated the contract due to non-fulfilment of obligations. Within this category, we find abandoned projects, projects not yet started, and projects in a start-up phase. In both cases no land has been developed and any improvement has been undertaken. This impasse accounts for about 30% of the contracts concluded in Ethiopia[27].
- Partial (or absent) land development. Although on Land Matrix there are 39 contracts in Ethiopia labelled as "in production" between 2000 and 2021, only 5% of investors have developed all the land under contract, while 36% are investors who have carried out partial land development. Still, more than half (59%) of the "in production" contracts paradoxically put 0 hectares under cultivation.

In this thesis we will focus more on failures at the level of investment and partial land development, trying to analyse whether the commodity price volatility has a significant impact on the exercise of the option to invest.

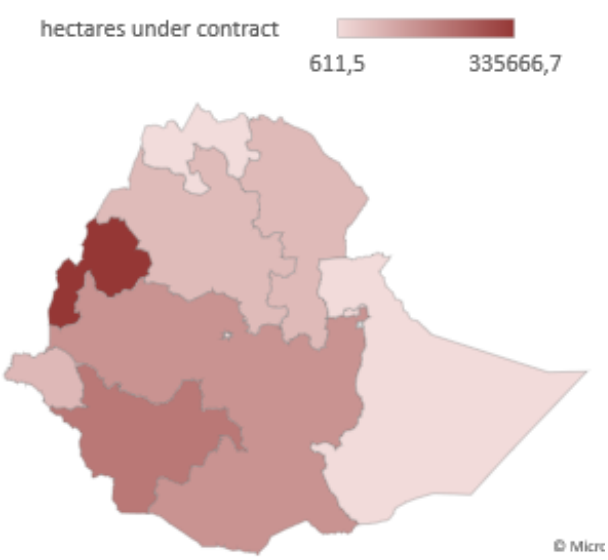
2.4.2. The Ethiopian paradox

The paradoxical situation presented in Section 2.4.1. characterizes the sealing of contracts in Ethiopia and other African countries. In Ethiopia it is considered the norm, becoming almost intrinsic when the contract is signed. While it is the target of many land contracts, it is also the one most affected by the delay in developing the land under contract.

[27]On the African continent, the average failure rate at the investment level is about 33%. It Reached 65% in the Democratic Republic of Congo, 51% in Ghana, and 38% in Mozambique.

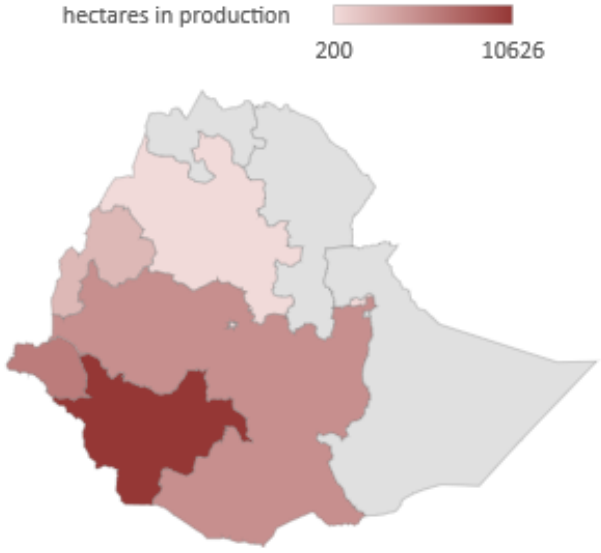
It is with this in mind that at every level (contract, investment, and failure to land development), directly or indirectly, failure is suffered by the Ethiopian Government, but especially by Ethiopians. Even in the presence of specific policies incentivising LSLAs and low land prices, the naivety and weak negotiating power of the Government results in the loss of a crucial opportunity for the infrastructural, economic and social development of the country.

Figure 3.A *Hectares under contract by region*



Source: own elaboration on Land Matrix data

Figure 3.B *Hectares under production by region*



Source: own elaboration on Land Matrix data

Figures 3.A and 3.B show the hectares under contract and hectares in production from 2000 to 2021 in Ethiopia, respectively. The total number of hectares under contract is around 917,000. The region that has attracted the most interest from foreign investors is Benishangul-Gumuz, reaching 335,667 hectares under contract. This situation is reversed if we consider the hectares actually in production. As a matter of facts, only 3% of the total area under contract has been put into production[28].

This paradox is caused by the different bargaining power of the two counterparts. On the one hand, the investor – having a high bargaining power – may, due to uncertain economic prospects, decide to postpone the production waiting for more favourable economic circumstances; on the other hand, the Ethiopian Government – with limited funding and weak bargaining power – wants the investor to fulfil its obligations. The lack of alternatives, the presence of bribes and local government malpractice, and the

[28]All contracts "in production" are taken into account.

marked difference in bargaining power between the two counterparts favour the delay in infrastructure and land development.

3. Theoretical perspective and methodology

In this chapter, consisting of six paragraphs, we will provide the theoretical background of the thesis. In the first section, we will address the limitations of Net Present Value (NPV). In the second one, we will present the Real Option Approach (ROA), while the reasons why we decided to use it are described in the third section. Next, we will introduce the methodology for calculating real options, focusing on binomial pricing. Finally, the last two sections will be devoted to statistical tests for studying the properties of the time series of commodity prices to be used in the numerical exercise.

3.1. Limits of NPV

In this section we will explain why the net present value (NPV) approach is unsuitable for analysing land acquisition in Africa for agricultural projects under market uncertainty and irreversible investment.

3.1.1. Net Present Value approach

The standard NPV approach measures the profitability of a project by comparing the present value of the net cash inflows associated with the project development with the initial investment cost (Welsch et al., 1988). Operatively, the NPV is then given by discounting the present value of the future net cash inflows discounted at the rate of return offered by any equivalent investment alternatives minus the initial investment costs (Brealey et al., 2012). The formula to be used is as follows:

$$NPV = C_0 + \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} \quad (1)$$

where:

- C_0 represents the initial investment. The cash flow at time 0 is negative if it is the initial outlay the company will make for initiating the project.
- C_t represents the cash flow at time t. It is defined as the difference between periodic revenues and operating costs. This implies that the time value of money is taken into account.

- r is the discount rate. It is the rate used for discounting future cash flows. This allows taking into account the time value of money[29]. The level of r must be chosen taking into account the risk associated with the contemplated investment project[30].
- T represents the project duration.

The project profitability depends on the NPV (as presented in equation (1)). If NPV ≥ 0, the project is considered profitable; otherwise - NPV < 0 - the project should be rejected.

3.1.2. The shortcomings of the NPV approach

The ease of use, the possibility of including positive and negative flow calculations, and quantifying and comparing the discounted values of inflows and outflows have favoured the widespread use of the NPV approach. It should be noted that, in parallel with its advantages, it also suffers from some shortcomings.

In its application, the NPV approach does not allow considering properly the temporal flexibility that may characterize the initiation of an investment project. This implies that by using the NPV approach one may underestimate the real value of the investment. The traditional approach assumes that projects are now or never, and that investments are reversible or cannot be recovered. Therefore, it does not take into account the value of the options at stake. In the dynamic world, characterised by uncertainty, not taking into account the possibility of delaying the development of a project is an important shortcoming of the NPV approach.

Some of the assumptions (Mascareñas, 2007) introduced when calculating the NPV can be considered as limitations:

- It implicitly assumes that cash flows generated during the life of a project must necessarily be reinvested at a known and constant rate identical to the opportunity cost of the capital being valued. However, this would not be a drawback if the cash flows were reinvested in projects with the same risk as to the current project and if the opportunity cost remained constant. But, if this is

[29]Mete (2014) defines it as "a measure of the minimum profitability required by the project to recover the investment, cover the costs and obtain benefits".
[30]It should be the rate at which one could ask for or borrow money (Altuve, 2004).

not respected, the actual NPV will be different from the NPV calculated earlier in the valuation. That is, its calculation methodology assumes a flat and unchanging time structure.

- Projecting expected prices over the project assessment horizon is risky, given the variability of these. Therefore, the projection of all possible scenarios over the planning horizon would be necessary. But, only a few of the many possibilities are arbitrarily chosen.

The inability of investors to delay or modify a project and the assumption that cash flows from an investment must be accurately predicted, make using the traditional approach weak when it comes to evaluating the profitability of an investment project.

3.2. Real Option Approach

The valuation of investment projects using the dynamic cash flow methodology is efficient under the premise of a sufficiently stable framework for carrying out the valuation. However, increasing globalisation, the processes of technology and innovation, and the importance of research and development (R&D) make analysis increasingly dynamic and changing. Thus, almost 30 years ago, some methodologies were developed to capture sudden and unexpected market changes. It was in 1984 Stewart Myers firstly presented the concept of real option[31].

3.2.1 Uncertainty and real options

It is clear that the valuation of real options is closely linked to uncertainty. From the traditional point of view, the valuation of a project will be lower as uncertainty increases. On the contrary, if real option approach is taken into account, it has been shown that as uncertainty increases, the value of assets also increases if managers are able to differentiate and use options flexibly[32] (Amram & Kulatilaka, 2000). Managing options increases their value and treats uncertainty as an opportunity[33]. As a matter of fact, managers can reformulate strategic investments and avoid losses.

[31]In this case, it refers to the adaptation of financial options to the application of non-financial assets, essentially focused on the investment in real assets that have some components of flexibility and uncertainty (Myeres, 1984).

[32]Flexibility makes it possible to collect information about the future, favouring targeted actions by companies. Thus, the more uncertain future conditions are, the more valuable flexibility is (Hull, 2017).

[33]A graphical representation can be found in Amram & Kulatilaka (2000), where the "cone of uncertainty" is presented.

In order to evaluate a project, we should not rely solely on the conventional NPV but should adjust it with the real option value of the project (Brealey et al., 2012). This sum can be called adjusted present value (APV):

$$APV = Conventional\ NPV + Value\ of\ real\ options \quad (2)$$

This formula is able to capture the dynamism and flexibility of the markets. Indeed, concerning the previous definition, although the conventional NPV is negative, it is possible to obtain a positive APV. In this case, it is worth investing in the project as long as the value of the actual options is sufficient to make up for the loss.

3.2.2. Variables to consider

The valuation of ROs has its roots in financial option theory. A financial option is a contract that gives the right, but not the obligation, to buy (call option) or sell (put option) at a specified price on or before a specified date (Brealey et al., 2012). In other words, the real option approach regards the company as the owner of an option to invest (Dixit & Pindyck, 1994). At a theoretical level, the value of a real option is a function of the following variables:

a. Underlying asset price (S_0). If the present value of the expected cash flows increases, the option value should follow the same trend.

b. Price of exercise or strike price (X). It is the price to be paid to take possession of the underlying real asset, which corresponds to the initial outlay, or failing that, the price at which the owner of the option has the right to sell it.

c. Time to maturity (T). It refers to the time by which the owner must exercise the option. The longer the temporal horizon, the higher the value of the option. Depending on the type of options one holds, it is possible to exercise the right only on the specified day; in this case, we refer to European options. In contrast, we refer to American options when the right can be exercised at any time before the expiring date (Brealey et al., 2012). Within this thesis, we refer exclusively to the latter.

d. Volatility or risk (σ). It is understood as the variance or standard deviation of the returns of the underlying asset.

e. Risk-free interest rate (r_f). Read as the time value of money, where an increase in its value increases the return on capital.

f. Dividends (D). It refers to the money that the underlying asset generates until the owner of the option exercises it or the money generated once the option is sold.

The variables above have a different impact on the option value. In this context, in the hypothetical scenario that events develop contrary to or different from the investor's interests, the latter will be more inclined to postpone the farming project. Moreover, an increase in the volatility of the project may enhance the value of the option (Machado, 2001). Thus, despite this positive relationship, an increase in volatility increases the option value to defer, causing a delay in investment. In other words, the increased risk reflects the need to wait more.

3.2.3. The types of real options

In the real options theory, three main options can be identified (Kodukula & Papudesu, 2006). In this section, we will present the ones more frequently used types. The first one will be fundamental for the development of the thesis.

3.2.3.1. The option to invest

This option gives its owner the right, but not the obligation, to postpone the execution of the project for a certain period of time. This right allows the owner to benefit from the reduction of uncertainty. Companies with exclusive rights widely use this option to invest in a project, so it is also very present when discussing land deals. As mentioned above, this type of option reduces the uncertainty of project execution given the behaviour of the value of the underlying asset in the near future, assessing the possibility of initiating the project by the expiration date of the option or not. But, in addition to evaluating whether the company should invest or not, the company must also determine when investing is optimal.

Schematically, it can be stated that if the investment option is exercised at time t, V_t is the NPV of the project. If the option is kept open at time t, the value of the project may change - up or down - in the following period. In this case, we represent with OV_t the

expected value of the option at time t. Thus, if at time t the firm decides to invest the option is worth V_t, otherwise, if it is kept open, it is worth OV_t.

So, at time t:

Maximum value	Implications
V_t	The project must be developed immediately.
OV_t	The project must be developed at $t+n$ (the option to defer is exercised).
0 or negative	The project should be abandoned.

3.2.3.2. The option to expand

This is defined as the right, but not the obligation, to increase the project's production scale, which strategically allows the company to capitalise on future growth (Kodukula & Papudesu, 2006). However - in general - this option will only be executable when the market is favourable.

The value of the option to expand is given by $pMax(V_e - C_e, 0)$ (3). Where p is the probability of a favourable market situation, C_e is the present value of the expansion costs and V_e is the cash flows from the follow-on project (under favourable market conditions). In this case, we can rewrite the adjusted present value as the sum of the conventional NPV and the option to expand: $APV = V + pMax(V_e - C_e, 0)$ (4)

3.2.3.3. The option to abandon

This type of option represents the possibility of abandoning (or downscale) a project when potential profits are drastically reduced or simply no longer exist. This option includes:

- The option to abandon. This option allows the project owner to exercise his right to sell, liquidate or simply abandon the project. It is evident that maintaining and creating the flexibility of this type of option has a cost. However, the benefits,

especially in projects that are highly volatile or risky, are very high. Moreover, an abandonment option increases the willingness to invest in a project by having an economic effect on investment decisions. Thus, the option to abandon is positively related to the uncertainty about the future value of the project, the time to exercise it, and the relationship between the abandonment value and the final value of the project[34]. The decision whether or not to abandon the project must be made by comparing the salvage value and the value of the project for the rest of its lifetime. Indeed, if the former exceeds the latter, then the option value will be the difference between the two. Otherwise, the option is worth zero.

- The option to mothball. This option allows its owner to abandon the development of the project temporarily. In this case, certain types of companies are more suitable for this option, such as natural resource extraction and cyclical production industries, among others. In these cases, the possibility of temporarily stopping production according to the contingencies that arise in the market is advantageous because it allows reducing the possible losses that may occur.

3.3. Why use ROA to evaluate land deals?

As mentioned in the previous section, ROA is a tool that allows the evaluation of an investment, taking into account its future flexibility (Dixit & Pindyck, 2012) and the uncertainty of the market in which it operates.

3.3.1. The characteristics of farm project investments

Investments in farming projects in Africa are characterised by a high uncertainty in future payoffs and flexibility in the investment timing. As a matter of fact, the profitability of land deals is influenced by exogenous events such as climate, commodity price and future costs. Global warming and the consequent increase in extreme weather events make agricultural investments risky and unpredictable. Moreover, to mitigate this uncertainty, investors can postpone the investment while waiting for more information on the future commodity price, the land productivity, and the production costs. Limited knowledge of the local market and the productivity of the

[34] The abandonment option is similar to an American put option.

leased land make uncertainty and the willingness to defer investment two predominant characteristics to be taken into account when analysing an agricultural project in Africa.

3.3.2. The advantages of real options

The objective of this thesis is to investigate why farming projects fail in Ethiopia. The RO method is a valuable tool to answer this question. Indeed, by incorporating the two features presented in Section 3.3.1 - the uncertainty of future payoffs and investment flexibility - it has some advantages over the traditional valuation method in its calculation procedures.

Real options "can help shape the strategic vision" (Amram & Kulatilaka, 2000, p.26). This statement is based on the fact that the real options methodology creates a way of learning from past performance as it distinguishes between fortuitous and expected contributions. At the same time, this options methodology expands the set of strategic alternatives that managers can consider. Finally, it establishes the framework in which the impact of uncertainty on project value can be predicted, reducing it into helpful information for managers (Amram & Kulatilaka, 2000).

There are two situations in which real options best reflect their importance. In the first scenario, when the investor can respond flexibly in a situation of high uncertainty. Incidentally, if there is little or no uncertainty (an investment in risk-free bonds, for example), real options would be worthless. In the second scenario, when the project is close to its viability threshold (if the NPV is very high, the project will almost certainly be carried out regardless of its flexibility; whereas if the NPV is very negative, the project will be discarded regardless of the value of flexibility). If the project has a net present value equal to zero, but its value can fluctuate very much in a positive or negative direction, the option of deferring - and therefore postponing the decision to invest - will take on great value, allowing the NPV trend to be assessed in the future.

In furthermore, the analysis of investment projects through the real options methodology considers the value of the flexibility to initiate or not a specific project not only at the time of valuation (as defined through the discounted cash flow method) but rather, the convenience of exercising the option within the term established by the contract.

This discussion will analyse whether the delay in the development of leased land is due to economic reasons through a real options approach. As mentioned in Section 2.4, a failure to exercise the option implies no gains from what may concern the host country's infrastructural, economic and social development.

3.4. Methodology for calculating real options

Three different methods for calculating the value of real options are usually indicated in the literature. This section will briefly present them, focusing on the binomial pricing model, as it is the model that we will use in this thesis.

3.4.1. Monte Carlo simulation model

In general terms, the Monte Carlo method[35] is a sampling technique mainly used to numerically operate complex systems with random components (Brealey et al., 2012). Focusing on the valuation of real options, Monte Carlo simulation responds to a series of procedures that analyse the distributions of random variables using random number simulation. The nature of this method allows the direct treatment of all types of assets to be generated, regardless of the number and pattern of the stochastic behaviour of the sources of uncertainty on which the predicted outcomes depend (Kodukula & Papudesu, 2006).

Although the model can estimate uncertainty, it has some limitations for calculating the value of real options within this thesis: the close relationship between output and input and computational inefficiency. Indeed, given the opacity and complex availability of data, the result could be biased or inconclusive.

3.4.2. Black-Scholes model

This model, developed in the 1970s, is based on the possibility of obtaining the value of options independent of both the expected return on the underlying asset and the option itself, leaving aside investor preferences (Black & Scholes, 2019). This may be accomplished through the perfect dynamic hedging approach in a free arbitrage market. The possibility of setting up a framework characterised by the randomness of the underlying asset price (considered as a random variable) and by a constant risk-free rate is the fundamental assumption underlying this methodology.

[35]Boyle introduced this simulation model in 1977.

The formula used in the Black-Scholes model is as follows (Kodukula & Papudesu, 2006):

$$C = N(d_1)S_0 - N(d_2)Xe^{-rT} \quad (5)$$

$$d_1 = \frac{[ln(\frac{S_0}{X}) + r(0.5\sigma^2)T]}{\sigma\sqrt{T}} \quad (6)$$

$$d_2 = 1 - \sigma\sqrt{T} \quad (7)$$

where C is the value of the call option, S_0 is the current value of the underlying asset, X is the cost of the investment (also known as the strike price), r is the risk-free rate of return, T is the expiry time, σ is the annual volatility (or uncertainty) of the future cash flows of S_0, and finally N(d_1) and N(d_2) are the values of the standard normal distribution at d_1 and d_2.

When we refer to a land contract, the investment option is similar to an American call. The owner of this option can decide whether to exercise it and when to do so after evaluating the project.

3.4.3. Binomial pricing model

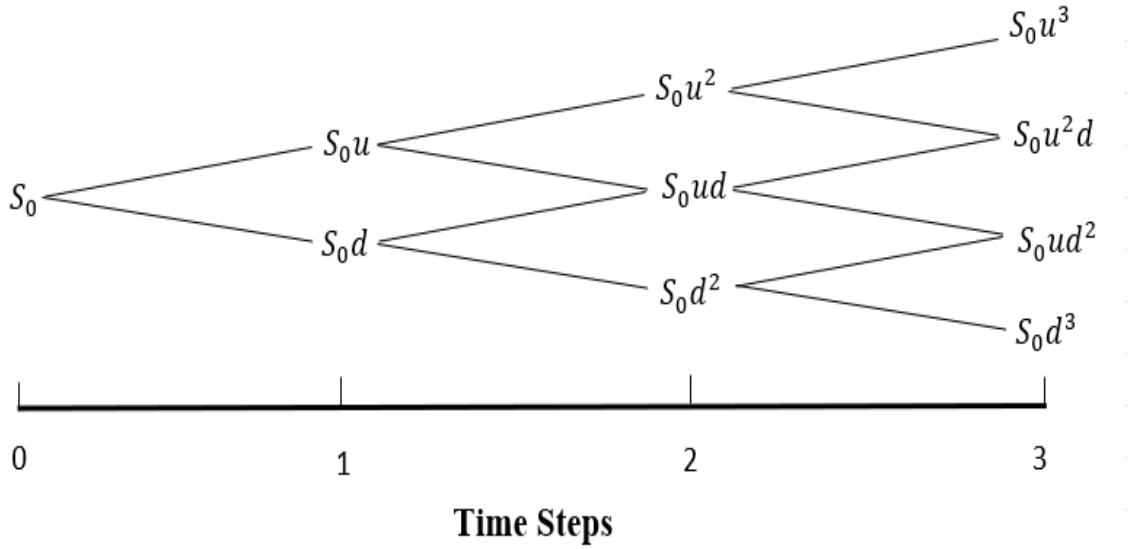
Binomial pricing model is a discrete model where the evolution of the underlying asset price varies according to the multiplicative binomial process[36]. In other words, it can only take on two values, one upwards and one downwards (Hull, 2017; Brealey et al., 2012), with associated probabilities p and $1-p$ respectively. The value of p is closely related to the expected return of the project and the amount of the up change (u) and down change (d). The upward or downward change can be obtained using price volatility (σ) and the time interval Δt. Thus, by extending this probability distribution

[36]It was presented for the first time in 1974 by Cox-Ross-Rubinstein.

for a number of periods T and then using backward induction, the option value can be determined.

The decision tree is widely used to obtain a graphic representation of the binomial pricing model, as shown in Figure 2. As mentioned, the initial value of the asset, S_0, at each step (node) can undergo an upward variation or a downward variation. As we can see later, the magnitude of the movements also depends on the underlying asset's volatility.

Figure 4. *Binomial tree using binomial pricing model*



Source: *Kodukula & Papudesu, 2006. p.70*

As can be seen from Figure 4, at the first time step (t_1), the values that the investment undertaken at time t_0 can assume are two, S_0u and S_0d. The number of future values increases as the time steps increase. In fact, at t_2 the nodes are three (S_0u^2, S_0ud, S_0d^2); at t_3 the nodes are four (S_0u^3, S_0u^2d, S_0ud^2, S_0d^3), and so on. The range of possible asset values at the end of the option's life can be found in the last node of the binomial lattice.

The literature proposed two approaches to solve the binomial lattice: i) risk-neutral probabilities (Brealey et al., 2012), ii) replicating-market portfolios (Copeland & Antikarov, 2001). In this thesis, we will use the risk-neutral probabilities.

If we lived in a risk-neutral world, the expected return on the underlying asset must be equal to the risk-free interest rate (Brealey et al., 2012). So,

$$Expected\ Return = [p \times upside\ change] + [(1 - p) \times downside\ change] \quad (8)$$

The procedure for calculating the RO value using the binomial model is as follows (Kodukula & Papudesu, 2006):

1) Identify the up and down factors, which are a function of the standard deviation of the natural logarithm of the returns on the underlying free cash flows (volatility), σ, and the time associated with each time step of the binomial tree, δt.

$$u = e^{\sigma\sqrt{\Delta t}} \quad (9)$$

$$d = e^{-\sigma\sqrt{\Delta t}} \ (10), \text{ it can be rewritten as } \ d = 1/u \ (11)$$

2) The risk-neutral probability of a rise (p) is

$$p = \frac{e^{r_f\sqrt{\Delta t}} - d}{u - d} \quad (12)$$

where r_f represents the risk-free interest rate or rate of return on a riskless asset during the option's life.

3) The expected option value at each node is

$$\frac{[p * option\ value\ if\ rise + (1-p) * option\ value\ if\ drop]}{1+r_f} \quad (13)$$

Other lattices can be used to evaluate real options, such as the trinomial, quadrinomial and multinomial trees. The case study will be developed using the binomial price model. We have chosen this model because of the tight timeframe for delivery of this paper.

3.5. Time series data

The time series is a collection of observations of a family of real random variables made sequentially through time (Cowpertwait & Metcalfe, 2009; Cryer & Chan, 2008), denoted by $(Y_t)_{t\in\Omega}$, where t=1,2,...,T and Ω represents the time-space which can be discrete - observations are taken only at specific times - or continuous - observations are made continuously over time.

We are interested in the evolution of time series data in order to describe, explain, predict and control the phenomenon in the future. Time series data can be categorised in different ways: fields of application, real/complex sequences, temporally or spectrally represented sequences, and stationary or non-stationary sequences (Prenat, 2011). In this thesis we will only focus on the latter.

A random process (and therefore also a time series) can be defined as stationary:

- in a broad sense or weakly stationary if (Prenat, 2011):

$$\begin{cases} \forall t \in \mathbb{Z}, E|X_t^2| < \infty \\ t \to E(X_t) \text{ is constant} \\ \forall\, r,s,t \in \mathbb{Z}, Cov(X_r, X_s) = Cov(X_{r+t}, X_{s+t}) \end{cases}$$

- in the strict sense, if the joint distribution of $Y_{t1}, \dots, Y_{tk}$ is the same as the joint distribution $Y_{t1+m}, \dots, Y_{tk+m}$ for all k and t (Cryer & Chan, 2008).

$$F(Y_{t1} \le y_{t1}, \dots, Y_{tk} \le y_{tk}) = F(Y_{t1-\tau} \le y_{t1-\tau}, \dots, Y_{t_k-\tau} \le y_{t_k-\tau}) \quad (14)$$

$$\forall (t_1, \dots, t_k) \in T^k \text{ and } \forall\, k, \tau \in Z$$

Thus, as one may immediately see a process is stationary if the expected value and covariances are stable over time[37].

In contrast, a time series is non-stationary if at least one of the mean and variance changes as time changes (it depends on t). Such non-stationarity makes it complex or impossible to generalise its behaviour to other periods (Hill et al., 2018).

[37]Mean, variance and autocovariance remain constant through time (Hill et al., 2018).

3.6. A unit root test: the Augmented Dickey-Fuller test

A characteristic of economic (and financial) series is that they may not be stationary. Some of the most used procedures to make the time series stationary is differentiation, applying logarithms or differences of logarithms. In order to study the stationarity (or non-stationarity) of a time series, it is possible to use unit root tests or stationarity tests. To better understand the difference between the two, consider the following decomposition of a time series y_t (Zivot & Wang, 2007):

$$y_t = TD_t + z_t \quad (15)$$

$$TD_t = \kappa + \delta t \quad (16)$$

$$z_t = \varphi z_{t-1} + \varepsilon_t \quad (17)$$

where $\varepsilon_t \sim WN(0, \sigma^2)$, TD_t is a deterministic (linear) trend, κ and δ are constants, and z_t is a stationary Autoregressive process of order one (AR(1)), thus $|\varphi| < 1$. When $\varphi = 1$, then the historical series is non-stationary, becoming a random walking process.

