Determining the Extent of Economical Sustainability of a Case Study Milk Farm in Bosnia and Herzegovina Based on the Real Options Model

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Abstract: The aim of this research was to determine a sustainable economic model of a milk farm in Bosnia and Herzegovina through the possibility of reorientation of raw milk production into cheese on-farm processing. All investment costs, annual production costs, production quantities, prices and annual income were collected through an unstructured questionnaire. The case study farm, originally engaged in milk production, reoriented itself to processing milk into several products. A cost–benefit analysis was applied for the 14-year project lifetime, as well as the Black–Scholes and binomial models of real options evaluation for shifting to cheese production in the fourth year of the project. The milk production farm is economically inefficient, and the investment project is unacceptable, resulting in negative net present value under assumed typical production parameters, and the payback period is longer than the project lifetime. The cheese production option value is positive according to the Black–Scholes and binominal models. Both real options models confirmed that processing milk into cheese is sustainable long-term and economically.

Keywords: milk; cheese; Bosnia and Herzegovina; NPV; real options; sustainable production

1. Introduction

Every potential business idea contains a dose of risk and uncertainty. To reduce these risks and uncertainties and determine the positive or negative effects of business more precisely, every project manager seeks to conduct a cost–benefit analysis with net present value and internal rate of return indicators. This analysis answers the questions of potential investors, whether the business is profitable and economically justified or not. However, like any method, it has its ambiguities and shortcomings, which are reflected in the inability to evaluate new options for diversifying of one’s own production. Discounted cash flow accounts for only the downside of the risk without considering the rewards and does not take into consideration the contingent decisions available and the managerial flexibility to act on those decisions because of the value of the future flexibility to expand, contract or abandon [1]. Traditional approaches to capital budgeting, such as discounted cash-flows, cannot entirely capture the project value for different reasons: it is assumed that the investment decision is irreversible, interactions between today’s decisions and future decisions are not considered and investment in assets seems to be passive (management does not interfere during the life of the project) [2]. For these reasons, the theory of real options evaluation was developed to be a helpful tool in the situation when the strategic project value includes not just the current economic features but also opportunities related to the basic model [3]. Another study stated that real options analysis allows for making better investment decisions as the value of flexibility of investment into the initial evaluation of that investment can be incorporated [4].
Several other authors have dealt with the evaluation of realistic options in agricultural research. Na et al. [5] conducted a study that presents a real-options-based framework for investment in land and water solar power projects in the idle areas of agricultural dams. Tzouramani and Matas [6] investigated the attempts to examine the effects of income variability upon the decision of adopting or not environmentally friendly production systems to evaluate the organic financial incentives to farmers by introducing the real options methodology. Pažek et al. [7] investigated the development and application of two real options models: Black–Scholes and binomial option models in the case of on-farm old wheat variety production. Hadelan et al. [8] conducted the appliance of option quantification on a model of plum and plum brandy production as an extension activity. Some authors [9] demonstrated the utility of the real options approach to irrigation dam investment analysis with the main objective to show how to calculate the option values of selected options that may be available to managers of irrigation dam investments. The application of the real options approach (ROA) is justified if an investment is characterized by uncertainty of returns, irreversibility of the investment costs and flexibility regarding investment timing [10]. An investment in modern dairy farming has these properties. Moreover, Xavier et al. (2020) mentioned another reason for applying the real options approach in addition to the traditional NPV methodology. The authors stated that traditional methodologies do not consider the uncertainties related to this activity (milk production) [11]. According to Ruten et al. (2018), in corporate investment decisions and strategic management under uncertainty, real options theory can be used to clarify the problem structure (e.g., the different options, management decisions and their timing) to appraise the options (i.e., estimating the net present value (NPV) of each option) and plan the implementation (i.e., a strategic timeline that defines at which moment what option should be executed) [12]. Moreover, other authors applied ROA methodology in milk production [13,14].

The livestock sector is socially and politically very significant; e.g., it accounts for 40% of agricultural gross domestic product, employs 1.3 billion people and creates livelihoods for one billion of the world’s poor people [15]. Milk production cost is influenced by a large range of environmental factors, but the main ones are represented by feeding cost, labor cost, heifer for replacing culled cows, medicines and veterinary services, frozen semen from the highest breeding value bulls and artificial insemination service, depreciation of sheds and specific equipment, water and electricity costs and rental value of land owned by the milk farmer [16]. The economic and socio-economic conditions of the mountainous area, which represents a significant part of Bosnia and Herzegovina, provide the livestock and milk sector the character of the leading branch of agriculture in the country. The importance of this sector for Republic of Srpska agriculture is reflected in the fact that about 270 million liters of cow’s milk are produced annually, and there are currently about 200,000 cattle in RS [17]. Research regarding milk cattle farms in RS mentioned that the value gained from cattle breeding products accounts for more than 40% of the total agricultural production in the Republic of Srpska [18]. In the analysis from 2016, it was stated that there were about 126,500 milk cows in RS annually for the period between 2007 and 2014 [19]. The same authors emphasized that the problems of the milk sector in RS are lower milk production per cow compared to the world and European average, low marketability and the fact that more than 50% of the milk comes from small farms that have up to five cows. Moreover, according to the introductory considerations of Al Sidawi et al., 2021 [20], 75% of all the farms are small family farms, which are the backbone of the economy in countries that depend heavily on agriculture.