Unit root tests refer to a different system of assumptions than the one used to test the stationarity of a time series. Indeed, the first test is based on the following assumptions:

$$H0: \varphi = 1$$

$$H1: |\varphi| < 1$$

If the null hypothesis is accepted, the characteristic polynomial of an autoregressive process of order one will have a root equal to unity[38]. While the stationarity test assumes as a null hypothesis the stationarity of the process, therefore:

$$H0 : |\varphi| < 1$$

$$H1 : \varphi = 1$$

In this dissertation, we will compute the Augmented Dickey-Fuller (ADF) test in order to study the stationarity of time series. The ADF test is a univariate test and assumes

[38]For simplicity, we consider μ (the level of the process) to be zero. So, the characteristic polynomial of an AR(1) is $Yt=\varphi 1 Yt\text{-}1+\varepsilon t$. If the null hypothesis is accepted $\varphi(z) = (1 - \varphi z) = 0$.

that a part of the y_t process has an Autoregressive Moving Average (ARMA) structure, for which the following regression is estimated (Zivot & Wang, 2007):

$$y_t = \beta' D_t + \varphi y_{t-1} + \sum_{j=1}^{p} \Delta y_{t-j} + \varepsilon_t \quad (18)$$

The regression is characterised by a vector containing deterministic terms (D_t), a parameter to be estimated (β'), p delayed differential variables, Δy_{t-j} which describes the error structure of the process. The value of p is chosen to make the ε_t errors uncorrelated, which is also assumed to be homoscedastic.

4. Empirical study with the binomial method

In this chapter, we will present the motivations behind rice cultivation in Ethiopia and the background to the empirical case.

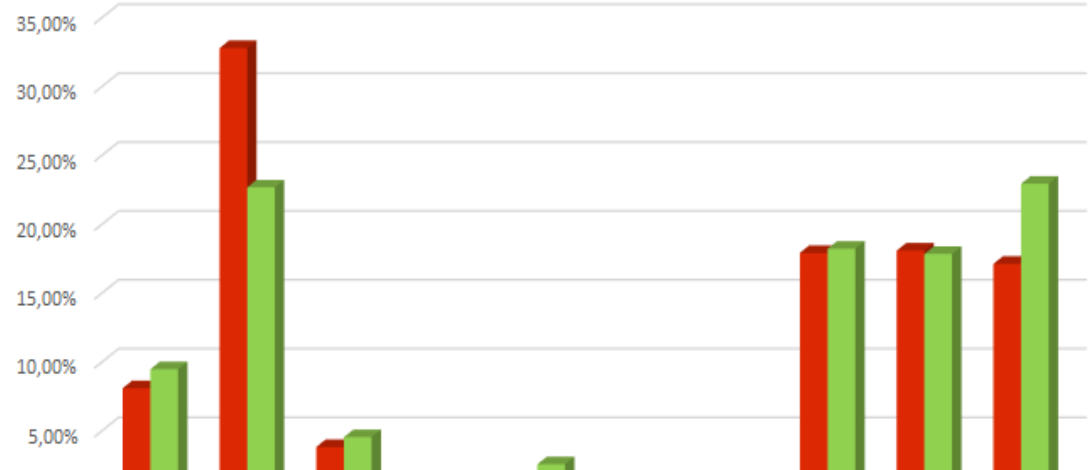
4.1. Rice and rice paddies in Ethiopia

The section examines the reasons for the growing importance of rice in Ethiopian agriculture and the national government's current policies.

4.1.1. Rice in Ethiopia

Ethiopia is quickly emerging as one of the big rice-producing countries in Sub-Saharan Africa. However, rice has just been recently introduced to Ethiopia[39] (Tilahun, 2020), recognising its importance as a food security crop and a source of income and employment opportunities. Therefore, the Ethiopian government has named it the "millennium crop" (EIAR, 2015, p.3) and has ranked it among the priority commodities of the country[40].

Figure 5. *Production (%) and area in hectares (%) of cereals in Ethiopia in 2019*



	Barley	Maize	Millet	Oats	Oilseeds nes	Pulses nes	Rice, paddy	Sorghum	Wheat	Teff
Production	8,09%	32,79%	3,83%	0,16%	0,99%	0,44%	0,58%	17,92%	18,09%	17,12%
Area	9,48%	22,67%	4,54%	0,21%	2,57%	0,96%	0,57%	18,22%	17,84%	22,93%

Source: FAO (2021), EIAR (2015)

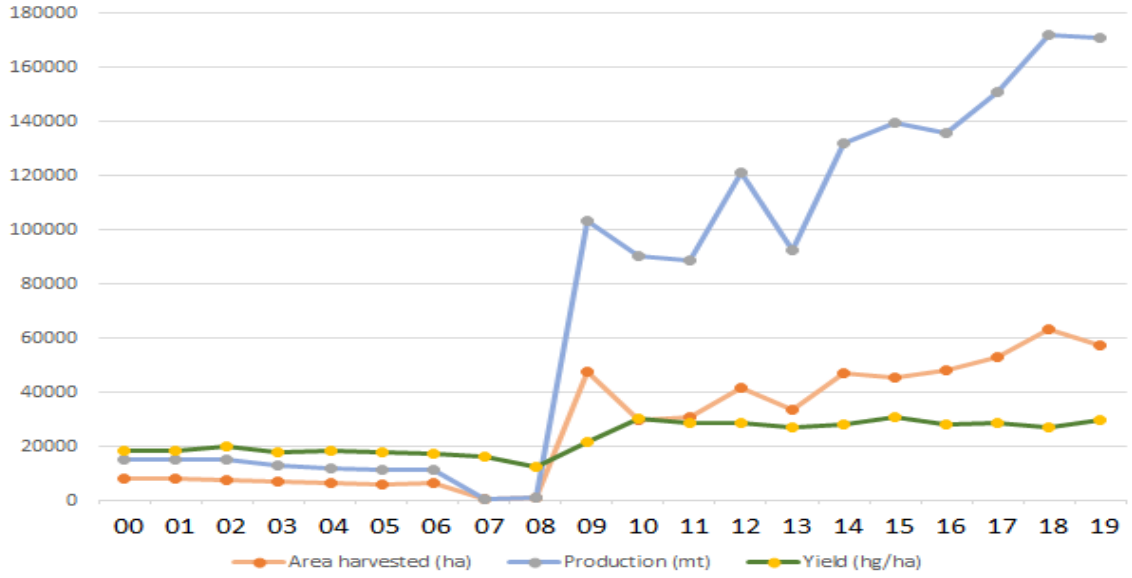
[39]Some historians claim that rice was first brought to Ethiopia by the Portuguese in the 16th century (Gashaw, 1989). Following the discovery of wild rice in the north-western parts of the country - Gambela region and Fogera plain - many governmental and non-governmental organisations have initiated some adaptation trials in different parts of the country (Gashaw, 1989; Mitiku 2011).

[40]In February 2020, the "National Rice Development Strategy-II 2020 - 2030" was published by the MoA, describing its vision, purpose and goals.

Until a few years ago, the staple food crops in Ethiopia were maize, wheat, sorghum, and teff[41]. Figure 5.shows the production and the area used for cereal production in Ethiopia in 2019. There is a clear predominance of the four types of cereals mentioned above. Indeed, together they account for around 86% of cereal production and around 81% of the area devoted to cereal cultivation.

Rice began to be appreciated in the country for its excellent productivity, available labour and vast areas suitable for rain-fed and irrigated-fed. In Ethiopia, the rice sector saw phenomenal growth from 2007 until today[42]. As a matter of fact, in 2007, the harvested area and production represented 421 hectares and 681 tons respectively, while in 2019, they reached 57,576 hectares and 170,630 tons (Figure 6).

Figure 6. *Evolution of rice production in Ethiopia from 2000 to 2019*



Source: own elaboration from FAO (2021)

According to the report published in 2020 by the Ministry of Agriculture and Rural Development (MARD), the potential area of rice production is estimated to be approximately 39,345,190 hectares. Thus, the current area under rice cultivation in Ethiopia is low compared to its potential (only 0.43%). The Ethiopian government pointed out that 5,590,895 hectares are highly suitable, 24,910,629 hectares are suitable and 8,852,666 hectares are moderately suitable (MARD, 2010. p.48). Moreover, the

[41]Teff is a fine grain, unique to Ethiopia.

[42]"The increased production is linked with the expansion of area in the wetland and upland areas. Rice production in irrigated areas has not increased substantially." (MoA, 2020. p.2)

number of rice farmers has increased over time in the country, quadrupling in a decade[43] (EIAR, 2015).

4.1.2. Factors explaining the strong growth in rice production in Ethiopia

Contrary to what one might think, there are many regions in Ethiopia where it is possible to grow both rain-fed rice and irrigated-fed rice[44]. The factors that have stimulated the increase in rice production are as follows:

- Rising food prices. As presented in Section 2.2.1, cereal prices have been rising since the early 2000s, peaking in 2007-2008.
- Government actions. The government has put in place fair policies to promote large modern farms in the private sector. Part of the Ethiopian government's strategy has been to invest in rural finance, market development, access to technology, infrastructure and resettlement programs (Kebede, 2011) to attract more foreign investors.
- Market demand and rural labour availability. Higher prices for rice grains compared to other cereals, increased urbanisation and consumption of rice, and the interconnectedness of the value chain have encouraged greater production of this cereal. This process has also been facilitated by the large availability of cheap rural labour.
- Technology, inputs, and research. Research (IRRI, EIAR and local universities) and technological progress have made it possible to identify the most profitable rice varieties and improve agricultural machinery.
- Other factors. These include intrinsic factors of rice compared to other crops, enabling factors for rice production and partnership and relationship factors.

4.2. Background of empirical study

A land rent contract signed between Saudi Star Agricultural Development Plc and the Ethiopian Ministry of Agriculture and Rural Development to produce and export rice will be used as an empirical study.

[43]Rice producers increased from 32 000 in 2006 to 119 000 in 2013 (EIAR, 2015).
[44]According to EIAR (2015) those regions are: The Central Western Highlands of the Amhara Region (Fogera, Gonder Zuria, Dembia, Takusa and Achefer); The North-Western plain of Amhara and Benshangul regions (Jawi, Pali, Metema and Dangur); Gameblla Regional State (Abobo and Etang woredas); Southern and South-Western lowlands of SNNPR (Beralee, Weyito, Omorate, Gura Ferda and Menit); Somali Region (Gode); South-Western highlands of Oromia Region (Illuababora, East and West Wellega and Jimma Zones).

4.2.1. Land lease contract: the case of Saudi Star Agricultural Development Plc[45]

Ethiopia's Ministry of Agriculture and Rural Development has signed seventy-two land contracts with companies or individuals over the past twenty years[46]. The predominance of land deals were concluded with Indian companies (15 contracts signed), followed by Saudi companies (12 contracts), and Israelian ones (8 contracts)[47]. The case of Saudi Arabia is interesting because all twelve land deals signed between MoA and Saudi Arabian operation companies have MIDROC group[48] as the top partner company.

The land lease contract between the Ethiopian Ministry of Agriculture and Saudi Star Agricultural Development Plc - henceforth abbreviated as SSAD - was executed on October 25th, 2010 (SSAD agreement, 2010). Details of the SSAD agreement (2010) are reviewed below.

The contract stipulates the coverage of 10,000 ha of rural land, located between Perbengo and Pukedi Kebeles, Abobo District of Agnuwa Zone in Gambela Region (article 1.1)[49]. The land is leased to SSAD to cultivate and develop a rice farm (article 1.2). The contract has a duration of 50 years, starting on 25/10/2010, with the possibility of renewal for additional years by mutual consent of the parties (article 2.1). The lessee has the right to develop, maintain and construct any type of infrastructure (irritation systems, buildings, and so on) in order to promote and facilitate rice production (article 3).

The amount that the company, owned by the Ethiopian-born Saudi millionaire Mohammed Hussein al-Amoudi, has to pay is 30 Ethiopian Birr (ETB) per hectare per year, for a total of 300,000 ETB per year for the entire land under contract (article 2.2).

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[45]The land contract can be found at this link: https://www.openlandcontracts.org/contract/ocds-591adf-9604461339/view#/pdf. Accessed: 15/09/2021

[46]Most of the contracts are available for download on the open land contracts website, under the link "Ethiopia" (www.landcontracts.org. Accessed: 15/09/2021).

[47]As presented in Chapter 2, India has a growing population and urbanisation and is seeking energy and food security. At the same time, Saudi Arabia and Israel are countries capital-rich but land-poor.

[48]The MIDROC group, owned by Sheikh Mohammed Hussein Ali Al-Amoudi, has more than 80 group companies and affiliates.

[49]Article 1 of the SSAD agreement (2010) can be referred to if needed. In Section 4.1.1 of this study, parenthesis in the same form represents the corresponding article of the agreement (2010).

If we consider the price of the deflated rent in 2010 using the Producer Price Index (PPI), this is equal to 14.5 USD/ha.

As stated in Article 4.2, "the lessee should take over the leased land within 30 days of execution of the agreement". The contract sets out the investor's obligation to start developing the land within the first six months from the date of execution[50] (article 4.3). Within the first year, the investor must develop one-fourth of the leased plot of land. Moreover, SSAD must develop the entire plot of land within four years from the date of exercise or the earliest practicable date (article 4.4). This means that within the first year (t=1), the foreign company is obliged to develop at least 2,500 ha, and within the fourth year (t=4), it has to develop the whole plot of land. There are no tax exemptions within the contract, such as tax holidays, and the investor must settle the current annual land rent to the district during the months of December up to June every year.

The land lease agreement can be terminated subject to written notice with "justified good cause" provided at least six months in advance (article 3.6). Grounds for contract termination are set out in Article 9, where the following reasons are cited: "force majeure"[51], failure to the lessee to perform its obligations or settle the annual rental, failure to the lessor to fulfil or observe any of its obligations. Once the land contract is terminated, the lessee shall surrender the leased land back to the lessor within one year from the date of termination (article 10.1). If the contract is terminated for reasons attributable to the host country (within the contract traceable to articles 9.3 and 9.6), the investor may claim reimbursement for improvements made to the land. Whereas if it is the lessor who has terminated the contract (for reasons presented in Articles 9.5, 9.7), in this case, no payment has to be made by the lessee (articles 10.2 and 10.3).

4.2.2. Rice production and costs

For the reasons outlined in the previous section, farming rice has attracted the interest of the Ethiopian government and foreign companies since 2007-2008. Although the available data are opaque and sometimes inconsistent, in this section, the costs of rain-fed rice production will be presented using the publications of Abera et al. (2020) and Takele (2017, 2010).

[50]Alternatively, from the date on which the lessee receives all necessary information.
[51]The conditions of force majeure shall be governed by the Ethiopian Civil Code (article 13).

As reported by the newspaper New Business Ethiopia (2010), the agreement between Saudi Star Agricultural Development Plc. and Satake International Co. Ltd will transfer its technology and facilitate the production of good quality rice. This agreement will enable the Saudi company to process 100,000 tons of rice per year. To process one million tons per year over the next seven years, the company owned by the Saudi billionaire Sheik Mohammed al-Amoudi will have to invest 350 million Birr. In the case study, using the data published by FAO (2021), the annual rice yield (2010) will be fixed at 30273 hg/ha[52]. To develop the 10,000 hectares in the Gambella region, the company has bought ETB 115,280,000 (2010 USD 8 million) in agricultural machinery from Caterpillar Inc.

Table 3. *Total Initial Investment*

Items	Cost (2010 USD)
Land Preparation	1,361,000.55
Machinery and equipment	8,000,000
Total initial investment	9,361,000.55

Source: Abera et al. (2020) and Takele (2017, 2010)

The contract provides that the lessee must start developing the land within the first six months of signing the contract. In furtherance, one-quarter of the land must be developed within the first year, from the earliest date (article 4.3 and 4.4). Moreover, the land under contract must be developed in its entirety by the fourth year. These are the only limitations presented in the contract. Breach of these duties should provide for termination of the contract (article 10). Therefore, the investor will develop land sequentially: within the first year, he will have to develop at least 2,500 hectares, but nothing prevents him from developing all the land immediately, gradually or delaying the development until the fourth year. Thus, the investor may decide to develop the farming project when the potential net returns are maximised.

The total initial investment is made up of the cost of machinery and tools and the preparation of the land. The latter refers to the costs of restoring and cleaning the land to foster rain-fed rice growth. The total cost that the investor would have to pay to start the

[52]Using data published by FAO (2021), it is clear that the Saudi company will be able to process 100,000 tonnes if it increases either the area under contract or the annual rice yield.

project, excluding the land rental costs, is estimated to be 2010 USD 9,361,000.55 as shown in Table 3. This sum must be paid within the first year.

Under favourable weather conditions and without exogenous complications (floods, drought, locust invasions, and so on) the annual production cost per hectare is estimated at 2010 USD 1,179 per hectare, as presented in Table 4. As agreed in the contract between the two parties, by the first year, the plant must be at least 25% operational, and by the fourth year, the remaining 75% of the contracted land must be developed. Within this thesis, the progressivity of production is taken into account, which means that to cultivate the entire land, Saudi Star Agricultural will have to develop the first 2,500 hectares. In other words, the Saudi company will only decide to develop the whole project when it can cover all the costs.

Table 4. *Annual production cost (USD/ha)*

Items	Cost (2010 USD)
A. Material Inputs (USD/ha)	**253.00**
Seed (USD/ha)	132.27
Herbicide (USD/ha)	16.81
Fertilizer (USD/ha)	103.97
B. Labour Cost (USD/ha)	**841.41**
Land preparation (USD/ha)	136.21
Plantation (USD/ha)	38.07
Fertilizer application (USD/ha)	4.43
Weeding (USD/ha)	412.87
Harvesting and pileup (USD/ha)	144.56
Maintenance, threshing and winnowing (USD/ha)	105.27
C. Other cost (USD/ha)	**84.71**
Water Management (USD/ha)	4.47
Transporting (USD/ha)	80.24
Production Cost (USD/ha)	**1,179**

Source: Abera et al. (2020) and Takele (2017, 2010)

In further detail, the depreciation rates of machinery and equipment is not taken into consideration in this study. In this case, we assume that the service life of the machinery and equipment is 10 years, at the end of this period their value is zero.

4.2.3. Annual world rice price

Annual income is obtained from the sale of rice. Theoretically, the net annual income can be influenced by some variables such as the yield of the paddy field per year, the price of rice and all kinds of costs. Within this thesis, due to time constraints, the price of rice is the only variable considered stochastic. The 2010 average annual paddy yield and operating costs presented in Figure 6 and Table 4 are used respectively. Consequently, the uncertainty of the cash flow stems only from the rice price.

Historical data of the annual world price of A.1 rice[53] - in nominal US dollar and real 2010 US dollar per ton - from 1990 to 2020 are presented in Table A.1. in Appendix A. A unit root test is conducted to test whether the time series data are stationary or non-stationary. Within this dissertation, stationarity is investigated using the augmented Dickey-Fuller (ADF) test incorporated in R[54]. The ADF test ascertains the stationarity of the time series by investigating the existence of a unit root. If, using the command *ur.df*[55] in R, the value of the test statistic is greater than the critical value of τ (tau), the null hypothesis - the presence of unit root - must be accepted. On a different note, using the command adf.test - present in the tseries package - the time series is non-stationary if the p-value is greater than 5%.

Using *adf.test* the Dickey-Fuller is equal to -1.8875 and the corresponding p-value is 0.6159. Since this p-value is bigger than 0.05, the null hypothesis cannot be rejected. We can conclude that the time series is non-stationary. The test statistics and p-values of ADF conducted by R using the command *ur.df* are presented in Table 5. The values to be taken into account are those presented in the time series study without trend and with intercept (constant). Indeed, the trend is not significant, while the intercept is

[53]There are various types of rice, and the cost increases as the whole grain increases. Type A.1 represents 100% (FAO, 2021) of the broken grains, i.e. the least valuable quality on the market. In effect, this thesis assumes that the rice grown in Ethiopia is not, at least for the first period, of high quality.

[54]R (o Rstudio) is an open-source programming language specifically for solving mathematical-statistical problems and working with data.

[55]The ur.df command, which allows to study the stationarity of the historical series and the presence of a deterministic trend, is included in the urca package.

significant. As a consequence, the constant cannot be eliminated for the sake of correctness.

Table 5. *Dickey-Fuller test test-statistics and critical values (using ur.df)*

		Test critical values (τ)		
	Test-statistic	1%	5%	10%
with trend and constant	-3.016	-4.21	-3.48	-3.15
with constant	-2.712	-3.62	-2.89	-2.67
without trend and constant	-2.1494	-2.53	-1.94	-1.67

The full results are shown in Table A.2. in Appendix A. Again, the null hypothesis cannot be rejected, so the time series is non-stationary. This means the application of the random walk model is justified.

The formula proposed by Hull (2017) to estimate the volatility of an asset's expected return using historical data can be described as:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\mu_i - \bar{\mu})^2} \qquad \text{where: } \mu_i = ln(\frac{S_i}{S_{i-1}}) \qquad (19)$$

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

According to Jarrow & Rudd (1983), using volatility and mean return, it is possible to calculate the expected growth rate - drift - of the annual rice price.

$$g = \bar{\mu} + \frac{\sigma^2}{2} \qquad (20)$$

Using the historical series of world rice prices from 1990 to 2020 and the two equations presented above, the volatility (σ) of the annual rice price is 17.78%, and the average

growth rate (g) is estimated at 3.64%[56]. The world price of rice is on an upward trend, as evidenced by the positive average growth rate. Saudi Star Agricultural Development's decision on the development of the land under contract is influenced by the volatility of the world price of rice, which represents the uncertainty within the case study.

The price used in the valuation of the project is the rice price in the year the land contract came into force, which is 2010. The real price in 2010 of rice was USD 383.66 per tonne.

4.3. Input Variables

In this section we will present the variables that influence the decision to delay the development of a farming project. There are many factors to take into account when evaluating the SSAD's investment project. These are present below.

Input	**Saudi Star Agricultural Development Plc study case**
Rental cost (RC)	The Saudi Arabian company will have to pay the revised annual lease rent of 2010 USD 145,000 at the beginning of each year every year.
Contract duration	The land contract signed between SSAD and the Ethiopian Ministry of Agriculture is valid for 50 years. The extension of the initial contract is not considered in this study.
Time to maturity (T)	It refers to the time remaining until the expiry of a given option. In the case of SSAD, 1/4 of the area under contract must be developed within the first year. The total development of the plot is foreseen within the 4th year from the entry into force of the agreement (SSAD agreement, 2010). Non-fulfilment of the timeline by the Saudi company should lead to rescission of the contract.
Annual Revenue (R)	Rice sales per year represent annual income. As previously mentioned in Section 4.4.2, only the price of rice is considered stochastic. As a result, the uncertainty of the

[56]Both estimations are presented in Table A.1.

	annual cash flows arises from the price of the commodity.
Costs (C)	The costs presented in Section 4.2.3 are expressed in 2010 USD/ha. The land under contract is 10,000 ha, and development is assumed to be sequential.
Project lifetime	If the paddy field is not prepared every year, production cannot take place. Furthermore, machinery and equipment are supposed to have a service life of 10 years, after which they have no value. Since the contract is for 50 years, the project must be renewed every 10 to produce rice. In this study, it is assumed that the efficiency of the machinery is constant, so it does not decrease over time.
Salvage value	It represents the estimated value of an asset at the end of its useful life. This thesis does not consider it.
Risk-free discount rate (r_f)	The risk-free discount rate is assumed using the average value of the US Treasury Long Term Rate in 2010 and is equal to 4.1%[57].
Change in time interval (Δt)	In the case study, it is chosen to be 1.
Probability of a raise (p), upside move (u), and downside move (d)	To determine these variables the volatility of the rice price (σ), the risk-free discount rate (r_f), change in time interval (Δt) are used. Estimates of the volatility value and the expected growth rate of the rice price are presented in Table A.1., in Appendix A
Taxes	The effect of taxes or tax relief is not taken into account in this empirical study.

4.4. Empirical study description using the binomial model

In this section, the binomial model is presented to assess whether to develop, delay or

[57]Treasury rates for 20-year long-term US are available on the Treasury website.

abandon the project. According to the land lease agreement, Saudi Star Agricultural Development is obliged to develop at least 25% of the total area within the first year. Since no down payment has been made, the company can abandon the project within the first year without incurring any losses. In extension, the entire plot of leased land should be developed within the fourth year. Therefore, considering the timeframe of preparing the land, the company will have to decide whether to develop the whole project by the beginning of the third year. Due to the fixed duration of the contract and the obligations in the land lease, the *wait and see* strategy shortens the lifetime of this project.

Table.6 *Input of empirical study - SSAD's case*

Initial Investment (2010 USD)	**9,361,000**	**Land contract**	
Land Preparation	1,361,000	Lease duration (year)	50
Machinery and equipment	8,000,000	Area under contract (ha)	10,000
Production cost (2010 USD)	**1.179**	Revised rent (2010 USD/ha per year)	14.50
Raw material (USD/ha)	253.00	Rent grace period (year)	0
Labour cost (USD/ha)	841.41	**Operation Scale**	
Other costs USD/ha)	84.71	1st operation year	25%
Renewal Cost (2010 USD)	8,000,000	4th operation year	100%
Machinery and equipment	8,000,000	**Other**	
World Rice Price		Annual yield of rice in 2010 (hg)	30,273
Annual volatility (σ)	17.78%	Lifetime without machinery renewal (year)	10
Annual expected growth rate (g)	3.64%	Risk-free discount rate (r_f)	4.1%
Current rice price (2010 USD/mt)	384.66		

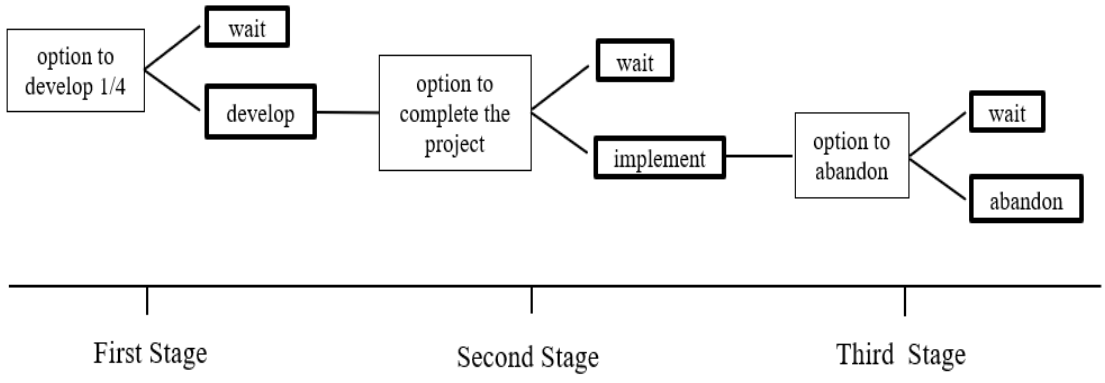
Source: SSAD agreement (2010); Abera et al. (2020); Takele (2017, 2010); WB (2021); FAO (2021)

On a theoretical level, paddy field development can be analysed as a multi-phase

project. It can be divided into three phases, and at each node an option is incorporated, as presented in Figure 7.

1. The first phase gives the Saudi company the right, but not the obligation, to develop 25% of the total land under contract within the first year. Given its characteristics, this right can be treated as a call option, where the exercise price is the investment cost required to develop the plot. The option should expire after the end of the first year. However, considering the different negotiating powers of the two counterparties, SSAD has an option to postpone the development.
2. Once 1/4 of the land has been developed, the company has the right, but not the obligation, to complete the project. This right can be considered a call option where the exercise price is calculated as the initial investment minus the expenses incurred during the first phase. This option allows SSAD to decide whether to delay or develop the project within the third year.
3. In the third phase, we have an abandonment option, which gives the right, but not the obligation, to abandon the whole project. This right is a put option, where the exercise price is the salvage value. The company can abandon the project for the project's duration, or it can delay the decision pending a better economic situation or reduce uncertainty.

Figure 7. *Sequential compound option - case of SSAD*



In the presence of real options, the decision to exercise the first option (stage 1) depends on the value of the second option (stage 2), which in turn depends on future cash flows. The latter is linked to the value of the option at stage 3. In other words, backward induction is required to obtain the option value at the beginning of the project.

The willingness to exercise the option to develop the whole project is determined by the project value tree in the third phase. As the option is valid until node t=3, i.e. the beginning of year 4, the investor can decide whether to invest immediately, wait or abandon the project in t=0, t=1, and t=2. In furtherance, the Saudi company at the beginning of fourth year can decide whether to invest immediately or to abandon (or wait, if the bargaining power is high).

As in stage 1, the option to develop 25% of the contracted land is decided by analysing the decision tree in the next stage (stage 2). As soon as the investor has the option to develop 1/4 of the land (t=0), he can decide whether to develop, abandon or wait. Being a sequential process, if the option is exercised in the first node, then SSAD can decide to invest, develop or abandon the project at the next node, t=1.

In this case study, we will not analyse the agricultural project using the sequential compound option. However, we will assume that the foreign company will decide to develop the whole land without sequential development when the net revenues (NR) derived from the 10,000 hectares are greater than the sunk costs. This simplification is possible because the only stochastic variable within the model is the price of rice, and production costs are assumed to be constant. Nevertheless, although the net revenues are greater than the cost of purchasing the machinery and its renewal, the investor will decide to delay the development of the land in order to maximise the project net returns.

The binomial tree of annual net revenues from rice sales can be built from the annual volatility of the world price of rice (σ), the annual growth rate of the commodity (g), the risk-free interest rate (r_f), and the change in the time interval (Δt). With these four variables, it is possible to calculate the upward (u) and downward (d) movements and the risk-neutral probability of rising (p). With this model, the option value can be obtained. The valuation process and the optimal Saudi Star Agricultural Development Plc strategy will be considered and developed in the next chapter.

5. Analysis and discussion

In this chapter, we will investigate whether “failure”, understood as a delay in land development, is an investor's rational decision, aiming to maximise his returns. The case of SSAD in Ethiopia is analysed, and the NPV approach and ROA results are presented.

5.1. Evaluation of the Saudi Star Agricultural Development case - Net Present Value approach

The input variables presented in Section 4.3 and summarized in Table 6 are necessary to calculate the project's net present value in question.

Table B.1., presented in Appendix B, presents the spreadsheet to evaluate the investment project undertaken by Saudi Star Agricultural Development. The purchase of the machinery and the preparation of the land represent the initial investment. This investment is a cost that must be made at t=0. The cost of renewing the machinery must be made every ten operating years. In other words, the Saudi company will have to pay at t=11,21,31 and 41. If the renewal is not done, the company will not be able to produce anything. For the calculation, the quantity of rice produced is assumed to be sold in full at the current price of 383.66 2010 USD/mt. During the NPV calculation, we have assumed that the farm will cultivate 1/4 the first three years and then develop the entire contracted land from the fourth year onwards. As mentioned earlier, the annual price of rice is expected to grow at a rate of 3.64%. Based on the above, the conventional NPV of the project is estimated at 2010 USD 183.217 million. The present values of the project are negative at t=0,1,4,11.

The NPV is positive even i) if SSAD decides to develop all the land in the first year, ii) if the company decides to develop the land gradually over time (25% in the first year, 50% in the second, 75% in the third and all the land in the fourth). In the first case the NPV is 2010 USD 231.788 million, in the second it is 2010 USD 182.829 million. This means that it does not make sense for the company to adopt the "wait and see" strategy because the NPV is positive in every situation.

On the basis of the criterion presented in Section 3.1.1, as the NPV of the project is positive, it makes sense for the Saudi Arabian company to invest in the development of the paddy field.

5.2. Evaluation of the Saudi Star Agricultural Development case - Real Option Approach

In this chapter, we will present the binomial model of the SSAD case, analysing the binomial tree step by step. Then, based on the data obtained, we will analyse the foreign investor's motivations for delaying land development.

5.2.1. Binomial Method

Using the binomial model, we want to show that behind the lack of development of Ethiopian land there is a rational delay to maximise the investors' return. Thus, the obligation to develop the land will only be fulfilled when the option value is large enough to cover sunk costs, variable costs, and land rent. Until this assumption is reached, the investor will not be interested in developing the land and will decide to keep the option open. Although the farming project has a positive NPV, the lessee may decide to delay his investment when uncertainty is very high, waiting for more information.

To analyse the value of the SSAD option, we will follow the steps proposed by Kodukula & Papudesu (2006, p.76):

a) Identify the input parameters:

- The value of the underlying asset at time zero (S_0) is the PV of the revenue stream for putting all 10,000 hectares under contract into cultivation at t=0. It is obtained by subtracting the PV (at t) of the flow of periodic revenues from the PV (at t) of the flow of periodic cost.
- The strike price (X) represents the purchase of the machinery, without which the project could not be implemented. For the sake of simplicity, let us assume that the Saudi Arabian company buys all the machinery needed to carry out the renovation at the same time. Technical obsolescence is not taken into account.
- The option has a duration (T) of forty-nine years and an incremental time step (Δt) over the option life of 1.

- The volatility of the logarithmic returns (σ) is presented in Table 1.A., in Appendix A.
- The risk-free rate is calculated using data published by the US Treasury on treasury long-term rate in 2010.
- The growth rate was calculated using the formula (20). The growth rate is lower when calculated using the following formula: $g = (\frac{RP_{2020}}{RP_{2010}})^{\frac{1}{10}} - 1$.

The parameters used in order to determine the value of the real option are summarised in Table 7.

Table 7. *Input parameters for ROA*

S_0	USD 11.645 million	X	USD 41.361 million
T	49	Δt	1
σ	17.78%	r_f	4.1%
g	3.64%	$r_f - g$	0.0046

b) Calculating option parameters.

Equations (9), (11) and (12) will be crucial in the construction of the binomial tree of PV of the revenue stream. It will also be necessary to use the volatility of the world rice price (σ), the risk-free rate (r_f), and the change in time interval (Δt) to obtain the up move (u), downward movements (d), and the risk-neutral probability of rise (p). In addition, to discount the revenue streams, it is necessary to use the opportunity cost represented by the difference between the risk-free rate and the growth rate.

$$u = e^{\sigma\sqrt{\Delta t}} = e^{0.1796\sqrt{1}} = 1.1967$$

$$d = 1/u = 1/1.1967 = 0.8356$$

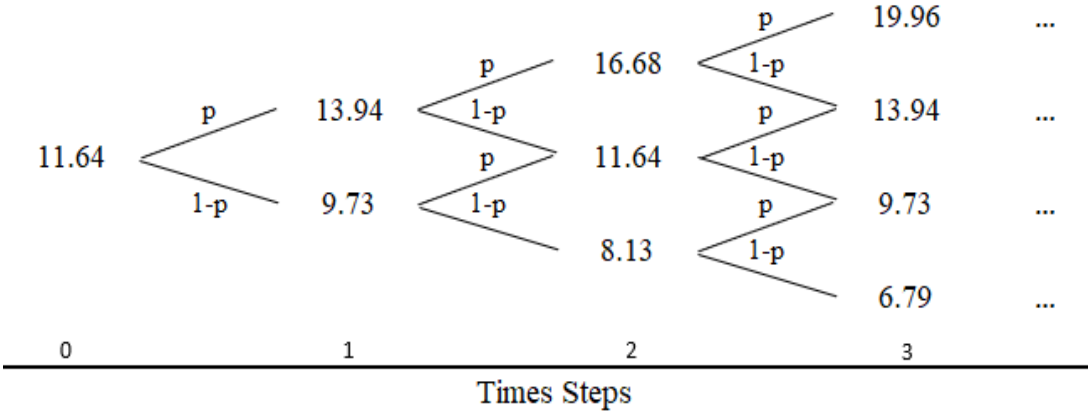
$$p = \frac{e^{r_f\sqrt{\Delta t}} - e^{-\sigma\sqrt{\Delta t}}}{e^{\sigma\sqrt{\Delta t}} - e^{-\sigma\sqrt{\Delta t}}} = \frac{e^{0.07\sqrt{1}} - d}{u - d} = 0.5711$$

$$1 - p = 0.4289$$

c) Building the binomial tree of PV of the revenue stream and calculate its values at each node.

In order to develop the binomial tree of the PV of the revenue stream, it is first necessary to develop the binomial lattice of the annual revenues (R). The value of the underlying asset at time zero is obtained by multiplying the world price of rice (2010 USD/mt) with the average yield of the entire plot of land in 2010 (mt/ha). As presented earlier in Section 3.4.3, at each lattice node, there are two possible future movements.

Starting from t=0, the S_0 is USD 11.64 million. The following year S_0 can increase, with a probability of 0.5711, to USD 13.94 million or decrease to USD 9.73 million with a probability of 0.4289. R may move down or up at each tree's node in the next period with a probability $1-p$ or p respectively. The binomial trend of the annual



revenues of the first four steps are presented in Figure 8.

Figure 8. *Annual revenues binomial lattice from t=0 to t=3 (million 2010 USD)*

Since within the model we do not consider the "dividend payment in each period in the form of cash flows" presented by Brandao & Dyer (2005, p.30), the downward

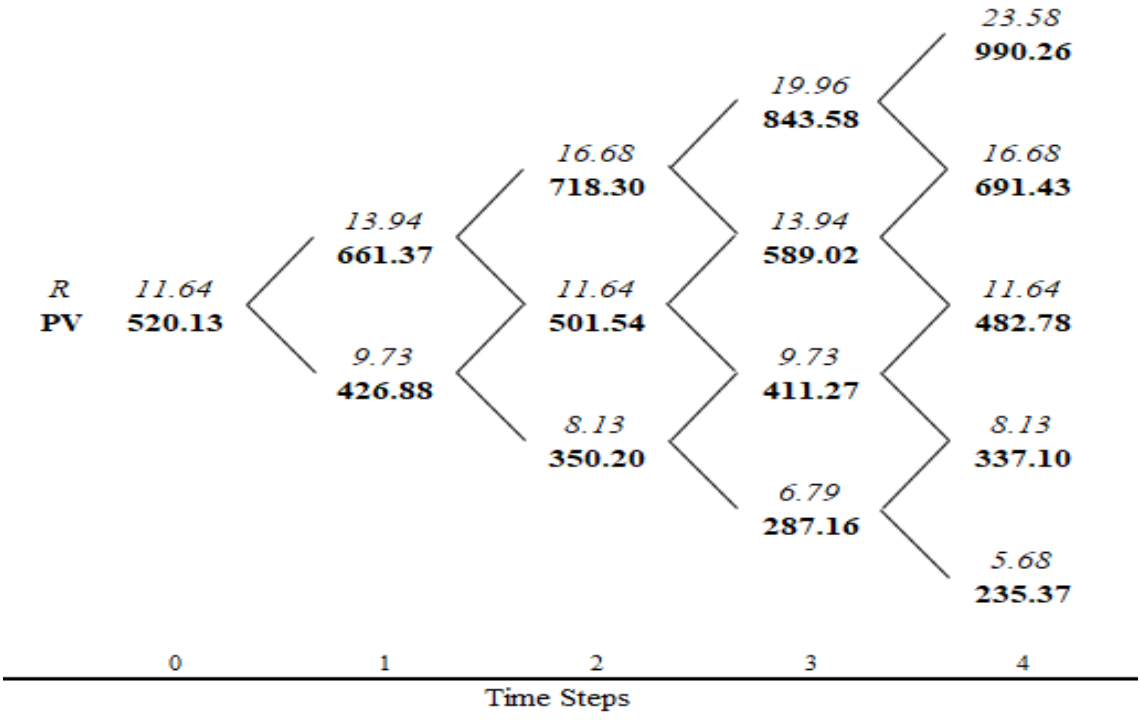
movement of S_0u and the upward movement of S_0d will have the same value at t=2 (S_0ud). The process continues with the same binomial pattern until the last time step. The complete binomial tree of revenues is presented in Figure B.2, Appendix B.

From the annual revenues binomial lattice is possible to obtain the binomial tree of the PV (at t) of the flow of periodic revenue. In this case, as the price of rice increases at a rate of 3%, the PV of the revenue streams at time zero is obtained by discounting the value of the underlying asset of the annual revenue by the difference between the risk-free rate and the expected perpetual annuity. In this way, the present value of the revenue is calculated, taking into account the expected increase in the price of rice.

$$\frac{[S_0(R_t)*(1-e^{-(rf-g)*(T-t)})]}{r_f-g} = \frac{[11.64*(1-e^{-0.0046*50})]}{0.0046} = 520.13$$

The rate used is the opportunity cost obtained by subtracting the growth rate from the risk-free rate[58].

Figure 9. *Annual revenues and PV of the flow of periodic revenues binomial lattice from t=0 to t=4 (million 2010 USD)*



[58]If the growth rate is less than the risk-free rate it is possible to calculate the present value as a present value of growing perpetuity (Brealey et al., 2012).

Proceeding as presented in Figure 9, it is possible to obtain the binomial tree of the PV of the flow of periodic revenues, which is presented in Table B.3. (top numbers) in Appendix B.

As stated earlier, the production costs are considered constant within this thesis. Therefore, the PV of the cost flows at time zero is calculated as:

$$\frac{[CP*(1-e^{-(r_f)(T-t)})]}{r_f} = \frac{11.79*(1-e^{-(0.041)(50-0)})}{0.041} = 250.54$$

Proceeding with this calculation up to the last step, it is possible to obtain the present value tree of the periodic cost flows, which is illustrated in Figure B.3 (bottom numbers) in Appendix B.

Finally, by subtracting the PV (at t) of the periodic cost streams from PV (at t) of the flow of periodic revenues, it is possible to obtain the binomial tree of the PV of the revenue stream.

d) Calculate the option values at each node using the backward induction.

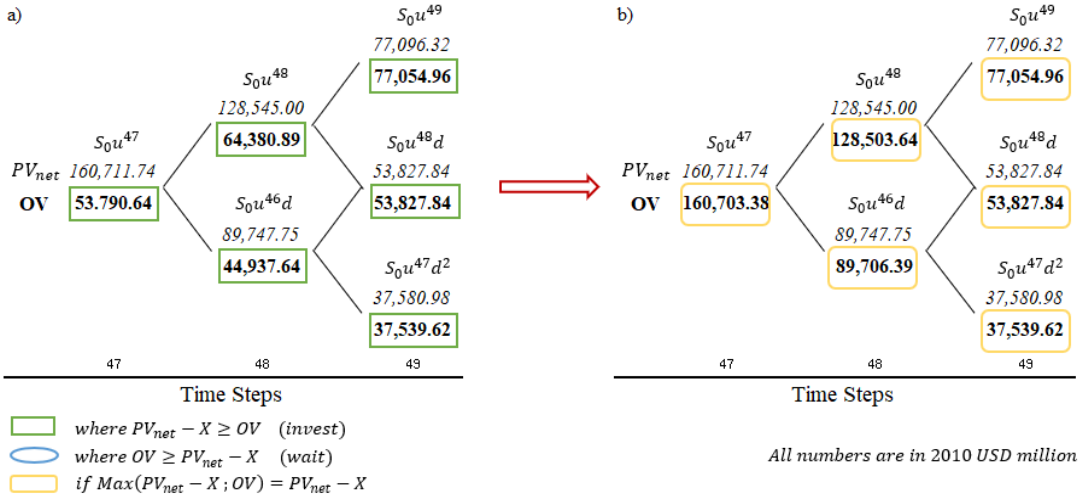
The option values, presented at the bottom in Table B.4 in Appendix B, represent the value maximisation of developing the land at that point or waiting until the next time step before the option expires. As mentioned above, in order to calculate the ROV at each node, it is necessary to proceed by backward induction. So, starting from the last node $S_0 u^{49}$, the expected value is USD 77,096.32 million if the company invested USD 41.361 million to purchase the machinery, as presented in Figure 8. Thus, the option value at this node is the difference between the NR at t=49 and the strike price:

$$OV(u^{49}) = NR(u^{49}) - X = 77,096.32 - 41.361 = USD\ 77,054.96\ million$$

However, since the contract - and consequently the option - has a duration of 49 years, if SSAD decides to wait until the next period, the revenues will be zero and the option worthless. Theoretically, in this case, the lessee should develop the farming project and not wait. The value of the option at this node will be USD $77,054.96$ million.

In practice, being the last year before the conclusion of the contract and not considering the possibility of renewing the land agreement, the investor might be discouraged to invest, considering a revenue stream of only one year.

Figure 10. *Option valuation binomial tree (a) and adjusted option valuation binomial tree (b) from* S_0u^{47}



For all terminal nodes with an expected PV of the revenue stream below the strike price, the investor will decide not to invest in the development of the land as it would incur a net loss. For example, at node $S_0\,u^{29}d^{20}$ there would be a loss of $29.29 - 41.36 = USD - 12.071\ million$. This means that starting from this node and for all underlying ones, the value of the option is zero.

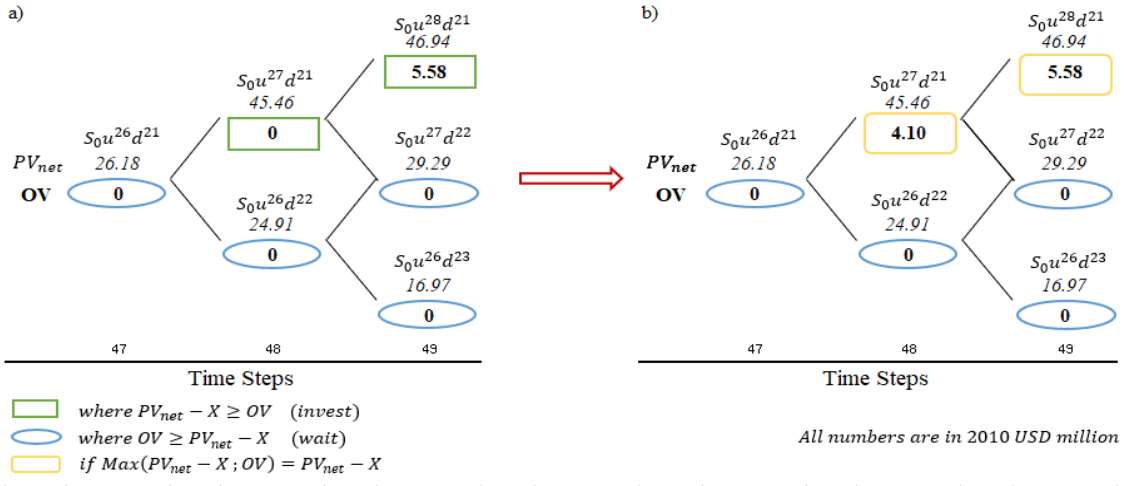
Moving on to intermediate nodes, starting from $S_0\,u^{48}$, the expected option value is calculated as follow:

$$e^{(-r_f \Delta t)} * [p(S_0u^{49}) + (1-p)(S_0u^{48}d)]$$

Intuitively, this represents "the discounted average of the potential value of the future option using the natural-risk probability" (Kodukula & Papudesu, 2006, p.79). In theory, the investor will decide to exercise the option if the difference between the payoff at t=48 and the strike price is greater than the option value at the same node. In the opposite situation, the investor will decide to wait to exercise the option because it has a

higher value. In our case, it would make sense for SSAD to invest from nodes $S_0\,u^{48}$ to $S_0\,u^{27}d^{21}$. Conversely, if the expected ROV for keeping the option open is zero or greater than the difference between the underlying asset (at t) and the strike price, the best option for the invaded company is to keep the option open and wait, as shown in Figure 11.

Figure 11. *Option valuation binomial tree (a) and adjusted option valuation binomial tree (b) from* $S_0u^{26}d^{21}$

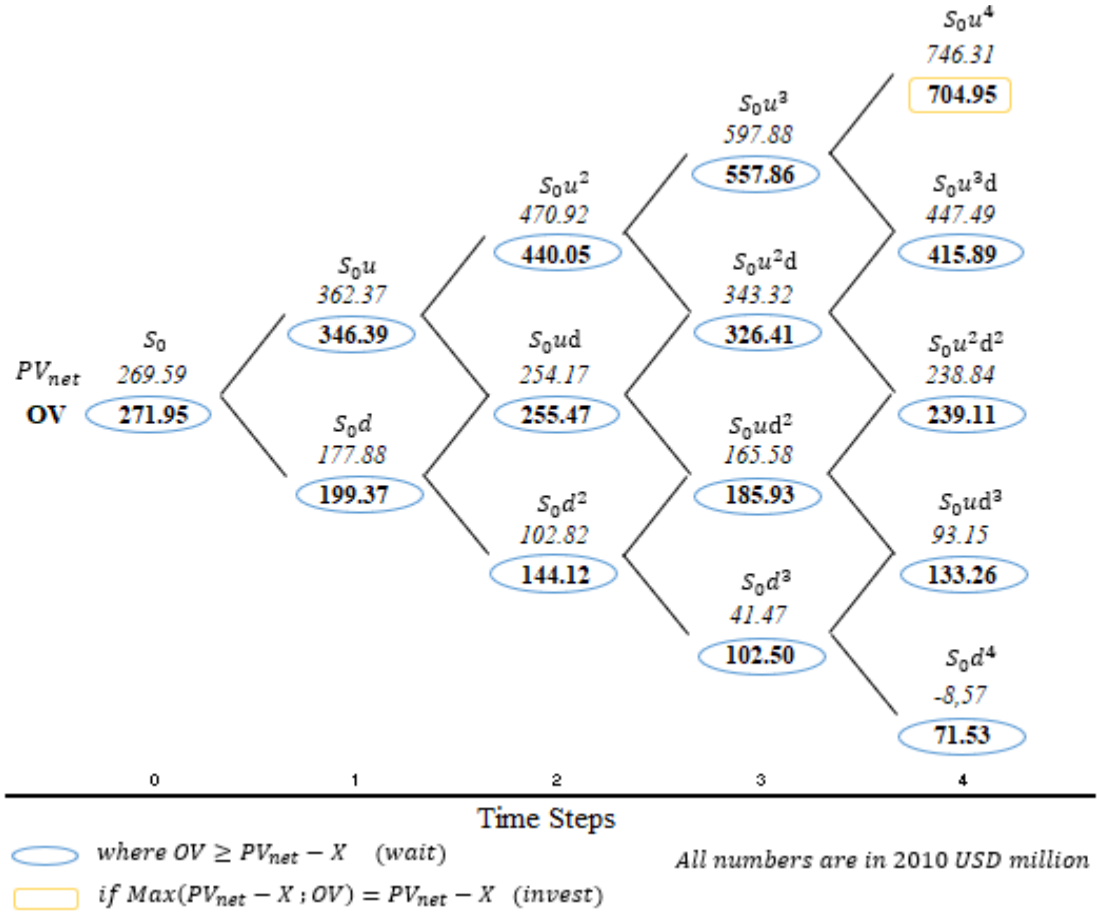


This means that, as presented in Section 3.2.3.1, if i) at time t $Max(PV_{net} - X; OV_t) = PV_{net} - X$, it makes sense for the lessee to invest in the project and develop the land. In this case, the option's value is the difference between the discounted stream of net revenues and sunk costs (yellow rectangle). Whereas if ii) $Max(PV_{net} - X; OV_t) = OV_t$, the company should decide to wait, and the value of the option is calculated as $e^{(-r_f \Delta t)} * [p(S_0u) + (1-p)(S_0d)]$ (blue circle).

The binomial tree of SSAD is obtained by backward induction at t=0. The expected value of keeping the option open is replaced with the difference between the expected value and the exercise cost if it makes sense for the Saudi investor to invest and not wait until the following year. The real option value at time zero is estimated to be USD 271.95 million, which is higher than the discounted price of the 50-year lease estimated

at USD 0.324 million. The option valuation binomial tree and the adjusted option valuation binomial tree are presented in Table B.4 and B.5 in Appendix B, respectively.

Figure 12. *Adjusted option valuation binomial tree (4 steps)*



5.2.2. Evaluation results

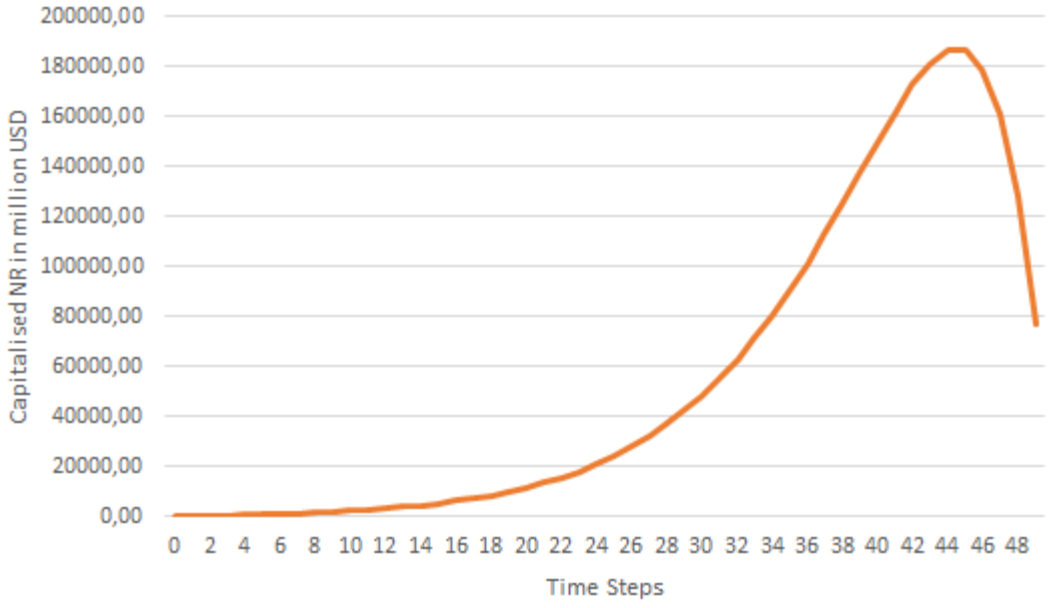
In order to better analyse the reasons for this rational delay, we developed a binomial tree consisting of both the NR values (top bold numbers) and the RO values for each node (bottom numbers). This binomial lattice is presented in 5.B. in Appendix B. Through backward induction and the steps presented in the previous section, we have identified in red the nodes where it would be beneficial for the Saudi company to invest in the farming project. In fact, at those nodes it is verified that $NR_t - X \geq OV_t$. In cases where this equation is verified, SSAD should exercise the option and not wait.