The world consumption of milk products is growing due to the increase in the human population and the influence of a large number of other factors. However, on the supply side, there are major problems for the producers of these products. Krizsan et al. (2021) considered that an initiative could be made by milk companies that should define and award sustainable milk farms, providing benefits according to a low input of human-edible feed, circular systems and good animal health and welfare [21]. Sustainable agriculture
approaches are economical in nature [22]. These approaches cost less because they use a low number of chemicals and produce high yields.

A key element of sustainable agriculture is the long-run profitability of the set of specific sustainable production practices comprising the farming system; i.e., to continue farming over a long period and ultimately transfer ownership of the farm to the next generation, the specific farming practices employed over the period must be profitable, at least in most years [23]. There are three different approaches to the sustainability of animal production. Economic sustainability through farmers’ net incomes, thus the viability of rural societies, ecological sustainability through decreased ecological footprints for the same production regarding natural resource use and emissions and social sustainability through improved food security [15,24]. The focus of this research is only on economic sustainability. The indicators of economic sustainability should be measured in a multi-year average (e.g., three-year average) because it better reflects the inter-annual variability regarding determinants of economic viability and principles of sustainability [25].

The main goal of this paper is to provide an economic assessment of milk production and milk processing based on the modeling parameters of a milk farm typical of Bosnia and Herzegovina. The specific goal of this analysis is the evaluation of the option of processing the raw milk into cheese and evaluation of the economical sustainability of a small milk farm in the circumstances of Bosnia and Herzegovina.

The research hypothesis is (H1):

Hypothesis 1 (H1). Diversification of the milk farm business in Bosnia and Herzegovina to milk processing into cheese is financially valuable.

In this way, we can expect better financial results compared to raw milk production for the milk industry.

2. Materials and Methods

Research framework consists of the following steps (Figure 1): (1) identification of the case study milk farm in BiH; (2) market data analysis and projection of traditional cash-flow (CF) model; (3) calculation of cash-flow efficiency of traditional farm model by cost–benefit dynamic analysis; (4) projection of on-farm diversification CF model; (5) further CF analysis by real options models; (6) recommendation for making decisions of sustainable farm investment.

2.1. Research Framework

The first step is conducted based on the data analysis of the structure of milk farms in Bosnia and Herzegovina and the identification of the milk farm model based on the number of milking cows. The category of market-oriented farms that sell milk to farm size of 6 to 10 milking cows was identified as the most common [26] and as a typical supplier of the milk industry, and further analysis was based on the model of a 10-cow farm. The newest data of the Ministry of Agriculture in the RS, one of the two BiH entities, confirmed that the average size of all farms that sell milk to dairies is 8.8 heads. A quarter of dairy herds have a size of 5–10 heads and these farms hold 21.2% of all dairy cows. The next 21% of cows are in herds of between 10 and 20 cows. It can be said that a farm with ten milking cows is a typical farm for the dairy sector in Bosnia and Herzegovina.

In the second step, the cash-flow projection was conducted for the case study milk farm. The parameters in the cash-flow model were set based on the combination of the case study method and market price analysis. An interview was conducted with an owner of a milk farm of indicated herd size that already followed investigated scenario of on-farm business diversification.

The third step was the calculation of the financial feasibility of the traditional scenario with the sale of milk. Traditional dynamic methods of CB analysis were applied (NPV, IRR, payback period).
The fourth step was the projection of the cash-flow model based on on-farm diversification of milk processing into milk products and their direct sale to customers.

The extended cash-flow model-based on-farm diversification was further analyzed by two real options models, the Black–Scholes model and the binomial model.

The last, sixth, step is a comparison and evaluation of results obtained in the third and fifth steps (optional models versus traditional CB analysis model) and recommends deciding if it is valuable for milk farm to invest in on-farm diversification of its business into on-farm milk processing.

Figure 1. Research framework steps.

2.2. Case Study Milk Farm in Bosnia and Herzegovina

The primary data were collected based on an unstructured questionnaire followed during an interview with a milk farmer in Bosnia and Herzegovina. This farmer was originally engaged in the production and selling of milk and then he reoriented, i.e., turned to milk processing into cheese, kefir and some other milk products. The farmer sells new products using a short value chain, by selling them on the farm, by personal delivery to the door of customers or by participating at fairs of local products. The case study farm has ten milking cows. The average milk yield per cow is 4575 L a year and the average milk price is EUR 0.37/L. This farm has three tractors with a power of 30–50 kW and produces most of the feed for livestock, and, for this reason, it has both basic and special machinery for tillage and harvesting, devices for processing and finishing livestock feed and its storage. The stock fund was formed by a combination of the purchase of imported heifers and own production of breeding heifers. Mostly, it is a combination of Czech Simmental and Holstein breeds. The milking method is open, with three movable milking machines and raw milk storage in lactofreezers. Stables and storage areas are mostly inherited from the previous generations with improvements and extensions. Mineral fertilizers are purchased by the farm from the market, while manure is used as a product from the farm. The costs that occur on this farm are mainly the costs of purchasing raw materials for the production
of animal feed and the purchase of animal feed that the farm does not produce, seasonal labor for the production of livestock feed, maintenance of agricultural machinery and tools, costs of small inventory, electricity, veterinary services and various analysis. The income of this farm comes from four sources; first, from the sale of milk to dairies, which are the greatest of all income, then the state subsidy, which represents up to 40% of the total raw milk price, income from the sale of calves and manure, which arises as a secondary product. The farm is managed by a young married couple, both of whom graduated from the Faculty of Agriculture, who also perform most of the work on the farm related to feeding the cattle, milking and feed preparing.

2.3. Net Present Value and Real Options Approach

The main method of this research is real options evaluation upgraded on the cost–benefit analysis of the investment in a small milk farm in Bosnia and Herzegovina. In addition to the traditional standard economic analysis, the paper includes an advanced analytical approach based on the analysis of real options, in this case, the processing of milk into cheese. A full cash-flow model was designed. The initial investment starts in 2022 with a project lifetime of 14 years. For input prices, as well as for output prices, their state in April 2022 has been used in the model. The basic investment processes were followed, starting with the investment in fixed assets and then adding the operational production costs during the project lifetime. Expenditures for gross salaries, depreciation and variable feed production costs were also calculated. An assessment of permanent working capital was performed and its value was incorporated into the cash-flow model. After the expenditure, the calculation of the revenue in milk production was conducted. Both financial and net cash-flows were derived from previous calculations.

The final phase of the analysis involves the computation of net present value, which represents the difference between discounted annual cash inflows and outflows increased by the initial value of the investment. The difference represents the total net financial gain or loss [27].

\[
\text{NPV} (S_0) = \sum_{t=1}^{n} \frac{V_t}{(1 + k)^t} - I
\]

where: \( V_t \) is net cash-flow (EUR), \( k \) is discount factor, \( t \) is period and \( I \) is investment cost.

The internal rate of return (IRR) is the discount rate that makes the NPV equal to zero, and, for this reason, it is also known as the break-even discount rate [28]. After using the trial and error procedure and finding the first positive NPV and the first negative NPV, the IRR will be calculated using the linear interpolation method.

\[
\text{IRR} = p_k + \frac{p_{k+1} - p_k}{\text{NSV}_{k+1} - \text{NSV}_k} \times (0 - \text{NSV})
\]

where: \( p_k \) is the discount rate when NPV is positive, \( p_{k+1} \) is the discount rate when NPV is negative, \( \text{NPV}_k \) for discount rate \( k \), \( \text{NPV}_{k+1} \) for discount rate \( k + 1 \) [29].

The payback period of the investment is the time point when all the money inflows are equal to all money outflows. This indicator will be calculated using the interpolation method.

After calculating indicators of the CB analysis, the methodology is expanded to analyzing the real options of the project that provide the possibility, but not the obligation, for additional investment after several years of the project lifetime

2.3.1. Black–Scholes Model (BS)

The revolution in the field of satisfactory equilibrium option pricing model happened in 1973 with the work of Robert C. Merton from Harvard University and Myron Scholes from Stanford University with the late Fischer Black, who received the Nobel Prize in Economics, and the title of the prize was “for a new method to determine the value of deriva-
Relation of a financial option is analogous to investment (real) option; i.e., the standard option pricing method can be used also in the investment analysis (in the valuation of the real option) without limitation [30]. In Table 1 the analogy of financial and real investment parameters will be compared.

Table 1. Parameters analogy—financial and real investment.