Proceeding backwards, if it is true that the foreign firm should invest at t=49, it could also happen at t=48. If the condition is verified at the forty-eighth step, then the previous step can be analysed and so on. Proceeding with this calculation, we have

identified that the node $S_0\,u^4$ is the first in which the value of the option is less than the difference between the net revenue and the operating cost: $746.31 - 41.36 = 704.95 \geq 699.07$. This means that before the fourth step the foreign investor will decide to keep the option open.

Although we know the year from which the investor should invest, nothing is suggested about the final decision the investor will actually make. In other words, there is a trade-off between returns and time horizon at the time of investing. Thus, the investor may decide to invest at the first viable time step and enjoy a relatively low-income stream for a long time, or he may decide to shorten the time horizon to achieve very high returns.

Figure 13. *Discounted NR trend for all the* S_0u^n



Assuming the investor is rational and considering only net income and time horizon, SSAD maximises its returns if it exercises the option at t=44. As a matter of fact, in this step the capitalised value of NR is USD 186,262 million. The highest values that capitalised net revenues can reach are represented by the values obtained from upward movements only (S_0u^n). The trend of capitalised NR is presented in Figure 13.

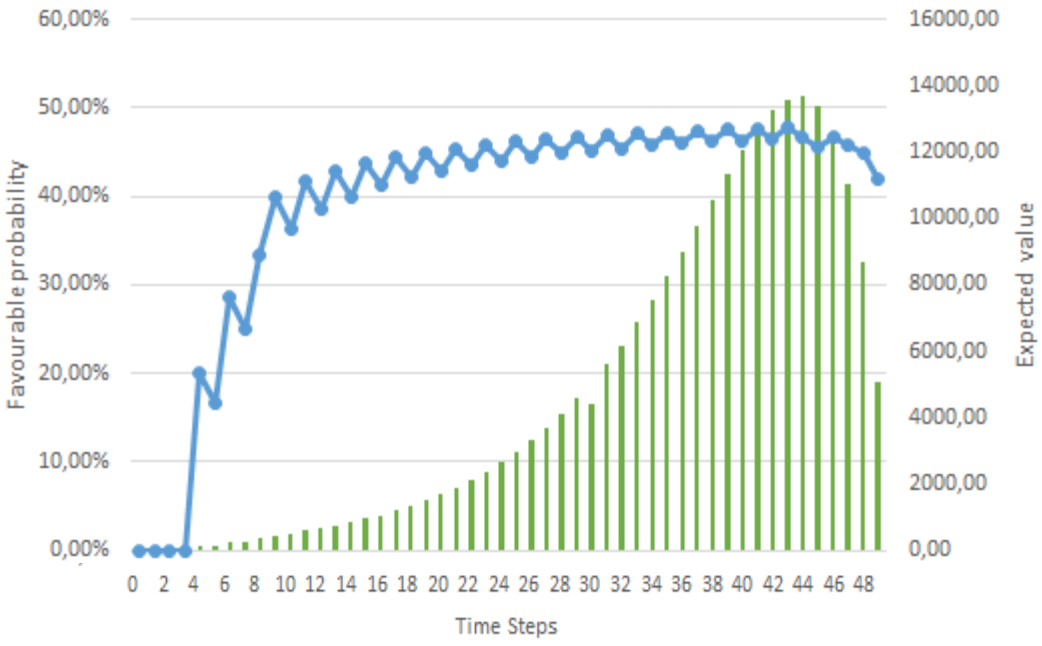
Using Table B.5 Appendix B, it is possible to calculate the probability that the difference between the discounted stream of net revenues and sunk costs is greater than

the option to wait. The formal probability of an event occurring, E, is the ratio of the possible favourable cases, r, to the number of possible cases, k.

$$P(E) = r/k \quad (21)$$

In our study, the favourable cases are those that satisfy this equation: $PV_{net} - X > OV_t$. In contrast, the possible cases are represented by all the real option values in one step. Looking at the blue line in Figure 12, from t=0 to t=3, the probability of a favourable event is zero. This means that SSAD will decide to postpone the development at least until t=4. With the passing of the steps, the probability of a favourable event occurring shows an increasing trend until time step 43, where it reaches the maximum level, 47.73%, and then decreases.

Figure 14. *Favourable probability and expected value for each time step*



The green histogram in Figure 14 represents the expected PV of the revenue stream for each time step. Therefore, it constitutes a measure of central tendency. The average value is calculated as the sum of the expected PV of the revenue stream in red presented in Table B.5 appendix B and the respective probability of its occurrence. Again, considering only the expected value, we obtain that the step that maximises the estimated PV of the revenue stream can be found at step 44.

Aware of what was stated before, one of the regions that motivate the delay in the development of the farming project is purely economic. The Saudi investor will decide to invest when on the one hand, the returns, the expected value and the probability of the favourable event occurring are maximised. On the other hand, the time horizon is long enough to enjoy the revenues from the paddy field. In our case study, in order to enjoy the largest revenue stream, SSAD would have to decide to develop the entire land surface at t=44. This means that there is a rational delay behind the time lag in exercising the development option. We do not know whether the foreign investor will develop the 10,000 ha at t=44, but based on the microeconomic hypothesis that sees the economic agent as rational and profit maximising, he will undoubtedly delay the development of the paddy field until his returns are maximised.

It is possible to identify a relationship between opportunity cost and the investor's decision to postpone the development of the contracted land. All things being equal, if the opportunity cost, given by the difference between the risk-free rate and the growth rate, increases, the investor will decide to exercise the option sooner. In contrast, the development of the land will be delayed much if it decreases longer. A rise in the risk-free, while keeping the growth rate fixed, increases the expected rate of return, which increases the risk-neutral probability of an increase (p). Thus, the higher the risk-free rate relative to the growth rate, all else being equal, the more the value of the option at time zero will decrease. Conversely, the closer the two rates are, the more the ROV increases.

5.2.3. Limitations of the model

Although thanks to the case study, we were able to detect that the delay in land development in Ethiopia is justified by the desire to maximise investors' returns, it is necessary to point out some limitations within our project:

- Based on the assumption that the investor will decide to exercise the option to develop the entire land when the net revenues are greater than the sunk costs and renovation costs, the three stages in the land development, presented in Figure 5, are not taken into account when calculating the option. This may lead to a simplification of the problem but does not reduce the veracity of the results.

- Within the thesis, we have deliberately omitted the option of abandoning the

farming project in order to avoid creating a non-binomial pricing model and a massive amount of output. In the real world, the option to abandon the project may be exercised each year throughout the contract. The decision of whether to abandon or wait is made by comparing the recovery value with the continuation value of the node. If the former exceeds the latter, it would be better to wait. If the abandonment option were exercised, the payoff of the next node would be represented by the recovery value in that step. The payoffs can be determined using the following formula:

$$NR - R_c + Max[(S, (pV_u + (1-p)V_d)e^{-r_f\sqrt{\Delta t}}] \quad (22)$$

where NR is the net revenue ($R - C$), R_c is the adjusted rental cost, V_u and V_d is the values of the farming project after upward and downward movements, p is the risk-neutral probability, and finally r_f is the risk-free discount rate. The foreign company will decide to abandon the project if $pV_u + (1-p)V_d)e^{-r_f\sqrt{\Delta t}}$, i.e. the continuation value, is less than the recovery value.

- Many exogenous variables influence the decision to postpone land development. In our study, we considered the price of rice to be the only stochastic variable. We are aware that weather conditions and risky events can influence the average yield of rice and production costs, which are considered fixed in our project to limit the sources of uncertainty within the thesis.

6. Conclusion

In this thesis, we have analysed whether the delay in developing the contracted land plot is justified by a deliberate choice to maximise returns by foreign investors. The case study used to substantiate this idea is the land contract signed in 2010 between Saudi Star Agricultural Development and the Ethiopian Ministry of Agriculture and Rural Development. The project to develop 10,000 hectares for rice production is evaluated using both NPV and ROA.

There is much uncertainty about whether a potential agricultural project will be beneficial or disappointing for the host country (Deininger et al., 2011). This disappointment is often linked to unmet expectations about project development and the associated social, economic and infrastructural commitments. In this study, we have shown that the failure to develop leased land is due to economic reasons. Thus, foreign investors will actually develop the contracted land, but only when their returns are maximised. This means that although sooner or later foreign investors will exercise their options, Ethiopia will face the economic costs associated with 'late development'.

From the case study presented above, it is possible to extrapolate (and generalise) that the deferral of land development can increase as the length of the lease increases. At the same time, an increase in the time horizon increases the value of the option and creates a disincentive to exercise it. The longer the option is exercised, the greater the economic costs for the company of not developing the agricultural project. At the same time, the closer the end of the contract is, the less interested the investor will be in exercising the option since the revenues will be too low compared to initial expectations. Thus, in theory, the investor will try to maximise the value of the option value by delaying development but will want to have enough time to cash the revenues from the project.

The economic development and the seller country's food and energy security consequences are not analysed in this research. The delay in land development by the lessee disincentives the increase in food availability for rural areas of the country[59], limiting the growth of production and productivity and technology transfer. To achieve a win-win situation and thus ensure the possibility of exploiting the capital mobilised by investments in agricultural land, it is necessary to ensure the power - decision-making

[59]Even if the project were to be developed, according to Hallam (2010), food availability could even decrease if the investment operations were to be to the detriment of local farmers or drive up the price of land.

and governance - and negotiating capacity of local communities and institutions. Before that, it is crucial to secure fundamental property rights for people to minimise arbitrary expropriations and obtain the best contracts and greater certainty about the legal value of investors' promises.

Even though the obligations of the two parties are well expressed in the contract, the delay rarely results in the rescission of the land deal. This 'immobility' of the Ethiopian government can be justified by the difference in bargaining power and the *double bind* theory[60] (Bateson,1963). In fact, the lessor, capital-poor but land-rich, is expecting that the lessee, capital-rich but land-poor, will develop the contracted land, fostering the country's economic growth. With strong bargaining power, the investor knows that he can delay developing the plot of land until revenues are maximised without incurring penalties or termination of the contract. A political establishment inclined to accept bribes can facilitate delay and avoid contract rescission. According to the Global Corruption Index (GCI), in 2019, Ethiopia scored 61.11, ranking it among the high corruption risk countries. Within the thesis, even though we are aware of the persistence of illicit and opaque behaviour, bribes are not taken into account.

Within the study, the only source of uncertainty on annual cash flows comes from the price of rice. Indeed, during the project evaluation, we considered the average paddy yield and the production cost fixed. These conditions can be considered as a further limitation of this research, as the paddy yield is stochastic. The yield is influenced by weather conditions, climate change, and hazardous events in the real world. Therefore, it can be considered as an additional source of uncertainty on future yields. In addition, production costs, which we have considered linear, might increase as the developed land increases.

Neither social nor political instability is taken into account in the case study. Indigenous communities or small villages often inhabit the "marginal" lands rented to foreign investors. They are forced to migrate and relocate to new lands (Laylin, 2012). This situation of coercion and frustration results in violent and bloody riots in most cases, as

[60]In 1956, in the United States, the British anthropologist Gregory Bateson formulated a theory that would have a long echo in psychology and psychiatry: the double bind theory. There are various interpretations of it, and opinions differ on its clinical value, but for the purposes of this thesis it is sufficient to recall the core. By double bind, Bateson meant the particular situation in which two human beings find themselves when the messages with which they communicate are systematically contradictory, because at one level they convey one content, and at another level they convey the opposite content.

happened in 2012 at the SSAD farm, where five people were killed and eleven injured (Environmental Justice Atlant, 2014). In Ethiopia, internal instability is fuelled by community tensions, political violence and state coups. The risk of expropriation[61] (Clark, 2003), together with the instabilities mentioned above, can act as a disincentive to developing leased land.

Although we are aware of the limitations of this dissertation, the scarcity of information, and the inconsistency between sources, we believe that this final thesis may help better understand the paradoxical situation experienced by many African countries, not only Ethiopia.

[61]It 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).

Acknowledgement

First of all, I wish to acknowledge all the lecturers of the master's degree in Global Development and Entrepreneurship for their useful and valuable teachings.Next, I would like to thank Ca' Foscari University of Venice for the many opportunities it has offered me (Erasmus+, Overseas, and Internships abroad), thanks to which I have grown both academically and professionally.

I would like to thank the VERA Academy for the opportunity to get to know and better understand the research world. Moreover, I would like to thank all the professors for whom I tutored during these two years of my Master's degree, particularly Professor Giancarlo Corò, Professor Mario Volpe, Professor Alessandro Minello, Professor Fabio Michelucci and Professor Matteo Maria Triossi. .

Furthermore, I would like to thank my supervisor, Luca Di Corato, sincerely. It has been a challenging year, first with the VERA project and then with the writing of the thesis, but thanks to his willingness and knowledge I am proud of the work done.

I am thankful to my parents, who have always encouraged me in my university journey. Thanks to my sister, my friends, amici, maes, amis, and ともだち, who have accompanied me during this university period. Thanks to my girlfriend who supported me during these two years of my master's degree, because she always believed in me and always spurred me on.

I wish to acknowledge Costa Rica and my host family: Mami Merce, Hellen, Laura and Valerie. Pura Vida. Finally, Marseille and its multiculturalism; Berlin and its proactivity; Kobe and its propensity for innovation.

References

Abera, S., Bekele, A., Assaye, A., & Melak, A., (2020). "Cost and Return Analysis of Rain-Fed Lowland Rice Production under Smallholder Farmers in Fogera District, North Western Ethiopia". *International Journal of Research Studies in Agricultural Sciences.*

Addis, A. K., Asongu, S., Zuping, Z., Addis, H. K., & Shifaw, E., (2020). "Chinese and Indian investment in Ethiopia: Infrastructure for 'debt-trap diplomacy' exchange and the land grabbing approach". *International Journal of Emerging Markets*.

Altuve, J. G., (2004). *"*El uso del valor actual neto y la tasa interna de retorno para la valoración de las decisiones de inversión". *Actualidad contable FACES,* 7(9), 7-17.

Amram, M., & Kulatilaka, N., (1998). "Real options:: Managing strategic investment in an uncertain world". *OUP Catalogue*.

Anseeuw, W., Lay, J., Messerli, P., Giger, M., & Taylor, M., (2013). "Creating a public tool to assess and promote transparency in global land deals: the experience of the Land Matrix". *Journal of Peasant Studies*, 40(3), 521-530.

Arezki, R., Deininger, K. & Selod, H., (2011). "*What Drives the Global 'Land Rush'?". World Bank Policy Research Working Paper Series.*

Bateson, G., Jackson, D. D., Haley, J., & Weakland, J. H.*, (1963).* "A note on the double bind-1962". *Family process,* 2(1), 154-161.

Black, F., & Scholes, M., (2019). "The pricing of options and corporate liabilities". *In World Scientific Reference on Contingent Claims Analysis in Corporate Finance: Volume 1: Foundations of CCA and Equity Valuation* (pp. 3-21).

Boamah, F., (2011). *The relationship between land grabbing for biofuels and food security, a bane or boon. The food security implications of jatropha biodiesel project in northern Ghana,* a paper presented at the International Conference on Global Land Grabbing (pp. 6-8).

Bongiorni, R., (2021). *Land Grabbing, una grande minaccia che incombe sulla sostenibilità del pianeta.* Il Sole 24 Ore. April, 21, 2021

Borras Jr, S. M., & Franco, J. C., (2012). "Global land grabbing and trajectories of agrarian change: A preliminary analysis". *Journal of agrarian change*, 12(1), 34-59.

Borras Jr, S. M., Hall, R., Scoones, I., White, B., & Wolford, W., (2011). "Towards a better understanding of global land grabbing: an editorial introduction". *The Journal of Peasant Studies*, 38(2), 209-216.

Boyle, P. P., (1977). "Options: A Monte Carlo approach". *Journal of financial economics,* 4(3), 323-338.

Brandao, L. E., & Dyer, J. S., (2005). "Decision analysis and real options: A discrete time approach to real option valuation*". Annals of operations research*, 135(1), 21-39.

Brealey, R. A., Myers, S. C., Allen, F., & Mohanty, P., (2012). "Principles of corporate finance". *Tata McGraw-Hill Education.*

Bujko, M., Fischer, C., Krieger, T., & Meierrieks, D., (2016). "How institutions shape land deals: The role of corruption". *Homo Oeconomicus*, 33(3), 205-217.

Carmody, P., (2017). "The new scramble for Africa". *John Wiley & Sons*.

Carroccio, A., Crescimanno, M., Galati, A., & Tulone, A., (2016). "The land grabbing in the international scenario: the role of the EU in land grabbing". *Agricultural and Food Economics*, 4(1), 1-9.

Chandran, R., & Tom, G., (2017). *Calls to end Africa's' horrific land deals after Indian firm's fallout*. Reuters*,* November, 28, 2017

Check, R., (2018). *Reality check: Is China burdening Africa with debt.* BBC News, 5. November, 5, 2018

Clark, E., (2003). "Pricing the cost of expropriation risk". *Review of International Economics*, 11(2), 412-422.

Cochet, H., & Merlet, M., (2011, April). *Land grabbing and share of the value added in agricultural processes. A new look at the distribution of land revenues.* In International Conference on Global Land Grabbing. Brighton.

Cochrane, L., & Scholar, V., (2016). "Land grabbing. Encyclopedia of food and agricultural ethics*". Springer Science*.

Copeland, T. E., & Antikarov, V., (2005*).* "Real options: Meeting the Georgetown challenge". *Journal of Applied Corporate Finance,* 17(2), 32-51.

Cotula, L., & Vermeulen, S., (2009). "Deal or no deal: the outlook for agricultural land investment in Africa". *International Affairs*, 85(6), 1233-1247.

Cotula, L., (2011). "Land deals in Africa: What is in the contracts?*". Iied*.

Cotula, L., (2012). "The international political economy of the global land rush: A critical appraisal of trends, scale, geography and drivers". *The journal of peasant studies*, 39(3-4), 649-680.

Cotula, L., Vermeulen, S., Leonard, R. & Keeley, J., (2009). "Land grab or development opportunity?: agricultural investment and international land deals in Africa*". IIED, FAO & IFAD*, London/Rom.

Cotula, L., Vermeulen, S., Mathieu, P., & Toulmin, C., (2011). "Agricultural investment and international land deals: evidence from a multi-country study in Africa". *Food Security*, *3*(1), 99-113.

Cowpertwait, P. S., & Metcalfe, A. V., (2009). "Introductory time series with R". *Springer Science & Business Media.*

Cryer, J. D., & Chan, K. S., (2008). “Time series analysis: with applications in R”. *Springer Science & Business Media.*

De Schutter, O., (2011). “How not to think of land-grabbing: three critiques of large-scale investments in farmland”. *The Journal of Peasant Studies*, *38*(2), 249-279.

Deininger, K. W., (2003). “Land policies for growth and poverty reduction”. World Bank Publications.

Deininger, K., & Byerlee, D., (2011). “Rising global interest in farmland: can it yield sustainable and equitable benefits?*”*. World Bank Publications.

Deininger, K., & Xia, F., (2016). “Quantifying spillover effects from large land-based investment: the case of Mozambique”. *World Development*, *87*, 227-241.

Dictionary, C., (2008). “Cambridge advanced learner’s dictionary”. accessed 05/05/2021*: https://dictionary. cambridge. org/es/diccionario/ingles/blended-learning*.

Dixit, R. K., & Pindyck, R. S., (2012*). “*Investment under uncertainty*”. Princeton university press.*

Economic Commission for Africa, (2009). “Land Tenure Systems and their Impact on Food Security and Sustainable Development in Africa”. *ECA press.*

EIA, (2008). *Investing in the agricultural sector of Ethiopia. A guide for new investors.*

Environmental Justice Atlant, (2014). *Saudi Star Agricultural and Irrigation Project in Gambela, Ethiopia.* Accessed 05/05/2021: https://ejatlas.org/conflict/saudi-star-agriculture-and-irrigation-project-in-gambela-ethiopia/

FAO, (2002). “Land tenure and rural development”. *FAO Land Tenure Studies*. 3.

Fiestbrook, C., (2010). “Dopo la tempesta - Cinque chiavi per il successo nella nuova realtà di mercato”. *Accenture,* Aprile, n.1.

Fuentes-Nieva, R., & Nicholls, M., (2013). “Poor Governance, Good Business: How land investors target countries with weak governance”. *Oxfam.*

Gashaw A., (1989). “Rice production in Ethiopia”. *Journal of emerging technology.*

Giovannetti, G., & Ticci, E., (2016). “Determinants of biofuel-oriented land acquisitions in Sub-Saharan Africa”. *Renewable and Sustainable Energy Reviews*, *54*, 678-687.

Hall, R., (2011). “Land grabbing in Southern Africa: the many faces of the investor rush”. *Review of African political economy*, *38*(128), 193-214.

Havnevik, K., Matondi, P. B., & Beyene, A., (2011). “Biofuels, land grabbing and food security in Africa”. *Zed Books; Nordiska Afrikainstitutet.*

Henrÿ, H., (1984). “Enjeux fonciers en Afrique noire”. *Verfassung und Recht in Übersee/Law and Politics in Africa, Asia and Latin America*, 359-366.

Hill, R. C., Griffiths, W. E., & Lim, G. C., (2018*).* "Principles of econometrics". *John Wiley & Sons.*

Hull, J.C., (2017). *"*Options, Futures, and other Derivatives". *Tenth Edition, Pearson Prentice Hall.*

Hvid, A., (2014). "Agricultural rent-seeking in developing countries: an empirical investigation". *Applied Economics Letters*, *21*(14), 951-954.

International Fund for Agricultural Development, (2009). The growing demand for land - risks and opportunities for smallholders farmers. *Discussion Paper and Proceedings Report of the Governing Council Round Table held in Conjunction with Thirty-second Session of IFAD's Governing Council, February.*

Karp, A., & Richter, G. M., (2011). "Meeting the challenge of food and energy security". *Journal of experimental botany*, *62*(10), 3263-3271.

Keeley, J., & International Institute for Environment and Development. (2014). *"*Large-scale land deals in Ethiopia: Scale, trends, features and outcomes to date". International Institute for Environment and Development.

Kugelman, M., & Levenstein, S. L., (2009). "Land grab? The race for the world's farmland". *Woodrow Wilson International Center for Scholars Asia Program.*

Laylin, T, (2012). *Saudi Star Among Firms Behind Thousands of Forced Relocations in Ethiopia. In green prophet.* Farmland.org. January, 24, 2012. Accessed 04/05/2021: https://www.greenprophet.com/2012/01/saudi-star-ethiopia/

Liu, L., (2012). *Land acquisition in Africa for agricultural purposes.* Swedish University of Agricultural Science.

Makki, F., & Geisler, C., (2011, April). *Development by dispossession: Land grabbing as new enclosures in contemporary Ethiopia.* In International Conference on Global Land Grabbing (Vol. 68). Future Agricultures Sussex, UK.

Margulis, M. E., McKeon, N., & Borras Jr, S. M., (2013). *"Land grabbing and global governance: critical perspectives". Globalizations*, *10*(1), 1-23.

Mascareñas, J., (2007). *"*Opciones reales en la valoración de proyectos de inversión". *Monografías sobre Finanzas Corporativas.*

Mete, M. R., (2014). *Valor actual neto y tasa de retorno: su utilidad como herramientas para el análisis y evaluación de proyectos de inversión.* Fides et Ratio-Revista de Difusión cultural y científica de la Universidad La Salle en Bolivia, 7(7), 67-85.

Mingyong, L., Shuijun, P., & Qun, B., (2006). "Technology spillovers, absorptive capacity and economic growth". *China economic review*, *17*(3), 300-320.

Mitchell, D., (2008). "A note on rising food prices*". World Bank Policy Research Working Paper Series, Vol*.

MoARD (Ministry of Agriculture and Rural Development), (2010). N*ational Rice Research and Development Strategy of Ethiopia.* The Federal Democratic Republic of Ethiopia, Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.

MoFa, (2018*). Investment guide for the agriculture sector in Ghana.*

Myers, S. C., (1984). *"*Finance theory and financial strategy*". Interfaces, 14(1), 126-137.*

Nalepa, R. A., Gianotti, A. G. S., & Bauer, D. M., (2017). "Marginal land and the global land rush: A spatial exploration of contested lands and state-directed development in contemporary Ethiopia". *Geoforum*, *82*, 237-251.

Nally, D., (2015). "Governing precarious lives: land grabs, geopolitics, and 'food security". The Geographical Journal, 181(4), 340-349.

New Business Ethiopian, (2012). *Sausi Star to install the first rice processing plant in Ethiopia*. BEHAK Multimedia. February, 16, 2010. Accessed 22/08/2021: https://newbusinessethiopia.com/agribusiness/saudi-star-to-install-first-rice-processing-plant-in-ethiopia/

Perrone, D., & Hornberger, G. M., (2014). "Water, food, and energy security: scrambling for resources or solutions?". *Wiley Interdisciplinary Reviews: Water*, *1*(1), 49-68.

Poulton, C., Tyler, G., Hazell, P., Dorward, A., Kydd, J., & Stockbridge, M., (2008). "Commercial agriculture in Africa: lessons from success and failure. Background paper for the Competitive Commercial Agriculture on Sub-Saharan Africa (CCAA) Study". *World Bank and FAO*.

Prenat, M., (2011). "Séries chronologiques Volume 1: cours et exercices". *Master Ingénierie Mathématiques, Université Paris Sud.*

Richard A. B., Stewart C. M., Franklin A., (2011). "Principles of Corporate Finance". McGraw-Hill, Irwin.

Robertson, B., & Pinstrup-Andersen, P. (2010). "Global land acquisition: neo-colonialism or development opportunity?". *Food Security*, *2*(3), 271-283.

Rocabert, J. P.*,* (2007). *"*Los criterios valor actual neto y tasa interna de rendimiento*". La Economía Pública, 1-11.*

Roudart, L., & Mazoyer, M., (2015). "Les acquisitions de terre à grande échelle: perspective historique". *International Development Policy*, *6*(6).

Scholvin, S., (2016). "A New Scramble for Africa?: The Rush for Energy Resources in Sub-Saharan Africa". Routledge.

Schoneveld, G. C., (2017). "Host country governance and the African land rush: 7 reasons why large-scale farmland investments fail to contribute to sustainable development*". Geoforum*, *83*, 119-132.

Semerari, A., (2011). C*risi dei prezzi, vulnerabilità dei mercati e strumenti di politica economica.* Atti della Tavola rotonda Aspen Institute Italia, Roma, 23, 2-3.

Shete, M., (2020). "Stakeholders' Perspectives on Large-Scale Agricultural Investment in Ethiopia: An Analysis of the Disconnects between Expectation and Reality". *Asian Journal of Agricultural Extension, Economics & Sociology*, 98-113.

Takele, A., (2010). *Analysis of rice profitability and marketing chain: The case of Fogera Woreda, South Gondar Zone, Amhara national regional state, Ethiopia*. Doctoral dissertation, Haramaya University.

Takele, A., (2017). "Determinants of Rice production and marketing in low producer farmers: the Case of Fogera Districts, North-Western Ethiopia". *International Journal of Environment, Agriculture and Biotechnology*, *2*(5), 238936.

Tham, J., & Vélez-Pareja, I., (2004). *"*Principles of cash flow valuation: An integrated market-based approach". *Elsevier.*

Tilahun, T., (2020). "History, current status and future directions of rice research in Ethiopia". *Fogera National Rice Research and Training Center*, *vol.7*, issue 2.

Timilsina, G. R., & Shrestha, A., (2010). "Biofuels: markets, targets and impacts". *World Bank Policy Research Working Paper*, (5364).

Tscharntke, T., Clough, Y., Wanger, T. C., Jackson, L., Motzke, I., Perfecto, I., ... & Whitbread, A., (2012). "Global food security, biodiversity conservation and the future of agricultural intensification". *Biological conservation*, *151*(1), 53-59.

Udry, C., (2011). "Land tenure". *The Oxford Companion to the Economics of Africa*, *1*.

Union, A., (2009). "Land policy in Africa: A framework to strengthen land rights, enhance productivity and secure livelihoods". *Addis Ababa: African Union and Economic Commission for Africa*.

Venables, A., & Collier, P., (2011). "Land deals in Africa: pioneers and speculators". CEPR Discussion Paper No. DP8644.

Vermeulen, S., & Cotula, L., (2010). "Over the heads of local people: consultation, consent, and recompense in large-scale land deals for biofuels projects in Africa*". The Journal of Peasant Studies*, *37*(4), 899-916.

Vidal, J., (2013). *Indian investors are forcing Ethiopians off their land.* The Guardian. February, 6 , 2013.

Welsch, G. A., Hilton, R. W., & Gordon, P. N., (1988*). "*Budgeting: profit planning and control". *New Jersey: Prentice-Hall.*

Zivot, E., & Wang, J., (2007). *"*Modeling financial time series with S-Plus®" (Vol. 191). *Springer Science & Business Media.*

Zupi, M., (2018). “Il futuro incerto del multilateralismo commerciale e il ruolo dell’Organizzazione mondiale del commercio”. *Osservatorio di politica internazionale, Roma, 23*, 1-68.

Internet

Ethiopian Agricultural Portal, 2021. *Land Leased.* Accessed 06/09/2021: http://www.cap.gov.et/

Food and Agriculture Organization, 2021. *Commodity prices*. Accessed 10/09/2021: http://www.fao.org/economic/est/statistical-data/en/

Food and Agriculture Organization, 2021. *Producer Price Index*. Accessed 12/09/2021: http://www.fao.org/faostat/en/#search/producer%20price

Open Land Contract, 2008. *Agro Africa - Senegal*. Accessed 14/09/2021: https://openlandcontracts.org/contract/ocds-591adf-3085478841/view#/pdf

Open Land Contract, 2009. *Emvest Chokwe Mauritius LTd & Pro-Alia Investment 1 - Mozambique*. Accessed 14/09/2021: https://openlandcontracts.org/contract/ocds-591adf-4298002167/view#/pdf

Open Land Contract, 2010. *PetroTech - Mali contact*. Accessed 14/04/2021: https://openlandcontracts.org/contract/ocds-591adf-6045003432/view#/pdf

Open Land Contract, 2010. *Saudi Star Agricultural Development Plc - Ethiopia*. Accessed 14/04/2021: https://openlandcontracts.org/contract/ocds-591adf-3291791899/view#/pdf

Open Land Contract, 2015. *Socfinaf - Ghana contract*. Accessed 14/09/2021: https://openlandcontracts.org/contract/ocds-591adf-9505117998/view#/pdf

U.S. Department of the Treasury, 2010. *Daily Treasury Long Term Rate Data.* Accessed 14/08/2021: https://www.treasury.gov/resource-center/data-chart-center/interest-rates/pages/TextView.aspx?data=longtermrateYear&year=2010

World Bank, 2019, *Agriculture, forestry, and fishing, value added (% of GDP) - Sub-Saharan Africa*. Accessed 15/09/2021: https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=ZG

World Bank, 2021, *Official exchange rate.* Accessed 03/09/2021: https://data.worldbank.org/indicator/PA.NUS.FCRF?locations=ET

Appendix A

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

Year	Nominal Price (USD/mt)	Real Price (2010 USD/mt)	Ln(RP_t/RP_{t-1}) *
1990	156,17	188,9	
1991	179,17	218,73	0,145902
1992	177,92	213,22	-0,0254
1993	157,58	182,55	-0,15452
1994	182,30	217,72	0,175305
1995	262,87	285,98	0,27162
1996	232,70	258,08	-0,10228
1997	210,38	244,85	-0,05242
1998	213,02	259,24	0,056883
1999	192,62	239	-0,08097
2000	143,47	180,33	-0,28032
2001	134,11	175,13	-0,0291
2002	150,18	198,44	0,124291
2003	151,47	190,24	-0,04198
2004	205,14	241,27	0,236524
2005	217,82	248,35	0,028805
2006	219,51	244,1	-0,01719
2007	272,32	285,36	0,155583
2008	482,28	468,99	0,495462
2009	326,36	338,33	-0,32574
2010	383,66	383,66	0,125387
2011	458,56	413,13	0,07382
2012	525,07	476,58	0,142552
2013	473,99	432,1	-0,09776

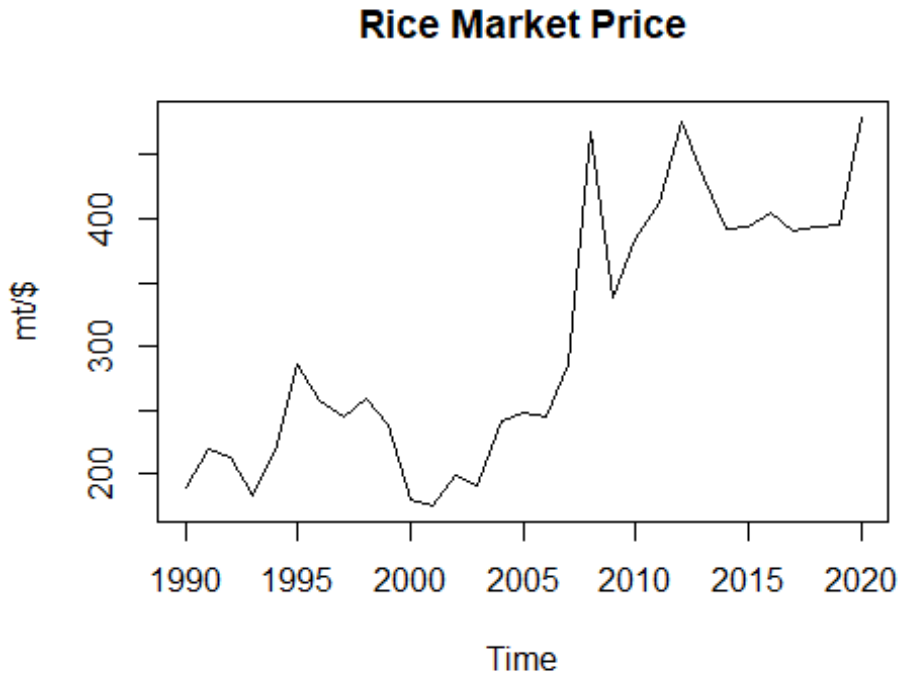
2014	425,15	392,86	-0,09497
2015	386,03	394,48	0,004105
2016	380,34	404,47	0,024947
2017	379,90	390,36	-0,03542
2018	401,07	394,06	0,00941
2019	393,49	395,56	0,00379
2020	474,62	479,46	0,191917

The standard deviation of the logarithmic return (σ)	0.1778306
The mean of the logarithmic return (μ)	0.031048
The mean of the geometric return (g)	0.0364476

Source: The real rice prices are provided by FAO (2021). The computation of standard deviation, mean, and geometric return are done by the author.
.

Table A.2 *The results of Dickey-Fuller tests*

```
faostat<-read.csv2("FAOSTAT.csv",header=T)
nom.rice.price<-ts(faostat[,1],start=1990)
ppi<-ts(faostat[,2],start=1990)
real.rice.price<-nom.rice.price/ppi
plot(real.rice.price,main="Rice Market Price",ylab="mt/$")
```



```
#first.adj.price<-ln(RPt/Rpt-1)
ratio<-real.rice.price[-c(1)]/real.rice.price[-c(31)]
first.adj.price<-log(ratio)
first.adj.price<-ts(first.adj.price,start=1991)
summary(first.adj.price)
```

```
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
## -0.326560 -0.050018  0.006775  0.031048  0.138589  0.496830
```

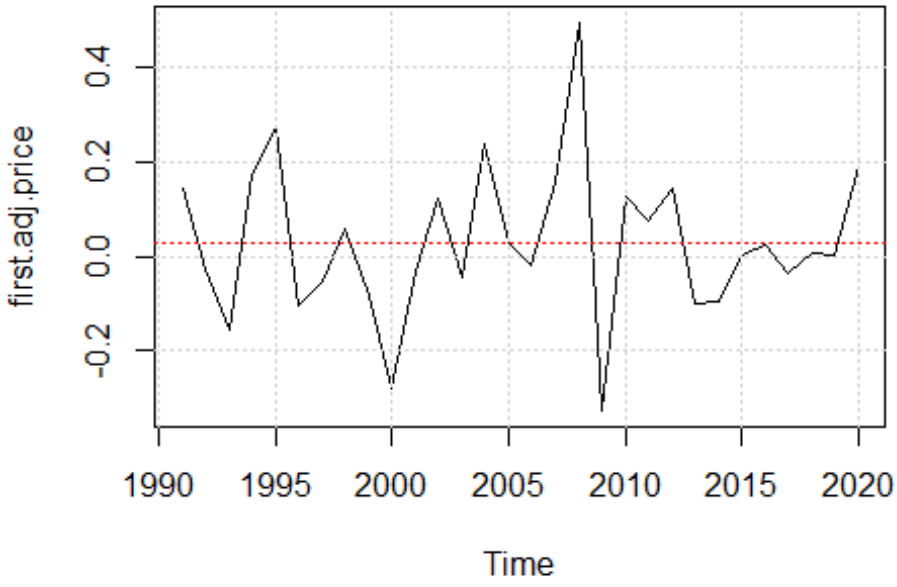
```
sd(first.adj.price)
```

```
## [1] 0.177865
```

```
library(psych)
geometric.mean(first.adj.price)
```

```
## [1] 0.034357
```

```
plot(first.adj.price)
grid()
abline(h=mean(first.adj.price),col="red",lty=3)
```




```
library(urca)
out1<-ur.df(first.adj.price,type="trend",selectlags = "B")
summary(out1)
```

```
##
## ###############################################
## # Augmented Dickey-Fuller Test Unit Root Test #
## ###############################################
##
## Test regression trend
```

```
##
##
## Call:
## lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.36043 -0.13227 -0.02874  0.11414  0.45452
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.032e-01  9.235e-02   1.072  0.29385
## z.lag.1     -8.394e-01  2.862e-01  -2.931  0.00732 **
## tt          -3.447e-05  4.653e-03  -0.007  0.98514
## z.diff.lag  -9.674e-02  2.102e-01  -0.451  0.66342
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1934 on 24 degrees of freedom
## Multiple R-squared:  0.4577, Adjusted R-squared:  0.3899
## F-statistic: 6.752 on 3 and 24 DF,  p-value: 0.00184
##
##
## Value of test-statistic is: -3.016 3.0456 4.5151
##
## Critical values for test statistics:
##       1pct  5pct 10pct
## tau3 -4.21 -3.48 -3.15
## phi2  7.13  5.42  4.29
## phi3  9.21  6.68  5.58
```

```
#trend is not significant
out2<-ur.df(first.adj.price,type="drift",selectlags = "B")
summary(out2)
```

```
##
## ###############################################
## # Augmented Dickey-Fuller Test Unit Root Test #
## ###############################################
##
## Test regression drift
##
##
## Call:
## lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.36019 -0.13203 -0.02899  0.11434  0.45449
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.09962    0.04612   2.069  0.04635 *
## z.lag.1     -0.83901    0.26256  -3.071  0.00654 **
```

```
## z.diff.lag  -0.09497    0.21209  -0.453  0.65793
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1895 on 25 degrees of freedom
## Multiple R-squared:  0.4577, Adjusted R-squared:  0.4143
## F-statistic: 10.55 on 2 and 25 DF,  p-value: 0.0004762
##
##
## Value of test-statistic is: -2.712 4.704
##
## Critical values for test statistics:
##       1pct  5pct 10pct
## tau2 -3.62 -2.89 -2.67
## phi1  7.02  4.87  3.98

#intercept is significant
out3<-ur.df(first.adj.price,type="none",selectlags = "B")
summary(out3)

##
## ###############################################
## # Augmented Dickey-Fuller Test Unit Root Test #
## ###############################################
##
## Test regression none
##
##
## Call:
## lm(formula = z.diff ~ z.lag.1 - 1 + z.diff.lag)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.31794 -0.07663  0.06603  0.18847  0.52208
##
## Coefficients:
##            Estimate Std. Error t value Pr(>|t|)
## z.lag.1     -0.4610     0.2165  -2.129   0.0429 *
## z.diff.lag  -0.2872     0.1924  -1.493   0.1476
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2012 on 26 degrees of freedom
## Multiple R-squared:  0.3646, Adjusted R-squared:  0.3157
## F-statistic: 7.458 on 2 and 26 DF,  p-value: 0.002754
##
##
## Value of test-statistic is: -2.1494
##
## Critical values for test statistics:
##       1pct  5pct 10pct
## tau1 -2.53 -1.94 -1.67

library(tseries)
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
adf.test(first.adj.price)
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  first.adj.price
## Dickey-Fuller = -1.8875, Lag order = 3, p-value = 0.6159
## alternative hypothesis: stationary
```

Appendix B

Table C.1 *SSAD project evaluation using NPV approach (Thousands 2010 USD)*

Year	0	1	2	3	4	5	6	7	8	9	10	11	12
Annual rent	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015
Initial investment	9361											8000	
Production cost		2948	2948	2948	11790	11790	11790	11790	11790	11790	11790	11790	11790
Annual sales		2911,20	3017	3127	11645	12069	12508	12963	13435	13924	14431	14956	15501
PV	-9361	-88	-40	5	-854	-672	-500	-338	-185	-42	93	-4976	339
NPV	**26166**												

Table C.1 *SSAD project evaluation using NPV approach (Thousands 2010 USD): continued*

Year	13	14	15	16	17	18	19	20	21	22	23	24
Annual rent	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015
Initial investment									8000			
Production cost	11790	11790	11790	11790	11790	11790	11790	11790	11790	11790	11790	11790
Annual sales	16065	16650	17256	17884	18535	19210	19909	20633	21384	22163	22970	23806
PV	451	556	654	745	831	910	984	1053	-2394	1175	1230	1280
NPV												

Table C.1 *SSAD project evaluation using NPV approach (Thousands 2010 USD): continued*

Year	25	26	27	28	29	30	31	32	33	34	35	36
Annual rent	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015
Initial investment							8000					
Production cost	11790	11790	11790	11790	11790	11790	11790	11790	11790	11790	11790	11790
Annual sales	24672	25570	26501	27466	28465	29502	30575	31688	32842	34037	35276	36560
PV	1326	1368	1406	1441	1473	1501	-845	1550	1569	1587	1602	1615
NPV												

Table C.1 *SSAD project evaluation using NPV approach (Thousands 2010 USD): continued*

Year	38	39	40	41	42	43	44	45	46	47	48	49
Annual rent	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015
Initial investment				8000								
Production cost	11790	11790	11790	11790	11790	11790	11790	11790	11790	11790	11790	11790
Annual sales	39270	40700	42181	43717	45308	46957	48666	50438	52274	54176	56149	58192
PV	1634	1640	1645	46	1650	1650	1649	1646	1642	1637	1631	1623

Table B.2. *Value tree of annual revenues of rice (million 2010 USD)*

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28	422,78	505,96	605,50	724,63	867,19	1037,80
	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28	422,78	505,96	605,50	724,63
		8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28	422,78	505,96
			6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28
				5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67
					4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23
						3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26
							3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97
								2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63
									2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94
										1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58
											1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96
												1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94
													1,13	1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73
														0,94	1,13	1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79
															0,79	0,94	1,13	1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74
																0,66	0,79	0,94	1,13	1,35	1,61	1,93	2,31	2,77	3,31
																	0,55	0,66	0,79	0,94	1,13	1,35	1,61	1,93	2,31
																		0,46	0,55	0,66	0,79	0,94	1,13	1,35	1,61
																			0,38	0,46	0,55	0,66	0,79	0,94	1,13
																				0,32	0,38	0,46	0,55	0,66	0,79
																					0,27	0,32	0,38	0,46	0,55
																						0,22	0,27	0,32	0,38
																							0,19	0,22	0,27
																								0,16	0,19
																									0,13

Thousand separator the dot (.).
Decimal separator the comma (,).

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
1241,98	1486,32	1778,74	2128,69	2547,48	3048,67	3648,46	4366,25	5225,26	6253,27	7483,53	8955,83	10717,78	12826,39	15349,83	18369,73	21983,77	26308,83	31484,79	37679,06	45091,98
867,19	1037,80	1241,98	1486,32	1778,74	2128,69	2547,48	3048,67	3648,46	4366,25	5225,26	6253,27	7483,53	8955,83	10717,78	12826,39	15349,83	18369,73	21983,77	26308,83	31484,79
605,50	724,63	867,19	1037,80	1241,98	1486,32	1778,74	2128,69	2547,48	3048,67	3648,46	4366,25	5225,26	6253,27	7483,53	8955,83	10717,78	12826,39	15349,83	18369,73	21983,77
422,78	505,96	605,50	724,63	867,19	1037,80	1241,98	1486,32	1778,74	2128,69	2547,48	3048,67	3648,46	4366,25	5225,26	6253,27	7483,53	8955,83	10717,78	12826,39	15349,83
295,20	353,28	422,78	505,96	605,50	724,63	867,19	1037,80	1241,98	1486,32	1778,74	2128,69	2547,48	3048,67	3648,46	4366,25	5225,26	6253,27	7483,53	8955,83	10717,78
206,12	246,67	295,20	353,28	422,78	505,96	605,50	724,63	867,19	1037,80	1241,98	1486,32	1778,74	2128,69	2547,48	3048,67	3648,46	4366,25	5225,26	6253,27	7483,53
143,92	172,23	206,12	246,67	295,20	353,28	422,78	505,96	605,50	724,63	867,19	1037,80	1241,98	1486,32	1778,74	2128,69	2547,48	3048,67	3648,46	4366,25	5225,26
100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28	422,78	505,96	605,50	724,63	867,19	1037,80	1241,98	1486,32	1778,74	2128,69	2547,48	3048,67	3648,46
70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28	422,78	505,96	605,50	724,63	867,19	1037,80	1241,98	1486,32	1778,74	2128,69	2547,48
48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28	422,78	505,96	605,50	724,63	867,19	1037,80	1241,98	1486,32	1778,74
34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28	422,78	505,96	605,50	724,63	867,19	1037,80	1241,98
23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28	422,78	505,96	605,50	724,63	867,19
16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28	422,78	505,96	605,50
11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20	353,28	422,78
8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12	246,67	295,20
5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92	172,23	206,12
3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49	120,26	143,92
2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17	83,97	100,49
1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99	58,63	70,17
1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21	40,94	48,99
0,94	1,13	1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89	28,58	34,21
0,66	0,79	0,94	1,13	1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68	19,96	23,89
0,46	0,55	0,66	0,79	0,94	1,13	1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64	13,94	16,68
0,32	0,38	0,46	0,55	0,66	0,79	0,94	1,13	1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13	9,73	11,64
0,22	0,27	0,32	0,38	0,46	0,55	0,66	0,79	0,94	1,13	1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68	6,79	8,13
0,16	0,19	0,22	0,27	0,32	0,38	0,46	0,55	0,66	0,79	0,94	1,13	1,35	1,61	1,93	2,31	2,77	3,31	3,96	4,74	5,68
0,11	0,13	0,16	0,19	0,22	0,27	0,32	0,38	0,46	0,55	0,66	0,79	0,94	1,13	1,35	1,61	1,93	2,31	2,77	3,31	3,96

0,09	0,11	0,13	0,16	0,19	0,22	0,27	0,32	0,38	0,46	0,55	0,66	0,79	0,94	1,13	1,35	1,61	1,93	2,31	2,77
	0,08	0,09	0,11	0,13	0,16	0,19	0,22	0,27	0,32	0,38	0,46	0,55	0,66	0,79	0,94	1,13	1,35	1,61	1,93
		0,06	0,08	0,09	0,11	0,13	0,16	0,19	0,22	0,27	0,32	0,38	0,46	0,55	0,66	0,79	0,94	1,13	1,35
			0,05	0,06	0,08	0,09	0,11	0,13	0,16	0,19	0,22	0,27	0,32	0,38	0,46	0,55	0,66	0,79	0,94
				0,04	0,05	0,06	0,08	0,09	0,11	0,13	0,16	0,19	0,22	0,27	0,32	0,38	0,46	0,55	0,66
					0,04	0,04	0,05	0,06	0,08	0,09	0,11	0,13	0,16	0,19	0,22	0,27	0,32	0,38	0,46
						0,03	0,04	0,04	0,05	0,06	0,08	0,09	0,11	0,13	0,16	0,19	0,22	0,27	0,32
							0,03	0,03	0,04	0,04	0,05	0,06	0,08	0,09	0,11	0,13	0,16	0,19	0,22
								0,02	0,03	0,03	0,04	0,04	0,05	0,06	0,08	0,09	0,11	0,13	0,16
									0,02	0,02	0,03	0,03	0,04	0,04	0,05	0,06	0,08	0,09	0,11
										0,02	0,02	0,02	0,03	0,03	0,04	0,04	0,05	0,06	0,08
											0,01	0,02	0,02	0,02	0,03	0,03	0,04	0,04	0,05
												0,01	0,01	0,02	0,02	0,02	0,03	0,03	0,04
													0,01	0,01	0,01	0,02	0,02	0,02	0,03
														0,01	0,01	0,01	0,01	0,02	0,02
															0,01	0,01	0,01	0,01	0,01
																0,01	0,01	0,01	0,01
																	0,00	0,01	0,01
																		0,00	0,00
																			0,00

47	48	49
53963,31	64579,98	77285,35
37679,06	45091,98	53963,31
26308,83	31484,79	37679,06
18369,73	21983,77	26308,83
12826,39	15349,83	18369,73
8955,83	10717,78	12826,39
6253,27	7483,53	8955,83
4366,25	5225,26	6253,27
3048,67	3648,46	4366,25
2128,69	2547,48	3048,67
1486,32	1778,74	2128,69
1037,80	1241,98	1486,32
724,63	867,19	1037,80
505,96	605,50	724,63
353,28	422,78	505,96
246,67	295,20	353,28
172,23	206,12	246,67
120,26	143,92	172,23
83,97	100,49	120,26
58,63	70,17	83,97
40,94	48,99	58,63
28,58	34,21	40,94
19,96	23,89	28,58
13,94	16,68	19,96
9,73	11,64	13,94
6,79	8,13	9,73
4,74	5,68	6,79

3,31	3,96	4,74
2,31	2,77	3,31
1,61	1,93	2,31
1,13	1,35	1,61
0,79	0,94	1,13
0,55	0,66	0,79
0,38	0,46	0,55
0,27	0,32	0,38
0,19	0,22	0,27
0,13	0,16	0,19
0,09	0,11	0,13
0,06	0,08	0,09
0,04	0,05	0,06
0,03	0,04	0,04
0,02	0,03	0,03
0,02	0,02	0,02
0,01	0,01	0,02
0,01	0,01	0,01
0,01	0,01	0,01
0,00	0,00	0,01
0,00	0,00	0,00
	0,00	0,00
		0,00

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
520,13	611,37	718,30	843,58	990,26	1161,89	1362,61	1597,17	1871,10	2190,78	2563,55	2997,88	3503,50	4091,57	4774,87	5567,98	6487,54	7552,45	8784,10
250,54	248,99	247,38	245,70	243,94	242,12	240,22	238,24	236,17	234,02	231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
	426,88	501,54	589,02	691,43	811,27	951,42	1115,20	1306,47	1529,68	1789,96	2093,23	2446,27	2856,88	3333,98	3887,76	4529,83	5273,38	6133,36
	248,99	247,38	245,70	243,94	242,12	240,22	238,24	236,17	234,02	231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
		350,20	411,27	482,78	566,46	664,31	778,67	912,22	1068,08	1249,81	1461,56	1708,07	1994,77	2327,90	2714,57	3162,88	3682,06	4282,53
		247,38	245,70	243,94	242,12	240,22	238,24	236,17	234,02	231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
			287,16	337,10	395,52	463,85	543,70	636,95	745,77	872,66	1020,51	1192,63	1392,82	1625,42	1895,40	2208,43	2570,94	2990,21
			245,70	243,94	242,12	240,22	238,24	236,17	234,02	231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
				235,37	276,17	323,87	379,63	444,74	520,72	609,32	712,56	832,74	972,51	1134,92	1323,44	1542,01	1795,12	2087,87
				243,94	242,12	240,22	238,24	236,17	234,02	231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
					192,83	226,14	265,07	310,53	363,59	425,45	497,53	581,45	679,04	792,44	924,07	1076,68	1253,42	1457,82
					242,12	240,22	238,24	236,17	234,02	231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
						157,90	185,08	216,82	253,87	297,06	347,39	405,99	474,13	553,31	645,22	751,78	875,18	1017,90
						240,22	238,24	236,17	234,02	231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
							129,23	151,39	177,26	207,42	242,56	283,47	331,05	386,34	450,51	524,92	611,08	710,73
							238,24	236,17	234,02	231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
								105,71	123,77	144,83	169,37	197,93	231,15	269,76	314,56	366,51	426,68	496,26
								236,17	234,02	231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
									86,42	101,12	118,26	138,20	161,40	188,35	219,64	255,91	297,92	346,51
									234,02	231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
										70,61	82,57	96,50	112,69	131,52	153,36	178,69	208,02	241,94
										231,78	229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
											57,65	67,38	78,69	91,83	107,08	124,77	145,25	168,93
											229,45	227,01	224,48	221,84	219,09	216,22	213,24	210,13
												47,05	54,94	64,12	74,77	87,12	101,42	117,95
												227,01	224,48	221,84	219,09	216,22	213,24	210,13
													38,36	44,77	52,21	60,83	70,81	82,36
													224,48	221,84	219,09	216,22	213,24	210,13
														31,26	36,45	42,47	49,44	57,51
														221,84	219,09	216,22	213,24	210,13
															25,45	29,66	34,52	40,15
															219,09	216,22	213,24	210,13
																20,71	24,11	28,04
																216,22	213,24	210,13
																	16,83	19,58
																	213,24	210,13
																		13,67
																		210,13

Table B.3. *Value tree of PV of the flow of periodic revenues - top inumbers - and of periodic starting cost - bottom underlined numbers (million 2010 USD)*

Thousand separator the dot (.).
Decimal separator the comma (,).
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19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
10206,64	11847,24	13736,30	15907,65	18398,77	21250,85	24508,78	28220,99	32439,12	37217,30	42611,14	48676,16	55465,53	63026,91	71398,19	80601,63	90636,14
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
7126,63	8272,16	9591,16	11107,27	12846,66	14838,08	17112,88	19704,88	22650,12	25986,41	29752,57	33987,38	38727,95	44007,58	49852,70	56278,85	63285,30
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
4976,06	5775,91	6696,88	7755,48	8969,98	10360,46	11948,80	13758,63	15815,10	18144,61	20774,28	23731,17	27041,20	30727,62	34808,88	39295,85	44187,99
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
3474,46	4032,94	4675,99	5415,15	6263,15	7234,03	8343,07	9606,75	11042,65	12669,20	14505,32	16569,93	18881,11	21455,09	24304,77	27437,72	30853,59
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
2425,99	2815,94	3264,94	3781,04	4373,15	5051,05	5825,42	6707,77	7710,36	8846,07	10128,12	11569,70	13183,44	14980,69	16970,43	19157,97	21543,04
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
1693,91	1966,19	2279,69	2640,06	3053,49	3526,82	4067,51	4683,60	5383,64	6176,63	7071,80	8078,36	9205,14	10460,04	11849,34	13376,76	15042,10
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
1182,75	1372,86	1591,76	1843,38	2132,05	2462,55	2840,08	3270,25	3759,05	4312,74	4937,78	5640,59	6427,35	7303,56	8273,62	9340,12	10502,92
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
825,83	958,58	1111,42	1287,11	1488,67	1719,44	1983,04	2283,40	2624,70	3011,31	3447,73	3938,46	4487,80	5099,60	5776,93	6521,59	7333,50
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
576,63	669,31	776,03	898,71	1039,44	1200,57	1384,63	1594,35	1832,65	2102,60	2407,32	2749,97	3133,53	3560,72	4033,65	4553,60	5120,50
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
402,62	467,34	541,85	627,51	725,77	838,28	966,80	1113,23	1279,62	1468,11	1680,88	1920,12	2187,94	2486,22	2816,44	3179,48	3575,31
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
281,12	326,31	378,34	438,15	506,76	585,32	675,05	777,30	893,48	1025,08	1173,65	1340,70	1527,70	1735,96	1966,53	2220,03	2496,41
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
196,29	227,84	264,17	305,93	353,84	408,69	471,34	542,74	623,86	715,75	819,48	936,12	1066,69	1212,11	1373,10	1550,10	1743,08
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
137,06	159,09	184,45	213,61	247,06	285,36	329,11	378,96	435,60	499,76	572,19	653,63	744,80	846,34	958,75	1082,33	1217,08
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
95,70	111,08	128,79	149,15	172,51	199,25	229,79	264,60	304,15	348,95	399,52	456,39	520,05	590,94	669,43	755,72	849,81
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
66,82	77,56	89,93	104,14	120,45	139,12	160,45	184,75	212,37	243,65	278,96	318,67	363,11	412,62	467,42	527,67	593,36
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
46,66	54,16	62,79	72,72	84,10	97,14	112,03	129,00	148,28	170,12	194,78	222,50	253,54	288,10	326,37	368,44	414,31
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
32,58	37,81	43,84	50,77	58,72	67,83	78,22	90,07	103,54	118,79	136,00	155,36	177,03	201,16	227,88	257,26	289,28
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
22,75	26,40	30,61	35,45	41,00	47,36	54,62	62,89	72,29	82,94	94,96	108,48	123,61	140,46	159,12	179,63	201,99
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
15,88	18,43	21,37	24,75	28,63	33,07	38,14	43,91	50,48	57,91	66,31	75,74	86,31	98,07	111,10	125,42	141,04
206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
11,09	12,87	14,92	17,28	19,99	23,09	26,63	30,66	35,24	40,44	46,30	52,89	60,26	68,48	77,57	87,57	98,48

206,89	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
	8,99	10,42	12,07	13,96	16,12	18,59	21,41	24,61	28,23	32,33	36,93	42,08	47,81	54,16	61,15	68,76
	203,51	199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
		7,28	8,43	9,75	11,26	12,98	14,95	17,18	19,71	22,57	25,78	29,38	33,39	37,82	42,69	48,01
		199,99	196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
			5,88	6,80	7,86	9,06	10,44	12,00	13,76	15,76	18,00	20,51	23,31	26,41	29,81	33,52
			196,33	192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
				4,75	5,49	6,33	7,29	8,38	9,61	11,00	12,57	14,32	16,28	18,44	20,82	23,41
				192,51	188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
					3,83	4,42	5,09	5,85	6,71	7,68	8,78	10,00	11,36	12,87	14,53	16,34
					188,53	184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
						3,09	3,55	4,08	4,69	5,36	6,13	6,98	7,94	8,99	10,15	11,41
						184,39	180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
							2,48	2,85	3,27	3,75	4,28	4,88	5,54	6,28	7,09	7,97
							180,07	175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
								1,99	2,28	2,62	2,99	3,40	3,87	4,38	4,95	5,56
								175,57	170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
									1,60	1,83	2,09	2,38	2,70	3,06	3,45	3,88
									170,88	166,00	160,91	155,61	150,09	144,33	138,34	132,09
										1,28	1,46	1,66	1,89	2,14	2,41	2,71
										166,00	160,91	155,61	150,09	144,33	138,34	132,09
											1,02	1,16	1,32	1,49	1,68	1,89
											160,91	155,61	150,09	144,33	138,34	132,09
												0,81	0,92	1,04	1,18	1,32
												155,61	150,09	144,33	138,34	132,09
													0,64	0,73	0,82	0,92
													150,09	144,33	138,34	132,09
														0,51	0,57	0,64
														144,33	138,34	132,09
															0,40	0,45
															138,34	132,09
																0,31
																132,09

36	37	38	39	40	41	42	43	44	45	46	47	48	49
101467,10	113012,99	125128,11	137580,11	150021,36	161952,07	172673,48	181228,34	186325,60	186245,26	178718,67	160778,02	128567,64	77107,87
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
70847,85	78909,59	87368,78	96063,21	104750,12	113080,55	120566,61	126539,92	130098,99	130042,90	124787,58	112260,79	89770,39	53839,39
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
49468,42	55097,42	61003,92	67074,66	73140,17	78956,77	84183,79	88354,56	90839,63	90800,46	87131,02	78384,38	62680,80	37592,53
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
34540,57	38470,93	42595,05	46833,86	51069,00	55130,35	58780,04	61692,22	63427,38	63400,03	60837,90	54730,69	43765,91	26248,41
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
24117,42	26861,74	29741,34	32701,02	35658,15	38493,93	41042,27	43075,65	44287,20	44268,10	42479,13	38214,87	30558,88	18327,55
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
16839,62	18755,80	20766,44	22832,99	24897,76	26877,79	28657,13	30076,91	30922,86	30909,53	29660,40	26682,95	21337,27	12796,93
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
11758,01	13095,95	14499,85	15942,79	17384,48	18767,01	20009,41	21000,74	21591,41	21582,10	20709,92	18630,96	14898,42	8935,26
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
8209,85	9144,04	10124,30	11131,81	12138,45	13103,78	13971,26	14663,45	15075,87	15069,37	14460,39	13008,78	10402,59	6238,91
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
5732,40	6384,69	7069,13	7772,61	8475,48	9149,51	9755,22	10238,53	10526,50	10521,96	10096,74	9083,18	7263,45	4356,22
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
4002,56	4458,01	4935,91	5427,11	5917,88	6388,51	6811,43	7148,90	7349,97	7346,80	7049,90	6342,19	5071,59	3041,67
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
2794,73	3112,74	3446,43	3789,40	4132,07	4460,68	4755,98	4991,61	5132,00	5129,79	4922,48	4428,34	3541,16	2123,80
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
1951,38	2173,42	2406,41	2645,89	2885,15	3114,60	3320,79	3485,31	3583,34	3581,80	3437,05	3092,02	2472,56	1482,91
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
1362,52	1517,56	1680,24	1847,45	2014,51	2174,72	2318,69	2433,57	2502,01	2500,93	2399,87	2158,96	1726,43	1035,42
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
951,36	1059,61	1173,20	1289,95	1406,60	1518,47	1618,99	1699,20	1746,99	1746,24	1675,67	1507,46	1205,45	722,96
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
664,27	739,86	819,17	900,69	982,14	1060,25	1130,43	1186,44	1219,81	1219,28	1170,01	1052,56	841,69	504,80
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
463,82	516,59	571,97	628,89	685,76	740,30	789,31	828,41	851,71	851,35	816,94	734,93	587,70	352,47
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
323,85	360,70	399,37	439,12	478,82	516,90	551,12	578,43	594,70	594,44	570,42	513,16	410,35	246,11
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
226,13	251,86	278,86	306,61	334,33	360,92	384,81	403,88	415,24	415,06	398,29	358,30	286,52	171,84
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
157,89	175,85	194,71	214,08	233,44	252,01	268,69	282,00	289,93	289,81	278,10	250,18	200,06	119,98
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
110,24	122,79	135,95	149,48	163,00	175,96	187,61	196,90	202,44	202,35	194,18	174,68	139,69	83,78

125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
76,98	85,73	94,93	104,37	113,81	122,86	130,99	137,48	141,35	141,29	135,58	121,97	97,53	58,50
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
53,75	59,86	66,28	72,88	79,47	85,79	91,47	96,00	98,70	98,65	94,67	85,16	68,10	40,84
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
37,53	41,80	46,28	50,88	55,49	59,90	63,86	67,03	68,91	68,88	66,10	59,46	47,55	28,52
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
26,20	29,19	32,31	35,53	38,74	41,82	44,59	46,80	48,12	48,10	46,15	41,52	33,20	19,91
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
18,30	20,38	22,56	24,81	27,05	29,20	31,14	32,68	33,60	33,58	32,23	28,99	23,18	13,90
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
12,77	14,23	15,75	17,32	18,89	20,39	21,74	22,82	23,46	23,45	22,50	20,24	16,19	9,71
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
8,92	9,93	11,00	12,09	13,19	14,24	15,18	15,93	16,38	16,37	15,71	14,13	11,30	6,78
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
6,23	6,94	7,68	8,44	9,21	9,94	10,60	11,12	11,44	11,43	10,97	9,87	7,89	4,73
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
4,35	4,84	5,36	5,90	6,43	6,94	7,40	7,77	7,99	7,98	7,66	6,89	5,51	3,30
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
3,04	3,38	3,74	4,12	4,49	4,85	5,17	5,42	5,58	5,57	5,35	4,81	3,85	2,31
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
2,12	2,36	2,61	2,87	3,13	3,38	3,61	3,79	3,89	3,89	3,73	3,36	2,69	1,61
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
1,48	1,65	1,83	2,01	2,19	2,36	2,52	2,64	2,72	2,72	2,61	2,35	1,88	1,12
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
1,03	1,15	1,27	1,40	1,53	1,65	1,76	1,85	1,90	1,90	1,82	1,64	1,31	0,79
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
0,72	0,80	0,89	0,98	1,07	1,15	1,23	1,29	1,33	1,32	1,27	1,14	0,91	0,55
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
0,50	0,56	0,62	0,68	0,75	0,80	0,86	0,90	0,93	0,92	0,89	0,80	0,64	0,38
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
0,35	0,39	0,43	0,48	0,52	0,56	0,60	0,63	0,65	0,65	0,62	0,56	0,45	0,27
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
0,25	0,27	0,30	0,33	0,36	0,39	0,42	0,44	0,45	0,45	0,43	0,39	0,31	0,19
125,59	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
	0,19	0,21	0,23	0,25	0,27	0,29	0,31	0,32	0,31	0,30	0,27	0,22	0,13
	118,81	111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
		0,15	0,16	0,18	0,19	0,20	0,21	0,22	0,22	0,21	0,19	0,15	0,09
		111,75	104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
			0,11	0,12	0,13	0,14	0,15	0,15	0,15	0,15	0,13	0,11	0,06

104,39	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
	0,09	0,09	0,10	0,10	0,11	0,11	0,10	0,09	0,07	0,04
	96,72	88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
		0,07	0,07	0,07	0,07	0,07	0,07	0,06	0,05	0,03
		88,73	80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
			0,05	0,05	0,05	0,05	0,05	0,05	0,04	0,02
			80,41	71,74	62,71	53,30	43,50	33,28	22,64	11,55
				0,04	0,04	0,04	0,04	0,03	0,03	0,02
				71,74	62,71	53,30	43,50	33,28	22,64	11,55
					0,03	0,03	0,02	0,02	0,02	0,01
					62,71	53,30	43,50	33,28	22,64	11,55
						0,02	0,02	0,02	0,01	0,01
						53,30	43,50	33,28	22,64	11,55
							0,01	0,01	0,01	0,01
							43,50	33,28	22,64	11,55
								0,01	0,01	0,00
								33,28	22,64	11,55
									0,00	0,00
									22,64	11,55
										0,00
										11,55

Table B.4. *Real options value binomial tree for SSAD (million 2010 USD)*

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
269,59	362,37	470,92	597,88	746,31	919,78	1122,39	1358,94	1634,93	1956,76	2331,77	2768,44	3276,49	3867,09	4553,03	5348,89	6271,32	7339,21	8573,97
6,88	**8,68**	**10,91**	**13,65**	**17,03**	**21,16**	**26,21**	**32,36**	**39,83**	**48,88**	**59,82**	**73,02**	**88,94**	**108,10**	**131,13**	**158,81**	**192,03**	**231,89**	**279,70**
	177,88	254,17	343,32	447,49	569,16	711,20	876,96	1070,30	1295,66	1558,18	1863,78	2219,25	2632,40	3112,14	3668,67	4313,61	5060,15	5923,24
	5,15	**6,56**	**8,31**	**10,49**	**13,18**	**16,51**	**20,58**	**25,58**	**31,67**	**39,08**	**48,07**	**58,95**	**72,11**	**87,97**	**107,08**	**130,07**	**157,69**	**190,86**
		102,82	165,58	238,84	324,34	424,10	540,44	676,05	834,05	1018,03	1232,12	1481,06	1770,29	2106,06	2495,48	2946,66	3468,82	4072,40
		3,78	**4,86**	**6,22**	**7,92**	**10,05**	**12,68**	**15,95**	**19,96**	**24,89**	**30,92**	**38,26**	**47,19**	**58,02**	**71,11**	**86,92**	**105,97**	**128,90**
			41,47	93,15	153,40	223,63	305,46	400,77	511,75	640,88	791,07	965,62	1168,34	1403,58	1676,32	1992,21	2357,70	2780,08
			2,72	**3,53**	**4,56**	**5,87**	**7,52**	**9,58**	**12,15**	**15,35**	**19,29**	**24,15**	**30,11**	**37,38**	**46,24**	**57,00**	**70,03**	**85,78**
				-8,57	34,05	83,66	141,39	208,57	286,70	377,54	483,11	605,72	748,03	913,09	1104,35	1325,78	1581,88	1877,74
				1,90	**2,50**	**3,27**	**4,25**	**5,50**	**7,09**	**9,09**	**11,59**	**14,71**	**18,58**	**23,36**	**29,23**	**36,43**	**45,21**	**55,90**
					-49,29	-14,08	26,83	74,36	129,56	193,67	268,09	354,43	454,56	570,60	704,98	860,46	1040,18	1247,69
					1,29	**1,72**	**2,27**	**3,00**	**3,93**	**5,12**	**6,64**	**8,56**	**10,99**	**14,03**	**17,81**	**22,50**	**28,29**	**35,40**
						-82,32	-53,16	-19,35	19,85	65,28	117,95	178,97	249,65	331,47	426,13	535,55	661,94	807,78
						0,85	**1,14**	**1,53**	**2,05**	**2,72**	**3,60**	**4,73**	**6,17**	**8,02**	**10,36**	**13,30**	**16,99**	**21,58**
							-109,01	-84,78	-56,76	-24,36	13,12	56,46	106,58	164,50	231,43	308,69	397,84	500,61
							0,53	**0,73**	**1,00**	**1,35**	**1,82**	**2,45**	**3,26**	**4,32**	**5,69**	**7,44**	**9,69**	**12,53**
								-130,46	-110,25	-86,95	-60,08	-29,08	6,68	47,92	95,48	150,29	213,44	286,13
								0,32	**0,45**	**0,62**	**0,86**	**1,18**	**1,60**	**2,17**	**2,92**	**3,90**	**5,18**	**6,85**
									-147,60	-130,66	-111,19	-88,81	-63,08	-33,49	0,55	39,69	84,68	136,38
									0,19	**0,26**	**0,37**	**0,52**	**0,72**	**1,00**	**1,38**	**1,89**	**2,57**	**3,48**
										-161,17	-146,87	-130,52	-111,78	-90,32	-65,73	-37,53	-5,22	31,82
										0,10	**0,15**	**0,21**	**0,30**	**0,42**	**0,60**	**0,84**	**1,17**	**1,62**
											-171,79	-159,64	-145,79	-130,01	-112,01	-91,46	-67,99	-41,19
											0,05	**0,08**	**0,11**	**0,16**	**0,23**	**0,33**	**0,48**	**0,68**
												-179,97	-169,54	-157,72	-144,32	-129,11	-111,82	-92,17
												0,02	**0,04**	**0,05**	**0,08**	**0,12**	**0,17**	**0,26**
													-186,12	-177,07	-166,88	-155,40	-142,42	-127,77
													0,01	**0,02**	**0,02**	**0,04**	**0,06**	**0,08**
														-190,58	-182,64	-173,75	-163,79	-152,62
														0,00	**0,01**	**0,01**	**0,02**	**0,02**
															-193,64	-186,57	-178,71	-169,97
															0,00	**0,00**	**0,00**	**0,01**
																-195,52	-189,13	-182,09
																0,00	**0,00**	**0,00**
																	-196,41	-190,55
																	0,00	**0,00**
																		-196,46
																		0,00

Thousand separator the dot (.).
Decimal separator the comma (,).
Top bold numbers are NR.
Bottom numbers are option values.
Option to exercise is exercised where the option value is not zero.

Table B.4 *Real options value binomial tree for SSAD (million 2010 USD), continued*

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
9999,76	*11643,73*	*13536,30*	*15711,32*	*18206,26*	*21062,32*	*24324,39*	*28040,92*	*32263,55*	*37046,41*	*42445,14*	*48515,25*	*55309,92*	*62876,83*	*71253,86*	*80463,29*
337,01	**405,71**	**488,01**	**586,62**	**704,74**	**846,22**	**1015,64**	**1218,52**	**1461,44**	**1752,29**	**2100,49**	**2517,35**	**3016,37**	**3613,72**	**4328,77**	**5184,65**
6919,75	*8068,65*	*9391,17*	*10910,95*	*12654,15*	*14649,55*	*16928,49*	*19524,81*	*22474,55*	*25815,53*	*29586,58*	*33826,47*	*38572,35*	*43857,49*	*49708,36*	*56140,51*
230,68	**278,43**	**335,69**	**404,33**	**486,58**	**585,13**	**703,19**	**844,59**	**1013,95**	**1216,76**	**1459,60**	**1750,37**	**2098,50**	**2515,27**	**3014,21**	**3611,47**
4769,18	*5572,40*	*6496,89*	*7559,16*	*8777,48*	*10171,93*	*11764,42*	*13578,56*	*15639,53*	*17973,73*	*20608,28*	*23570,26*	*26885,59*	*30577,53*	*34664,55*	*39157,51*
156,48	**189,60**	**229,35**	**277,05**	**334,26**	**402,83**	**485,02**	**583,51**	**701,50**	**842,83**	**1012,11**	**1214,85**	**1457,61**	**1748,30**	**2096,34**	**2513,02**
3267,57	*3829,43*	*4476,00*	*5218,82*	*6070,65*	*7045,50*	*8158,68*	*9426,68*	*10867,08*	*12498,32*	*14339,33*	*16409,02*	*18725,50*	*21305,00*	*24160,44*	*27299,39*
104,77	**127,64**	**155,16**	**188,22**	**227,92**	**275,56**	**332,70**	**401,21**	**483,33**	**581,74**	**699,66**	**840,92**	**1010,12**	**1212,77**	**1455,45**	**1746,05**
2219,10	*2612,43*	*3064,95*	*3584,72*	*4180,64*	*4862,52*	*5641,04*	*6527,70*	*7534,79*	*8675,19*	*9962,12*	*11408,79*	*13027,83*	*14830,60*	*16826,10*	*19019,63*
68,86	**84,53**	**103,46**	**126,27**	**153,72**	**186,72**	**226,36**	**273,93**	**331,01**	**399,45**	**481,50**	**579,83**	**697,67**	**838,85**	**1007,96**	**1210,52**
1487,02	*1762,68*	*2079,70*	*2443,73*	*2860,98*	*3338,29*	*3883,13*	*4503,53*	*5208,07*	*6005,75*	*6905,81*	*7917,45*	*9049,53*	*10309,95*	*11705,01*	*13238,42*
44,10	**54,70**	**67,58**	**83,18**	**102,04**	**124,78**	**152,16**	**185,10**	**224,66**	**272,17**	**329,17**	**397,53**	**479,50**	**577,76**	**695,51**	**836,59**
975,86	*1169,35*	*1391,77*	*1647,05*	*1939,54*	*2274,02*	*2655,69*	*3090,18*	*3583,48*	*4141,86*	*4771,78*	*5479,68*	*6271,74*	*7153,47*	*8129,29*	*9201,78*
27,27	**34,28**	**42,89**	**53,40**	**66,19**	**81,71**	**100,49**	**123,16**	**150,47**	**183,33**	**222,83**	**270,25**	**327,18**	**395,46**	**477,34**	**575,51**
618,95	*755,07*	*911,43*	*1090,78*	*1296,16*	*1530,91*	*1798,66*	*2103,33*	*2449,13*	*2840,42*	*3281,73*	*3777,55*	*4332,19*	*4949,51*	*5632,60*	*6383,26*
16,11	**20,60**	**26,17**	**33,08**	**41,57**	**51,98**	**64,68**	**80,11**	**98,81**	**121,39**	**148,63**	**181,41**	**220,83**	**268,18**	**325,01**	**393,21**
369,74	*465,80*	*576,04*	*702,38*	*846,93*	*1012,04*	*1200,24*	*1414,28*	*1657,09*	*1931,72*	*2241,33*	*2589,06*	*2977,93*	*3410,63*	*3889,32*	*4415,26*
8,98	**11,71**	**15,18**	**19,54**	**24,99**	**31,77**	**40,15**	**50,44**	**63,04**	**78,37**	**96,97**	**119,48**	**146,63**	**179,33**	**218,66**	**265,92**
195,73	*263,83*	*341,86*	*431,18*	*533,27*	*649,75*	*782,41*	*933,16*	*1104,05*	*1297,23*	*1514,88*	*1759,21*	*2032,33*	*2336,13*	*2672,10*	*3041,14*
4,67	**6,23**	**8,25**	**10,85**	**14,18**	**18,40**	**23,71**	**30,35**	**38,60**	**48,77**	**61,24**	**76,47**	**94,98**	**117,39**	**144,46**	**177,07**
74,24	*122,80*	*178,35*	*241,82*	*314,25*	*396,79*	*490,66*	*597,23*	*717,91*	*854,20*	*1007,65*	*1179,79*	*1372,09*	*1585,88*	*1822,20*	*2081,69*
2,23	**3,05**	**4,14**	**5,59**	**7,48**	**9,94**	**13,12**	**17,18**	**22,34**	**28,82**	**36,91**	**46,94**	**59,29**	**74,40**	**92,81**	**115,12**
-10,60	*24,33*	*64,18*	*109,60*	*161,33*	*220,16*	*286,96*	*362,67*	*448,29*	*544,87*	*653,48*	*775,21*	*911,08*	*1062,02*	*1228,77*	*1411,76*
0,96	**1,35**	**1,89**	**2,62**	**3,61**	**4,93**	**6,68**	**8,99**	**12,00**	**15,88**	**20,86**	**27,16**	**35,08**	**44,95**	**57,16**	**72,15**
-69,83	*-44,42*	*-15,54*	*17,28*	*54,55*	*96,83*	*144,72*	*198,89*	*260,03*	*328,88*	*406,19*	*492,72*	*589,19*	*696,25*	*814,41*	*943,99*
0,37	**0,54**	**0,77**	**1,10**	**1,56**	**2,20**	**3,07**	**4,26**	**5,86**	**8,00**	**10,82**	**14,50**	**19,26**	**25,36**	**33,09**	**42,78**
-111,19	*-92,43*	*-71,20*	*-47,18*	*-20,00*	*10,72*	*45,41*	*84,53*	*128,58*	*178,07*	*233,53*	*295,48*	*364,44*	*440,85*	*525,10*	*617,38*
0,13	**0,19**	**0,28**	**0,41**	**0,60**	**0,87**	**1,25**	**1,79**	**2,55**	**3,59**	**5,03**	**6,97**	**9,57**	**13,02**	**17,54**	**23,40**
-140,07	*-125,95*	*-110,06*	*-92,18*	*-72,06*	*-49,41*	*-23,93*	*4,69*	*36,80*	*72,77*	*112,96*	*157,76*	*207,50*	*262,53*	*323,09*	*389,33*
0,04	**0,06**	**0,09**	**0,13**	**0,20**	**0,30**	**0,44**	**0,65**	**0,96**	**1,41**	**2,04**	**2,93**	**4,18**	**5,91**	**8,27**	**11,45**
-160,23	*-149,35*	*-137,20*	*-123,61*	*-108,41*	*-91,39*	*-72,35*	*-51,07*	*-27,29*	*-0,76*	*28,78*	*61,59*	*97,93*	*138,02*	*182,04*	*230,10*
0,01	**0,01**	**0,02**	**0,03**	**0,05**	**0,08**	**0,13**	**0,20**	**0,31**	**0,46**	**0,70**	**1,05**	**1,55**	**2,29**	**3,34**	**4,83**
-174,31	*-165,70*	*-156,15*	*-145,55*	*-133,78*	*-120,70*	*-106,16*	*-89,99*	*-72,03*	*-52,09*	*-30,00*	*-5,55*	*21,42*	*51,08*	*83,55*	*118,92*
0,00	**0,00**	**0,00**	**0,01**	**0,01**	**0,02**	**0,03**	**0,05**	**0,08**	**0,13**	**0,20**	**0,31**	**0,47**	**0,73**	**1,11**	**1,68**
-184,14	*-177,11*	*-169,38*	*-160,88*	*-151,51*	*-141,17*	*-129,77*	*-117,17*	*-103,28*	*-87,94*	*-71,04*	*-52,43*	*-32,00*	*-9,63*	*14,78*	*41,29*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,01**	**0,01**	**0,02**	**0,03**	**0,04**	**0,07**	**0,11**	**0,18**	**0,29**	**0,46**
-191,00	*-185,07*	*-178,62*	*-171,57*	*-163,88*	*-155,46*	*-146,25*	*-136,15*	*-125,09*	*-112,97*	*-99,69*	*-85,17*	*-69,30*	*-52,01*	*-33,23*	*-12,92*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,01**	**0,01**	**0,02**	**0,03**	**0,05**	**0,09**

Table B.4 *Real options value binomial tree for SSAD (million 2010 USD): continued*

-195,80	*-190,64*	*-185,07*	*-179,04*	*-172,52*	*-165,44*	*-157,76*	*-149,41*	*-140,32*	*-130,44*	*-119,70*	*-108,02*	*-95,35*	*-81,61*	*-66,76*	*-50,77*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,01**	**0,01**
	-194,52	*-189,57*	*-184,26*	*-178,55*	*-172,41*	*-165,79*	*-158,66*	*-150,96*	*-142,65*	*-133,67*	*-123,98*	*-113,53*	*-102,27*	*-90,17*	*-77,19*
	0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
		-192,72	*-187,90*	*-182,76*	*-177,27*	*-171,40*	*-165,12*	*-158,39*	*-151,17*	*-143,43*	*-135,13*	*-126,23*	*-116,70*	*-106,51*	*-95,64*
		0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
			-190,44	*-185,70*	*-180,67*	*-175,32*	*-169,63*	*-163,57*	*-157,12*	*-150,24*	*-142,91*	*-135,10*	*-126,78*	*-117,93*	*-108,53*
			0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
				-187,76	*-183,04*	*-178,06*	*-172,78*	*-167,19*	*-161,27*	*-154,99*	*-148,34*	*-141,29*	*-133,81*	*-125,90*	*-117,52*
				0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
					-184,70	*-179,97*	*-174,98*	*-169,72*	*-164,17*	*-158,31*	*-152,13*	*-145,61*	*-138,72*	*-131,46*	*-123,81*
					0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
						-181,30	*-176,51*	*-171,48*	*-166,20*	*-160,63*	*-154,78*	*-148,63*	*-142,15*	*-135,34*	*-128,19*
						0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
							-177,59	*-172,72*	*-167,61*	*-162,25*	*-156,63*	*-150,73*	*-144,55*	*-138,06*	*-131,25*
							0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
								-173,58	*-168,60*	*-163,38*	*-157,92*	*-152,20*	*-146,22*	*-139,95*	*-133,39*
								0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
									-169,29	*-164,17*	*-158,82*	*-153,23*	*-147,39*	*-141,27*	*-134,88*
									0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
										-164,72	*-159,45*	*-153,95*	*-148,20*	*-142,20*	*-135,93*
										0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
											-159,89	*-154,45*	*-148,77*	*-142,84*	*-136,65*
											0,00	**0,00**	**0,00**	**0,00**	**0,00**
												-154,80	*-149,17*	*-143,29*	*-137,16*
												0,00	**0,00**	**0,00**	**0,00**
													-149,44	*-143,61*	*-137,52*
													0,00	**0,00**	**0,00**
														-143,83	*-137,77*
														0,00	**0,00**
															-137,94
															0,00

Table B.4 *Real options value binomial tree for SSAD (million 2010 USD): continued*

35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
90504,05	*101341,51*	*112894,19*	*125016,36*	*137475,73*	*149924,64*	*161863,34*	*172593,07*	*181156,60*	*186262,89*	*186191,96*	*178675,18*	*160744,74*	*128545,00*	*77096,32*
6209,11	**7435,29**	**8902,91**	**10659,47**	**12761,81**	**15278,00**	**18289,43**	**21893,57**	**26207,03**	**31369,38**	**37547,62**	**44941,64**	**53790,64**	**64380,89**	**77054,96**
63153,20	*70722,26*	*78790,78*	*87257,04*	*95958,82*	*104653,40*	*112991,82*	*120486,20*	*126468,17*	*130036,28*	*129989,60*	*124744,08*	*112227,51*	*89747,75*	*53827,84*
4326,42	**5182,21**	**6206,56**	**7432,64**	**8900,15**	**10656,59**	**12758,81**	**15274,87**	**18286,18**	**21890,18**	**26203,50**	**31365,69**	**37543,78**	**44937,64**	**53786,48**
44055,90	*49342,84*	*54978,61*	*60892,17*	*66970,28*	*73043,45*	*78868,03*	*84103,38*	*88282,82*	*90776,92*	*90747,16*	*87087,52*	*78351,10*	*62658,16*	*37580,98*
3011,86	**3609,03**	**4323,87**	**5179,55**	**6203,79**	**7429,76**	**8897,14**	**10653,46**	**12755,56**	**15271,48**	**18282,64**	**21886,50**	**26199,66**	**31361,70**	**37539,62**
30721,49	*34414,98*	*38352,12*	*42483,30*	*46729,47*	*50972,28*	*55041,62*	*58699,63*	*61620,48*	*63364,67*	*63346,73*	*60794,40*	*54697,41*	*43743,27*	*26236,86*
2093,99	**2510,58**	**3009,31**	**3606,37**	**4321,11**	**5176,67**	**6200,79**	**7426,63**	**8893,89**	**10650,07**	**12752,02**	**15267,79**	**18278,80**	**21882,50**	**26195,50**
21410,95	*23991,84*	*26742,93*	*29629,60*	*32596,64*	*35561,43*	*38405,19*	*40961,85*	*43003,90*	*44224,49*	*44214,80*	*42435,63*	*38181,59*	*30536,24*	*18316,00*
1453,10	**1743,60**	**2091,45**	**2507,92**	**3006,55**	**3603,49**	**4318,11**	**5173,55**	**6197,54**	**7423,24**	**8890,35**	**10646,38**	**12748,18**	**15263,79**	**18274,64**
14910,01	*16714,04*	*18636,99*	*20654,69*	*22728,60*	*24801,04*	*26789,06*	*28576,72*	*30005,17*	*30860,15*	*30856,23*	*29616,91*	*26649,67*	*21314,63*	*12785,38*
1005,61	**1208,07**	**1450,56**	**1740,95**	**2088,68**	**2505,04**	**3003,55**	**3600,37**	**4314,85**	**5170,15**	**6194,00**	**7419,55**	**8886,51**	**10642,38**	**12744,02**
10370,82	*11632,42*	*12977,14*	*14388,10*	*15838,40*	*17287,76*	*18678,27*	*19928,99*	*20929,00*	*21528,70*	*21528,80*	*20666,43*	*18597,68*	*14875,78*	*8923,71*
693,16	**834,15**	**1003,07**	**1205,42**	**1447,79**	**1738,07**	**2085,68**	**2501,92**	**3000,29**	**3596,97**	**4311,31**	**5166,47**	**6190,16**	**7415,56**	**8882,35**
7201,41	*8084,26*	*9025,24*	*10012,55*	*11027,42*	*12041,72*	*13015,04*	*13890,85*	*14591,70*	*15013,16*	*15016,07*	*14416,89*	*12975,50*	*10379,95*	*6227,36*
475,00	**573,06**	**690,61**	**831,50**	**1000,30**	**1202,54**	**1444,79**	**1734,94**	**2082,42**	**2498,52**	**2996,76**	**3593,29**	**4307,48**	**5162,47**	**6186,00**
4988,41	*5606,81*	*6265,88*	*6957,39*	*7668,23*	*8378,76*	*9060,78*	*9674,81*	*10166,78*	*10463,79*	*10468,66*	*10053,25*	*9049,90*	*7240,81*	*4344,67*
322,67	**390,76**	**472,45**	**570,41**	**687,85**	**828,61**	**997,30**	**1199,41**	**1441,53**	**1731,55**	**2078,89**	**2494,84**	**2992,92**	**3589,29**	**4303,31**
3443,22	*3876,97*	*4339,20*	*4824,17*	*5322,72*	*5821,16*	*6299,77*	*6731,02*	*7077,15*	*7287,26*	*7293,50*	*7006,40*	*6308,91*	*5048,95*	*3030,11*
216,31	**263,47**	**320,12**	**388,11**	**469,68**	**567,53**	**684,85**	**825,49**	**994,04**	**1196,02**	**1438,00**	**1727,87**	**2075,05**	**2490,84**	**2988,75**
2364,31	*2669,14*	*2993,93*	*3334,68*	*3685,01*	*4035,35*	*4371,94*	*4675,57*	*4919,86*	*5069,29*	*5076,49*	*4878,99*	*4395,06*	*3518,52*	*2112,25*
142,10	**174,62**	**213,76**	**260,82**	**317,35**	**385,23**	**466,68**	**564,40**	**681,59**	**822,09**	**990,51**	**1192,34**	**1434,16**	**1723,87**	**2070,88**
1610,99	*1825,79*	*2054,61*	*2294,67*	*2541,50*	*2788,43*	*3025,87*	*3240,38*	*3413,57*	*3520,63*	*3528,50*	*3393,55*	*3058,74*	*2449,92*	*1471,36*
90,44	**112,66**	**139,53**	**171,95**	**210,99**	**257,94**	**314,35**	**382,10**	**463,43**	**561,01**	**678,06**	**818,41**	**986,67**	**1188,34**	**1430,00**
1084,98	*1236,93*	*1398,75*	*1568,50*	*1743,06*	*1917,79*	*2085,99*	*2238,28*	*2361,82*	*2439,30*	*2447,63*	*2356,37*	*2125,67*	*1703,79*	*1023,87*
54,83	**69,68**	**87,86**	**109,98**	**136,75**	**169,07**	**207,99**	**254,81**	**311,09**	**378,71**	**459,89**	**557,32**	**674,22**	**814,41**	**982,51**
717,71	*825,77*	*940,80*	*1061,46*	*1185,57*	*1309,88*	*1429,73*	*1538,58*	*1627,46*	*1684,28*	*1692,94*	*1632,17*	*1474,18*	*1182,81*	*711,41*
30,91	**40,40**	**52,28**	**66,99**	**85,05**	**107,06**	**133,73**	**165,94**	**204,73**	**251,42**	**307,56**	**375,02**	**456,05**	**553,33**	**670,05**
461,27	*538,68*	*621,05*	*707,43*	*796,30*	*885,42*	*971,51*	*1050,02*	*1114,70*	*1157,10*	*1165,98*	*1126,51*	*1019,28*	*819,05*	*493,25*
15,70	**21,28**	**28,52**	**37,79**	**49,48**	**64,05**	**81,99**	**103,90**	**130,47**	**162,54**	**201,20**	**247,74**	**303,72**	**371,03**	**451,89**
282,21	*338,23*	*397,79*	*460,23*	*524,51*	*589,04*	*651,57*	*708,90*	*756,67*	*789,00*	*798,05*	*773,45*	*701,65*	*565,06*	*340,92*
6,92	**9,80**	**13,72**	**18,97**	**25,91**	**34,91**	**46,40**	**60,82**	**78,67**	**100,48**	**126,93**	**158,86**	**197,36**	**243,74**	**299,56**
157,19	*198,27*	*241,90*	*287,63*	*334,73*	*382,10*	*428,17*	*470,71*	*506,68*	*531,99*	*541,14*	*526,92*	*479,87*	*387,71*	*234,55*
2,53	**3,76**	**5,53**	**8,06**	**11,59**	**16,45**	**23,02**	**31,72**	**42,99**	**57,30**	**75,08**	**96,80**	**123,09**	**154,86**	**193,19**
69,89	*100,54*	*133,05*	*167,11*	*202,22*	*237,61*	*272,19*	*304,40*	*332,14*	*352,53*	*361,76*	*354,79*	*325,02*	*263,88*	*160,29*
0,72	**1,13**	**1,76**	**2,71**	**4,14**	**6,25**	**9,31**	**13,68**	**19,79**	**28,14**	**39,21**	**53,47**	**71,24**	**92,80**	**118,93**
8,94	*32,30*	*57,05*	*82,96*	*109,70*	*136,72*	*163,27*	*188,28*	*210,26*	*227,22*	*236,51*	*234,60*	*216,90*	*177,42*	*108,43*
0,15	**0,25**	**0,41**	**0,67**	**1,08**	**1,74**	**2,78**	**4,39**	**6,87**	**10,61**	**16,13**	**24,06**	**35,03**	**49,47**	**67,07**

Table B.4 *Real options value binomial tree for SSAD (million 2010 USD): continued*

-33,62	*-15,34*	*3,98*	*24,21*	*45,09*	*66,28*	*87,23*	*107,20*	*125,16*	*139,73*	*149,05*	*150,68*	*141,40*	*117,05*	*72,23*	
0,02	**0,03**	**0,06**	**0,10**	**0,18**	**0,31**	**0,53**	**0,90**	**1,52**	**2,57**	**4,30**	**7,16**	**11,79**	**19,22**	**30,86**	
-63,33	*-48,61*	*-33,07*	*-16,82*	*-0,02*	*17,09*	*34,13*	*50,58*	*65,74*	*78,64*	*87,99*	*92,08*	*88,69*	*74,90*	*46,94*	
0,00	**0,00**	**0,00**	**0,01**	**0,01**	**0,02**	**0,05**	**0,08**	**0,15**	**0,28**	**0,50**	**0,92**	**1,68**	**3,06**	**5,58**	
-84,08	*-71,84*	*-58,95*	*-45,47*	*-31,51*	*-17,25*	*-2,95*	*11,05*	*24,25*	*35,99*	*45,35*	*51,17*	*51,88*	*45,46*	*29,29*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-98,57	*-88,06*	*-77,01*	*-65,47*	*-53,50*	*-41,23*	*-28,84*	*-16,55*	*-4,71*	*6,20*	*15,58*	*22,60*	*26,18*	*24,91*	*16,97*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-108,69	*-99,38*	*-89,62*	*-79,43*	*-68,86*	*-57,98*	*-46,91*	*-35,82*	*-24,94*	*-14,59*	*-5,20*	*2,66*	*8,24*	*10,56*	*8,36*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-115,75	*-107,29*	*-98,43*	*-89,18*	*-79,58*	*-69,67*	*-59,53*	*-49,28*	*-39,06*	*-29,11*	*-19,72*	*-11,27*	*-4,29*	*0,54*	*2,35*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-120,68	*-112,81*	*-104,58*	*-95,99*	*-87,07*	*-77,83*	*-68,34*	*-58,67*	*-48,93*	*-39,25*	*-29,85*	*-20,99*	*-13,04*	*-6,45*	*-1,84*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-124,13	*-116,67*	*-108,87*	*-100,75*	*-92,29*	*-83,53*	*-74,50*	*-65,23*	*-55,81*	*-46,33*	*-36,93*	*-27,78*	*-19,15*	*-11,34*	*-4,77*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-126,53	*-119,36*	*-111,87*	*-104,06*	*-95,94*	*-87,51*	*-78,79*	*-69,81*	*-60,62*	*-51,27*	*-41,87*	*-32,53*	*-23,41*	*-14,75*	*-6,82*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-128,21	*-121,24*	*-113,96*	*-106,38*	*-98,49*	*-90,29*	*-81,79*	*-73,01*	*-63,98*	*-54,72*	*-45,32*	*-35,84*	*-26,39*	*-17,13*	*-8,25*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-129,38	*-122,55*	*-115,43*	*-108,00*	*-100,27*	*-92,23*	*-83,89*	*-75,25*	*-66,32*	*-57,13*	*-47,73*	*-38,15*	*-28,47*	*-18,79*	*-9,24*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-130,20	*-123,47*	*-116,45*	*-109,13*	*-101,51*	*-93,59*	*-85,35*	*-76,80*	*-67,96*	*-58,82*	*-49,41*	*-39,76*	*-29,92*	*-19,95*	*-9,94*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-130,77	*-124,11*	*-117,16*	*-109,92*	*-102,38*	*-94,53*	*-86,37*	*-77,89*	*-69,10*	*-59,99*	*-50,58*	*-40,89*	*-30,94*	*-20,76*	*-10,43*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-131,17	*-124,55*	*-117,66*	*-110,47*	*-102,99*	*-95,19*	*-87,08*	*-78,65*	*-69,90*	*-60,81*	*-51,40*	*-41,68*	*-31,64*	*-21,33*	*-10,77*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-131,45	*-124,87*	*-118,00*	*-110,86*	*-103,41*	*-95,65*	*-87,58*	*-79,18*	*-70,45*	*-61,39*	*-51,98*	*-42,22*	*-32,14*	*-21,72*	*-11,00*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-131,64	*-125,08*	*-118,25*	*-111,12*	*-103,70*	*-95,98*	*-87,93*	*-79,56*	*-70,84*	*-61,79*	*-52,38*	*-42,61*	*-32,48*	*-22,00*	*-11,17*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
-131,78	*-125,24*	*-118,42*	*-111,31*	*-103,91*	*-96,20*	*-88,17*	*-79,81*	*-71,11*	*-62,06*	*-52,65*	*-42,88*	*-32,72*	*-22,19*	*-11,28*	
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
	-125,34	*-118,53*	*-111,44*	*-104,05*	*-96,36*	*-88,34*	*-79,99*	*-71,30*	*-62,26*	*-52,85*	*-43,06*	*-32,89*	*-22,33*	*-11,36*	
	0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
		-118,62	*-111,53*	*-104,15*	*-96,47*	*-88,46*	*-80,12*	*-71,44*	*-62,40*	*-52,99*	*-43,19*	*-33,01*	*-22,42*	*-11,42*	
		0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	

Table B.4 *Real options value binomial tree for SSAD (million 2010 USD): continued*

-111,60	*-104,22*	*-96,54*	*-88,54*	*-80,21*	*-71,53*	*-62,49*	*-53,08*	*-43,28*	*-33,09*	*-22,49*	*-11,46*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
	-104,27	*-96,60*	*-88,60*	*-80,27*	*-71,59*	*-62,56*	*-53,15*	*-43,35*	*-33,15*	*-22,53*	*-11,49*
	0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
		-96,63	*-88,64*	*-80,31*	*-71,64*	*-62,60*	*-53,19*	*-43,39*	*-33,19*	*-22,57*	*-11,51*
		0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
			-88,67	*-80,34*	*-71,67*	*-62,64*	*-53,23*	*-43,42*	*-33,22*	*-22,59*	*-11,52*
			0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
				-80,36	*-71,69*	*-62,66*	*-53,25*	*-43,45*	*-33,24*	*-22,60*	*-11,53*
				0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
					-71,71	*-62,67*	*-53,26*	*-43,46*	*-33,25*	*-22,61*	*-11,54*
					0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
						-62,69	*-53,27*	*-43,47*	*-33,26*	*-22,62*	*-11,54*
						0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
							-53,28	*-43,48*	*-33,27*	*-22,63*	*-11,54*
							0,00	**0,00**	**0,00**	**0,00**	**0,00**
								-43,48	*-33,27*	*-22,63*	*-11,55*
								0,00	**0,00**	**0,00**	**0,00**
									-33,27	*-22,63*	*-11,55*
									0,00	**0,00**	**0,00**
										-22,63	*-11,55*
										0,00	**0,00**
											-11,55
											0,00

Table B.5 *Adjusted real options value binomial tree for SSAD (million 2010 USD)*

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
269,59	*362,37*	*470,92*	*597,88*	*746,31*	*919,78*	*1122,39*	*1358,94*	*1634,93*	*1956,76*	*2331,77*	*2768,44*	*3276,49*	*3867,09*	*4553,03*	*5348,89*	*6271,32*	*7339,21*	*8573,97*
271,95	**346,39**	**440,05**	**557,64**	**704,95**	**878,41**	**1081,03**	**1317,57**	**1593,57**	**1915,40**	**2290,41**	**2727,08**	**3235,13**	**3825,73**	**4511,67**	**5307,53**	**6229,96**	**7297,85**	**8532,61**
	177,88	*254,17*	*343,32*	*447,49*	*569,16*	*711,20*	*876,96*	*1070,30*	*1295,66*	*1558,18*	*1863,78*	*2219,25*	*2632,40*	*3112,14*	*3668,67*	*4313,61*	*5060,15*	*5923,24*
	199,37	**255,47**	**326,41**	**415,89**	**528,48**	**669,84**	**835,60**	**1028,94**	**1254,30**	**1516,82**	**1822,42**	**2177,89**	**2591,04**	**3070,78**	**3627,31**	**4272,24**	**5018,46**	**5881,87**
		102,82	*165,58*	*238,84*	*324,34*	*424,10*	*540,44*	*676,05*	*834,05*	*1018,03*	*1232,12*	*1481,06*	*1770,29*	*2106,06*	*2495,48*	*2946,66*	*3468,82*	*4072,40*
		144,12	**185,93**	**239,11**	**306,55**	**391,82**	**499,37**	**634,69**	**792,69**	**976,67**	**1190,76**	**1439,69**	**1728,93**	**2064,70**	**2454,12**	**2905,30**	**3427,46**	**4038,72**
			41,47	*93,15*	*153,40*	*223,63*	*305,46*	*400,77*	*511,75*	*640,88*	*791,07*	*965,62*	*1168,34*	*1403,58*	*1676,32*	*1992,21*	*2357,70*	*2780,08*
			102,50	**133,26**	**172,65**	**222,91**	**286,84**	**367,91**	**470,39**	**599,52**	**749,71**	**924,26**	**1126,98**	**1362,22**	**1634,96**	**1950,85**	**2316,34**	**2738,72**
				-8,57	*34,05*	*83,66*	*141,39*	*208,57*	*286,70*	*377,54*	*483,11*	*605,72*	*748,03*	*913,09*	*1104,35*	*1325,78*	*1581,88*	*1877,74*
				71,53	**93,81**	**122,57**	**159,54**	**206,89**	**267,34**	**344,23**	**441,75**	**564,36**	**706,67**	**871,72**	**1062,99**	**1284,42**	**1540,52**	**1836,38**
					-49,29	*-14,08*	*26,83*	*74,36*	*129,56*	*193,67*	*268,09*	*354,43*	*454,56*	*570,60*	*704,98*	*860,46*	*1040,18*	*1247,69*
					48,84	**64,68**	**85,30**	**112,05**	**146,59**	**191,03**	**247,97**	**320,68**	**413,20**	**529,24**	**663,62**	**819,10**	**998,82**	**1206,33**
						-82,32	*-53,16*	*-19,35*	*19,85*	*65,28*	*117,95*	*178,97*	*249,65*	*331,47*	*426,13*	*535,55*	*661,94*	*807,78*
						32,51	**43,52**	**58,01**	**76,99**	**101,73**	**133,84**	**175,35**	**228,78**	**297,28**	**384,77**	**494,19**	**620,58**	**766,41**
							-109,01	*-84,78*	*-56,76*	*-24,36*	*13,12*	*56,46*	*106,58*	*164,50*	*231,43*	*308,69*	*397,84*	*500,61*
							21,02	**28,48**	**38,40**	**51,56**	**68,89**	**91,63**	**121,31**	**159,89**	**209,78**	**274,05**	**356,48**	**459,25**
								-130,46	*-110,25*	*-86,95*	*-60,08*	*-29,08*	*6,68*	*47,92*	*95,48*	*150,29*	*213,44*	*286,13*
								13,13	**18,03**	**24,64**	**33,50**	**45,34**	**61,04**	**81,79**	**109,04**	**144,68**	**191,03**	**251,04**
									-147,60	*-130,66*	*-111,19*	*-88,81*	*-63,08*	*-33,49*	*0,55*	*39,69*	*84,68*	*136,38*
									7,89	**10,99**	**15,24**	**21,02**	**28,84**	**39,38**	**53,47**	**72,24**	**97,07**	**129,76**
										-161,17	*-146,87*	*-130,52*	*-111,78*	*-90,32*	*-65,73*	*-37,53*	*-5,22*	*31,82*
										4,53	**6,41**	**9,03**	**12,65**	**17,63**	**24,45**	**33,71**	**46,22**	**63,01**
											-171,79	*-159,64*	*-145,79*	*-130,01*	*-112,01*	*-91,46*	*-67,99*	*-41,19*
											2,46	**3,55**	**5,09**	**7,25**	**10,28**	**14,50**	**20,34**	**28,36**
												-179,97	*-169,54*	*-157,72*	*-144,32*	*-129,11*	*-111,82*	*-92,17*
												1,26	**1,85**	**2,70**	**3,92**	**5,67**	**8,15**	**11,64**
													-186,12	*-177,07*	*-166,88*	*-155,40*	*-142,42*	*-127,77*
													0,60	**0,89**	**1,33**	**1,98**	**2,92**	**4,28**
														-190,58	*-182,64*	*-173,75*	*-163,79*	*-152,62*
														0,26	**0,40**	**0,61**	**0,92**	**1,39**
															-193,64	*-186,57*	*-178,71*	*-169,97*
															0,10	**0,16**	**0,25**	**0,38**
																-195,52	*-189,13*	*-182,09*
																0,03	**0,06**	**0,09**
																	-196,41	*-190,55*
																	0,01	**0,02**
																		-196,46

Thousand separator the dot (.).
Decimal separator the comma (,).
Top bold numbers are NR.
Bottom numbers are adjusted option values.
Option to exercise is exercised where the option value is not zero.
Red nodes, where the rational decision would be to invest.

Table B.5 *Adjusted real options value binomial tree for SSAD (million 2010 USD): continued*

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
9999,76	*11643,73*	*13536,30*	*15711,32*	*18206,26*	*21062,32*	*24324,39*	*28040,92*	*32263,55*	*37046,41*	*42445,14*	*48515,25*	*55309,92*	*62876,83*	*71253,86*	*80463,29*
9958,40	**11602,37**	**13494,94**	**15669,96**	**18164,90**	**21020,96**	**24283,03**	**27999,56**	**32222,19**	**37005,05**	**42403,78**	**48473,89**	**55268,56**	**62835,47**	**71212,50**	**80421,93**
6919,75	*8068,65*	*9391,17*	*10910,95*	*12654,15*	*14649,55*	*16928,49*	*19524,81*	*22474,55*	*25815,53*	*29586,58*	*33826,47*	*38572,35*	*43857,49*	*49708,36*	*56140,51*
6878,39	**8027,29**	**9349,81**	**10869,59**	**12612,79**	**14608,19**	**16887,13**	**19483,45**	**22433,19**	**25774,16**	**29545,22**	**33785,11**	**38530,98**	**43816,13**	**49667,00**	**56099,15**
4769,18	*5572,40*	*6496,89*	*7559,16*	*8777,48*	*10171,93*	*11764,42*	*13578,56*	*15639,53*	*17973,73*	*20608,28*	*23570,26*	*26885,59*	*30577,53*	*34664,55*	*39157,51*
4727,82	**5531,04**	**6455,53**	**7517,80**	**8736,12**	**10130,57**	**11723,06**	**13537,20**	**15598,72**	**17932,37**	**20566,92**	**2358,90**	**26844,23**	**30536,17**	**34623,19**	**39116,15**
3267,57	*3829,43*	*4476,00*	*5218,82*	*6070,65*	*7045,50*	*8158,68*	*9426,68*	*10867,08*	*12498,32*	*14339,33*	*16409,02*	*18725,50*	*21305,00*	*24160,44*	*27299,39*
3226,21	**3788,07**	**4434,64**	**5177,46**	**6029,29**	**7004,14**	**8117,32**	**9385,32**	**10825,72**	**12456,95**	**14297,96**	**16367,65**	**18684,13**	**21263,64**	**24119,07**	**27258,02**
2219,10	*2612,43*	*3064,95*	*3584,72*	*4180,64*	*4862,52*	*5641,04*	*6527,70*	*7534,79*	*8675,19*	*9962,12*	*11408,79*	*13027,83*	*14830,60*	*16826,10*	*19019,63*
2177,74	**2571,07**	**3023,59**	**3543,36**	**4139,28**	**4821,16**	**5599,67**	**6486,34**	**7493,43**	**8633,83**	**9920,76**	**11367,43**	**12986,47**	**14789,24**	**16784,74**	**18978,27**
1487,02	*1762,68*	*2079,70*	*2443,73*	*2860,98*	*3338,29*	*3883,13*	*4503,53*	*5208,07*	*6005,75*	*6905,81*	*7917,45*	*9049,53*	*10309,95*	*11705,01*	*13238,42*
1445,66	**1721,32**	**2038,34**	**2402,37**	**2819,62**	**3296,93**	**3841,76**	**4462,17**	**5166,71**	**5964,39**	**6864,45**	**7876,09**	**9008,17**	**10268,59**	**11663,65**	**13197,06**
975,86	*1169,35*	*1391,77*	*1647,05*	*1939,54*	*2274,02*	*2655,69*	*3090,18*	*3583,48*	*4141,86*	*4771,78*	*5479,68*	*6271,74*	*7153,47*	*8129,29*	*9201,78*
934,50	**1127,99**	**1350,41**	**1605,69**	**1898,18**	**2232,66**	**2614,33**	**3048,82**	**3542,12**	**4100,50**	**4730,42**	**5438,32**	**6230,38**	**7112,11**	**8087,93**	**9160,42**
618,95	*755,07*	*911,43*	*1090,78*	*1296,16*	*1530,91*	*1798,66*	*2103,33*	*2449,13*	*2840,42*	*3281,73*	*3777,55*	*4332,19*	*4949,51*	*5632,60*	*6383,26*
577,59	**713,71**	**870,07**	**1049,42**	**1254,80**	**1489,55**	**1757,29**	**2061,97**	**2407,77**	**2799,06**	**3240,37**	**3736,19**	**4290,30**	**4908,15**	**5591,24**	**6341,89**
369,74	*465,80*	*576,04*	*702,38*	*846,93*	*1012,04*	*1200,24*	*1414,28*	*1657,09*	*1931,72*	*2241,33*	*2589,06*	*2977,93*	*3410,63*	*3889,32*	*4415,26*
328,38	**424,17**	**534,68**	**661,02**	**805,57**	**970,68**	**1158,88**	**1372,92**	**1615,72**	**1890,36**	**2199,97**	**2547,70**	**2936,56**	**3369,27**	**3847,96**	**4373,90**
195,73	*263,83*	*341,86*	*431,18*	*533,27*	*649,75*	*782,41*	*933,16*	*1104,05*	*1297,23*	*1514,88*	*1759,21*	*2032,33*	*2336,13*	*2672,10*	*3041,14*
172,55	**228,29**	**300,50**	**389,82**	**491,91**	**608,39**	**741,05**	**891,80**	**1062,69**	**1255,86**	**1473,25**	**1717,85**	**1990,97**	**224,77**	**2630,74**	**2999,78**
74,24	*122,80*	*178,35*	*241,82*	*314,25*	*396,79*	*490,66*	*597,23*	*717,91*	*854,20*	*1007,65*	*1179,79*	*1372,09*	*1585,88*	*1822,20*	*2081,69*
85,43	**115,18**	**154,40**	**205,84**	**272,89**	**355,43**	**449,30**	**555,87**	**676,55**	**812,84**	**966,29**	**1138,43**	**1330,73**	**1544,51**	**1780,84**	**2040,33**
-10,60	*24,33*	*64,18*	*109,60*	*161,33*	*220,16*	*286,96*	*362,67*	*448,29*	*544,87*	*653,48*	*775,21*	*911,08*	*1062,02*	*1228,77*	*1411,76*
39,31	**54,16**	**74,18**	**100,99**	**136,63**	**183,74**	**245,60**	**321,31**	**406,93**	**503,51**	**612,12**	**733,85**	**869,72**	**1020,66**	**1187,41**	**1370,40**
-69,83	*-44,42*	*-15,54*	*17,28*	*54,55*	*96,83*	*144,72*	*198,89*	*260,03*	*328,88*	*406,19*	*492,72*	*589,19*	*696,25*	*814,41*	*943,99*
16,54	**23,36**	**32,79**	**45,73**	**63,37**	**87,24**	**119,29**	**162,05**	**218,67**	**287,52**	**364,83**	**451,36**	**547,83**	**654,89**	**773,05**	**902,63**
-111,19	*-92,43*	*-71,20*	*-47,18*	*-20,00*	*10,72*	*45,41*	*84,53*	*128,58*	*178,07*	*233,53*	*295,48*	*364,44*	*440,85*	*525,10*	*617,38*
6,25	**9,07**	**13,09**	**18,76**	**26,71**	**37,78**	**53,06**	**74,00**	**102,46**	**140,83**	**192,16**	**254,12**	**323,08**	**399,49**	**483,74**	**576,02**
-140,07	*-125,95*	*-110,06*	*-92,18*	*-72,06*	*-49,41*	*-23,93*	*4,69*	*36,80*	*72,77*	*112,96*	*157,76*	*207,50*	*262,53*	*323,09*	*389,33*
2,08	**3,11**	**4,62**	**6,81**	**10,00**	**14,58**	**21,11**	**30,36**	**43,33**	**61,37**	**86,23**	**120,19**	**166,14**	**221,17**	**281,73**	**347,97**
-160,23	*-149,35*	*-137,20*	*-123,61*	*-108,41*	*-91,39*	*-72,35*	*-51,07*	*-27,29*	*-0,76*	*28,78*	*61,59*	*97,93*	*138,02*	*182,04*	*230,10*
0,60	**0,92**	**1,40**	**2,14**	**3,24**	**4,88**	**7,30**	**10,86**	**16,05**	**23,53**	**34,25**	**49,43**	**70,73**	**100,25**	**140,67**	**188,74**
-174,31	*-165,70*	*-156,15*	*-145,55*	*-133,78*	*-120,70*	*-106,16*	*-89,99*	*-72,03*	*-52,09*	*-30,00*	*-5,55*	*21,42*	*51,08*	*83,55*	*118,92*
0,14	**0,23**	**0,36**	**0,56**	**0,88**	**1,37**	**2,12**	**3,28**	**5,02**	**7,64**	**11,56**	**17,37**	**25,90**	**38,31**	**56,21**	**81,75**
-184,14	*-177,11*	*-169,38*	*-160,88*	*-151,51*	*-141,17*	*-129,77*	*-117,17*	*-103,28*	*-87,94*	*-71,04*	*-52,43*	*-32,00*	*-9,63*	*14,78*	*41,29*
0,03	**0,05**	**0,07**	**0,12**	**0,19**	**0,31**	**0,50**	**0,80**	**1,27**	**2,01**	**3,17**	**4,96**	**7,71**	**11,90**	**18,22**	**27,68**
-191,00	*-185,07*	*-178,62*	*-171,57*	*-163,88*	*-155,46*	*-146,25*	*-136,15*	*-125,09*	*-112,97*	*-99,69*	*-85,17*	*-69,30*	*-52,01*	*-33,23*	*-12,92*

Table B.5 *Adjusted real options value binomial tree for SSAD (million 2010 USD): continued*

0,00	**0,01**	**0,01**	**0,02**	**0,03**	**0,05**	**0,09**	**0,15**	**0,25**	**0,41**	**0,67**	**1,10**	**1,78**	**2,88**	**4,63**	**7,40**
-195,80	*-190,64*	*-185,07*	*-179,04*	*-172,52*	*-165,44*	*-157,76*	*-149,41*	*-140,32*	*-130,44*	*-119,70*	*-108,02*	*-95,35*	*-81,61*	*-66,76*	*-50,77*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,01**	**0,01**	**0,02**	**0,03**	**0,06**	**0,10**	**0,17**	**0,29**	**0,49**	**0,83**	**1,40**
	-194,52	*-189,57*	*-184,26*	*-178,55*	*-172,41*	*-165,79*	*-158,66*	*-150,96*	*-142,65*	*-133,67*	*-123,98*	*-113,53*	*-102,27*	*-90,17*	*-77,19*
	0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,01**	**0,01**	**0,02**	**0,03**	**0,05**	**0,09**	**0,16**
		-192,72	*-187,90*	*-182,76*	*-177,27*	*-171,40*	*-165,12*	*-158,39*	*-151,17*	*-143,43*	*-135,13*	*-126,23*	*-116,70*	*-106,51*	*-95,64*
		0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,01**
			-190,44	*-185,70*	*-180,67*	*-175,32*	*-169,63*	*-163,57*	*-157,12*	*-150,24*	*-142,91*	*-135,10*	*-126,78*	*-117,93*	*-108,53*
			0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
				-187,76	*-183,04*	*-178,06*	*-172,78*	*-167,19*	*-161,27*	*-154,99*	*-148,34*	*-141,29*	*-133,81*	*-125,90*	*-117,52*
				0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
					-184,70	*-179,97*	*-174,98*	*-169,72*	*-164,17*	*-158,31*	*-152,13*	*-145,61*	*-138,72*	*-131,46*	*-123,81*
					0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
						-181,30	*-176,51*	*-171,48*	*-166,20*	*-160,63*	*-154,78*	*-148,63*	*-142,15*	*-135,34*	*-128,19*
						0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
							-177,59	*-172,72*	*-167,61*	*-162,25*	*-156,63*	*-150,73*	*-144,55*	*-138,06*	*-131,25*
							0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
								-173,58	*-168,60*	*-163,38*	*-157,92*	*-152,20*	*-146,22*	*-139,95*	*-133,39*
								0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
									-169,29	*-164,17*	*-158,82*	*-153,23*	*-147,39*	*-141,27*	*-134,88*
									0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
										-164,72	*-159,45*	*-153,95*	*-148,20*	*-142,20*	*-135,93*
										0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
											-159,89	*-154,45*	*-148,77*	*-142,84*	*-136,65*
											0,00	**0,00**	**0,00**	**0,00**	**0,00**
												-154,80	*-149,17*	*-143,29*	*-137,16*
												0,00	**0,00**	**0,00**	**0,00**
													-149,44	*-143,61*	*-137,52*
													0,00	**0,00**	**0,00**
														-143,83	*-137,77*
														0,00	**0,00**
															-137,94
															0,00

Table B.5 *Adjusted real options value binomial tree for SSAD (million 2010 USD): continued*

35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
90504,05	*101341,51*	*112894,19*	*125016,36*	*137475,73*	*149924,64*	*161863,34*	*172593,07*	*181156,60*	*186262,89*	*186191,96*	*178675,18*	*160744,74*	*128545,00*	*77096,32*
90462,68	**101300,15**	**112852,82**	**124975,00**	**137434,37**	**149883,28**	**161821,98**	**172551,71**	**181115,24**	**186221,52**	**186150,60**	**178633,82**	**160703,38**	**128503,64**	**77054,96**
63153,20	*70722,26*	*78790,78*	*87257,04*	*95958,82*	*104653,40*	*112991,82*	*120486,20*	*126468,17*	*130036,28*	*129989,60*	*124744,08*	*112227,51*	*89747,75*	*53827,84*
63111,84	**70680,90**	**78749,42**	**87215,68**	**95917,46**	**104612,04**	**112950,46**	**120444,84**	**126426,81**	**129994,92**	**129948,24**	**124702,72**	**112186,15**	**89706,39**	**53786,48**
44055,90	*49342,84*	*54978,61*	*60892,17*	*66970,28*	*73043,45*	*78868,03*	*84103,38*	*88282,82*	*90776,92*	*90747,16*	*87087,52*	*78351,10*	*62658,16*	*37580,98*
44014,53	**49301,48**	**54937,25**	**60850,81**	**66928,92**	**73002,09**	**78826,67**	**84062,02**	**88241,45**	**90732,56**	**90705,80**	**87046,16**	**78309,74**	**62616,80**	**37539,62**
30721,49	*34414,98*	*38352,12*	*42483,30*	*46729,47*	*50972,28*	*55041,62*	*58699,63*	*61620,48*	*63364,67*	*63346,73*	*60794,40*	*54697,41*	*43743,27*	*26236,86*
30680,13	**34373,62**	**38310,76**	**42441,94**	**46688,11**	**50930,92**	**55000,26**	**58658,27**	**61579,11**	**63323,31**	**63305,37**	**60753,04**	**54656,05**	**43701,91**	**26195,50**
21410,95	*23991,84*	*26742,93*	*29629,60*	*32596,64*	*35561,43*	*38405,19*	*40961,85*	*43003,90*	*44224,49*	*44214,80*	*42435,63*	*38181,59*	*30536,24*	*18316,00*
21369,59	**23950,48**	**26701,57**	**29588,24**	**32555,28**	**35520,07**	**38363,83**	**40920,49**	**42962,54**	**44183,13**	**44173,44**	**42394,27**	**38140,23**	**30494,88**	**18274,64**
14910,01	*16714,04*	*18636,99*	*20654,69*	*22728,60*	*24801,04*	*26789,06*	*28576,72*	*30005,17*	*30860,15*	*30856,23*	*29616,91*	*26649,67*	*21314,63*	*12785,38*
14868,65	**16672,67**	**18595,63**	**20613,33**	**22687,24**	**24759,67**	**26747,70**	**28535,36**	**29963,81**	**30818,79**	**30814,86**	**29575,55**	**26608,30**	**21273,27**	**12744,02**
10370,82	*11632,42*	*12977,14*	*14388,10*	*15838,40*	*17287,76*	*18678,27*	*19928,99*	*20929,00*	*21528,70*	*21528,80*	*20666,43*	*18597,68*	*14875,78*	*8923,71*
10329,46	**11591,06**	**12935,78**	**14346,74**	**15797,04**	**17246,40**	**18636,91**	**19887,63**	**20887,64**	**21487,34**	**21487,44**	**20625,07**	**18556,32**	**14834,42**	**8882,35**
7201,41	*8084,26*	*9025,24*	*10012,55*	*11027,42*	*12041,72*	*13015,04*	*13890,85*	*14591,70*	*15013,16*	*15016,07*	*14416,89*	*12975,50*	*10379,95*	*6227,36*
7160,05	**8042,90**	**8983,88**	**9971,19**	**10986,06**	**12000,36**	**12973,68**	**13849,49**	**14550,34**	**14971,80**	**14974,71**	**14375,53**	**12934,14**	**10338,59**	**6186,00**
4988,41	*5606,81*	*6265,88*	*6957,39*	*7668,23*	*8378,76*	*9060,78*	*9674,81*	*10166,78*	*10463,79*	*10468,66*	*10053,25*	*9049,90*	*7240,81*	*4344,67*
4947,05	**5565,45**	**6224,52**	**6916,03**	**7626,86**	**8337,40**	**9019,42**	**9633,45**	**10125,42**	**10422,43**	**10427,30**	**10011,89**	**9008,54**	**7199,45**	**4303,31**
3443,22	*3876,97*	*4339,20*	*4824,17*	*5322,72*	*5821,16*	*6299,77*	*6731,02*	*7077,15*	*7287,26*	*7293,50*	*7006,40*	*6308,91*	*5048,95*	*3030,11*
3401,86	**3835,61**	**4297,84**	**4782,81**	**5281,36**	**5779,79**	**6258,41**	**6689,66**	**7035,79**	**7245,89**	**7252,14**	**6965,04**	**6267,55**	**5007,59**	**2988,75**
2364,31	*2669,14*	*2993,93*	*3334,68*	*3685,01*	*4035,35*	*4371,94*	*4675,57*	*4919,86*	*5069,29*	*5076,49*	*4878,99*	*4395,06*	*3518,52*	*2112,25*
2322,95	**2627,78**	**2952,57**	**3293,32**	**3643,65**	**3993,98**	**4330,58**	**4634,20**	**4878,50**	**5027,93**	**5035,13**	**4837,63**	**4353,70**	**3477,16**	**2070,88**
1610,99	*1825,79*	*2054,61*	*2294,67*	*2541,50*	*2788,43*	*3025,87*	*3240,38*	*3413,57*	*3520,63*	*3528,50*	*3393,55*	*3058,74*	*2449,92*	*1471,36*
1569,62	**1784,43**	**2013,25**	**2253,31**	**2500,14**	**2747,07**	**2984,50**	**3199,02**	**3372,21**	**3479,27**	**3487,13**	**3352,19**	**3017,38**	**2408,56**	**1430,00**
1084,98	*1236,93*	*1398,75*	*1568,50*	*1743,06*	*1917,79*	*2085,99*	*2238,28*	*2361,82*	*2439,30*	*2447,63*	*2356,37*	*2125,67*	*1703,79*	*1023,87*
1043,62	**1195,57**	**1357,39**	**1527,14**	**1701,70**	**1876,43**	**2044,63**	**2196,92**	**2320,46**	**2397,94**	**2406,27**	**2315,09**	**2084,31**	**1662,43**	**982,51**
717,71	*825,77*	*940,80*	*1061,46*	*1185,57*	*1309,88*	*1429,73*	*1538,58*	*1627,46*	*1684,28*	*1692,94*	*1632,17*	*1474,18*	*1182,81*	*711,41*
676,35	**784,41**	**899,44**	**1020,10**	**1144,21**	**1268,52**	**1388,37**	**1497,22**	**1586,10**	**1642,92**	**1651,58**	**1590,81**	**1432,82**	**1141,45**	**670,05**
461,27	*538,68*	*621,05*	*707,43*	*796,30*	*885,42*	*971,51*	*1050,02*	*1114,70*	*1157,10*	*1165,98*	*1126,51*	*1019,28*	*819,05*	*493,25*
419,91	**497,32**	**579,69**	**666,06**	**754,94**	**844,06**	**930,15**	**1008,66**	**1073,34**	**1115,74**	**1124,62**	**1085,15**	**977,92**	**777,69**	**451,89**
282,21	*338,23*	*397,79*	*460,23*	*524,51*	*589,04*	*651,57*	*708,90*	*756,67*	*789,00*	*798,05*	*773,45*	*701,65*	*565,06*	*340,92*
240,85	**296,87**	**356,43**	**418,87**	**483,15**	**547,68**	**610,21**	**667,54**	**715,31**	**747,64**	**756,69**	**732,09**	**660,29**	**523,70**	**299,56**
157,19	*198,27*	*241,90*	*287,63*	*334,73*	*382,10*	*428,17*	*470,71*	*506,68*	*531,99*	*541,14*	*526,92*	*479,87*	*387,71*	*234,55*
117,83	**156,90**	**200,53**	**246,27**	**293,37**	**340,74**	**386,81**	**429,35**	**465,32**	**490,62**	**499,78**	**485,56**	**438,51**	**346,35**	**193,19**
69,89	*100,54*	*133,05*	*167,11*	*202,22*	*237,61*	*272,19*	*304,40*	*332,14*	*352,53*	*361,76*	*354,79*	*325,02*	*263,88*	*160,29*
41,68	**62,15**	**91,69**	**125,75**	**160,86**	**196,25**	**210,82**	**263,04**	**290,77**	**311,17**	**320,40**	**313,43**	**283,66**	**222,52**	**118,93**
8,94	*32,30*	*57,05*	*82,96*	*109,70*	*136,72*	*163,27*	*188,28*	*210,26*	*227,22*	*236,51*	*234,60*	*216,90*	*177,42*	*108,43*

Table B.5 *Adjusted real options value binomial tree for SSAD (million 2010 USD): continued*

11,74	**18,49**	**28,88**	**44,66**	**68,33**	**95,36**	**121,91**	**146,92**	**168,90**	**185,86**	**195,15**	**193,24**	**175,54**	**136,06**	**67,07**
-33,62	*-15,34*	*3,98*	*24,21*	*45,09*	*66,28*	*87,23*	*107,20*	*125,16*	*139,73*	*149,05*	*150,68*	*141,40*	*117,05*	*72,23*
2,34	**3,90**	**6,47**	**10,68**	**17,50**	**28,46**	**45,86**	**65,83**	**83,80**	**98,37**	**107,69**	**109,32**	**100,04**	**75,69**	**30,86**
-63,33	*-48,61*	*-33,07*	*-16,82*	*-0,02*	*17,09*	*34,13*	*50,58*	*65,74*	*78,64*	*87,99*	*92,08*	*88,69*	*74,90*	*46,94*
0,28	**0,49**	**0,86**	**1,51**	**2,64**	**4,62**	**8,06**	**14,03**	**24,38**	**37,28**	**46,63**	**50,72**	**47,33**	**33,53**	**5,58**
-84,08	*-71,84*	*-58,95*	*-45,47*	*-31,51*	*-17,25*	*-2,95*	*11,05*	*24,25*	*35,99*	*45,35*	*51,17*	*51,88*	*45,46*	*29,29*
0,01	**0,02**	**0,04**	**0,08**	**0,15**	**0,27**	**0,49**	**0,89**	**1,62**	**2,95**	**5,38**	**9,81**	**10,52**	**4,10**	**0,00**
-98,57	*-88,06*	*-77,01*	*-65,47*	*-53,50*	*-41,23*	*-28,84*	*-16,55*	*-4,71*	*6,20*	*15,58*	*22,60*	*26,18*	*24,91*	*16,97*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-108,69	*-99,38*	*-89,62*	*-79,43*	*-68,86*	*-57,98*	*-46,91*	*-35,82*	*-24,94*	*-14,59*	*-5,20*	*2,66*	*8,24*	*10,56*	*8,36*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-115,75	*-107,29*	*-98,43*	*-89,18*	*-79,58*	*-69,67*	*-59,53*	*-49,28*	*-39,06*	*-29,11*	*-19,72*	*-11,27*	*-4,29*	*0,54*	*2,35*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-120,68	*-112,81*	*-104,58*	*-95,99*	*-87,07*	*-77,83*	*-68,34*	*-58,67*	*-48,93*	*-39,25*	*-29,85*	*-20,99*	*-13,04*	*-6,45*	*-1,84*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-124,13	*-116,67*	*-108,87*	*-100,75*	*-92,29*	*-83,53*	*-74,50*	*-65,23*	*-55,81*	*-46,33*	*-36,93*	*-27,78*	*-19,15*	*-11,34*	*-4,77*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-126,53	*-119,36*	*-111,87*	*-104,06*	*-95,94*	*-87,51*	*-78,79*	*-69,81*	*-60,62*	*-51,27*	*-41,87*	*-32,53*	*-23,41*	*-14,75*	*-6,82*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-128,21	*-121,24*	*-113,96*	*-106,38*	*-98,49*	*-90,29*	*-81,79*	*-73,01*	*-63,98*	*-54,72*	*-45,32*	*-35,84*	*-26,39*	*-17,13*	*-8,25*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-129,38	*-122,55*	*-115,43*	*-108,00*	*-100,27*	*-92,23*	*-83,89*	*-75,25*	*-66,32*	*-57,13*	*-47,73*	*-38,15*	*-28,47*	*-18,79*	*-9,24*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-130,20	*-123,47*	*-116,45*	*-109,13*	*-101,51*	*-93,59*	*-85,35*	*-76,80*	*-67,96*	*-58,82*	*-49,41*	*-39,76*	*-29,92*	*-19,95*	*-9,94*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-130,77	*-124,11*	*-117,16*	*-109,92*	*-102,38*	*-94,53*	*-86,37*	*-77,89*	*-69,10*	*-59,99*	*-50,58*	*-40,89*	*-30,94*	*-20,76*	*-10,43*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-131,17	*-124,55*	*-117,66*	*-110,47*	*-102,99*	*-95,19*	*-87,08*	*-78,65*	*-69,90*	*-60,81*	*-51,40*	*-41,68*	*-31,64*	*-21,33*	*-10,77*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-131,45	*-124,87*	*-118,00*	*-110,86*	*-103,41*	*-95,65*	*-87,58*	*-79,18*	*-70,45*	*-61,39*	*-51,98*	*-42,22*	*-32,14*	*-21,72*	*-11,00*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-131,64	*-125,08*	*-118,25*	*-111,12*	*-103,70*	*-95,98*	*-87,93*	*-79,56*	*-70,84*	*-61,79*	*-52,38*	*-42,61*	*-32,48*	*-22,00*	*-11,17*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
-131,78	*-125,24*	*-118,42*	*-111,31*	*-103,91*	*-96,20*	*-88,17*	*-79,81*	*-71,11*	*-62,06*	*-52,65*	*-42,88*	*-32,72*	*-22,19*	*-11,28*
0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
	-125,34	*-118,53*	*-111,44*	*-104,05*	*-96,36*	*-88,34*	*-79,99*	*-71,30*	*-62,26*	*-52,85*	*-43,06*	*-32,89*	*-22,33*	*-11,36*
	0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
		-118,62	*-111,53*	*-104,15*	*-96,47*	*-88,46*	*-80,12*	*-71,44*	*-62,40*	*-52,99*	*-43,19*	*-33,01*	*-22,42*	*-11,42*

Table B.5 *Adjusted real options value binomial tree for SSAD (million 2010 USD): continued*

0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
	-111,60	*-104,22*	*-96,54*	*-88,54*	*-80,21*	*-71,53*	*-62,49*	*-53,08*	*-43,28*	*-33,09*	*-22,49*	*-11,46*
	0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
		-104,27	*-96,60*	*-88,60*	*-80,27*	*-71,59*	*-62,56*	*-53,15*	*-43,35*	*-33,15*	*-22,53*	*-11,49*
		0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
			-96,63	*-88,64*	*-80,31*	*-71,64*	*-62,60*	*-53,19*	*-43,39*	*-33,19*	*-22,57*	*-11,51*
			0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
				-88,67	*-80,34*	*-71,67*	*-62,64*	*-53,23*	*-43,42*	*-33,22*	*-22,59*	*-11,52*
				0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
					-80,36	*-71,69*	*-62,66*	*-53,25*	*-43,45*	*-33,24*	*-22,60*	*-11,53*
					0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
						-71,71	*-62,67*	*-53,26*	*-43,46*	*-33,25*	*-22,61*	*-11,54*
						0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
							-62,69	*-53,27*	*-43,47*	*-33,26*	*-22,62*	*-11,54*
							0,00	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
								-53,28	*-43,48*	*-33,27*	*-22,63*	*-11,54*
								0,00	**0,00**	**0,00**	**0,00**	**0,00**
									-43,48	*-33,27*	*-22,63*	*-11,55*
									0,00	**0,00**	**0,00**	**0,00**
										-33,27	*-22,63*	*-11,55*
										0,00	**0,00**	**0,00**
											-22,63	*-11,55*
											0,00	**0,00**
												-11,55
												0,00