<table>
<thead>
<tr>
<th>Call Option</th>
<th>Variable</th>
<th>Investment Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock price</td>
<td>$S$</td>
<td>Present value of a project’s operating assets to be acquired</td>
</tr>
<tr>
<td>Exercise price</td>
<td>$X$</td>
<td>Expenditure required to acquire the project assets</td>
</tr>
<tr>
<td>Time to expiration</td>
<td>$t$</td>
<td>Length of time the decision may be deferred</td>
</tr>
<tr>
<td>The risk-free rate of return</td>
<td>$r_f$</td>
<td>Time value of money</td>
</tr>
<tr>
<td>Var. of returns on stock</td>
<td>$\sigma^2$</td>
<td>The riskiness of the project assets</td>
</tr>
</tbody>
</table>

Source: Adopted Leuhrman (1998) [31].

The Black–Scholes model based on stochastic calculus is as shown below [4]:

\[
\text{OV} = SN(d_1) - X/e^{rt} N(d_2)
\]

\[
d_1 = \frac{\ln(S/X) + (r + \frac{1}{2} \sigma^2) \cdot t}{\sigma \sqrt{t}}
\]

\[
d_2 = d_1 - \sigma \sqrt{t}
\]

(1)

where:

- **OV**—option value (EUR)
- **S**—the present value of cash-flows from optional investment (EUR)
- **$d_1$**—lognormal distribution of **$d_1$**
- **$d_2$**—lognormal distribution of **$d_2$**
- **X**—investment expenditure (EUR)
- **$r$**—annual risk-free continuously compounded rate (%)
- **$\sigma$**—annualized variance (risk) of the investment’s project
- **$t$**—period until investment (years)
- **$e^{rt}$**—the exponential term (2.71828)

Option value = $SN(d_1) -$ present value of X times $N(d_2)$

$N(d_1)$ and $N(d_2)$ represent the probability distributions. Values of $N(d_1)$ and $N(d_2)$ are obtained from normal probability distribution tables. They give us the probability that S or X will be below $d_1$ and $d_2$. In the BS model, they measure the risk associated with the volatility of the value of S.

2.3.2. Binomial Model

In 1979, Cox, Ross and Rubinstein released a new view of the valuation option. They thought that the mathematical tools employed in the Black–Scholes and Merton articles were quite advanced and tended to obscure the underlying economics [32]. They presented a simple discrete-time option pricing formula with fundamental economic principles of option valuation. The binomial option pricing model is based upon a simple formulation for the asset price process, in which the asset, in any period, can move to one of two possible prices [33]. The following 6 items are required to apply the binomial valuation method of real options [2]:

- **S**—underlying asset; its value (S) is calculated with the DCF method;
- **exercise price**—is the cost of implementing the project; the model is working under the assumption that this is constant in real terms and is affected only by inflation;
• time to maturity—is established as the period that an investor enjoys exclusivity for the analyzed project or at least has an important competitive advantage that allows him to defer the project without risking its achievement by another firm;
• risk-free rate—is represented by the expected rate of return for riskless security (treasury bill or treasury bond), with the same maturity as the real option;
• volatility of the underlying asset—it appears because of the errors associated with the estimation of the financial cash-flows and value of the underlying asset, and it is the most difficult element to appraise because the underlying asset is not traded
• dividend yield—delay of investment generates a loss of cash-flows for each year.

\[
\text{CALL option price} = S \times e^{-\delta \times t} \times N(d_1) - E \times e^{-r \times t} \times N(d_2)
\]
\[
\text{PUT option price} = S \times e^{-\delta \times t} \times N(-d_1) + E \times e^{-r \times t} \times N(-d_2)
\]

where:
\[
d_1 = \frac{\ln \left( \frac{S}{E} \right) + \left[ (r - \delta) + \frac{1}{2} \times \delta^2 \right] \times t}{\delta \times \sqrt{t}}
\]
\[
d_2 = d_1 - \delta \times \sqrt{t}
\]

N(d) is the cumulated probability of normal distribution

The general formulation of a stock price process that follows the binomial model is shown in the Figure 2.

### Figure 2. The binomial model general formulation of a stock price process (source: Damoradan, 2005) [33]. Where: S—the current stock price; Su—the price moves up with probability p in any period; Sd—the price moves down with probability 1-p in any period (the up factor) = \( e^{\delta \times \sqrt{dt} \times (r - \delta^2/2) \times dt} \), d (the down factor) = \( e^{-\delta \times \sqrt{dt} \times (r - \delta^2/2) \times dt} \), dt = 1/number of periods from a year, until maturity.

Binomial model, using a binomial tree, describes price movements over time, where the asset value can move to one of two possible prices (up or down) with associated probabilities. This method consists of the two-step process [8]:

- The binomial tree for the value of the underlying asset
- The binomial tree for the CALL option to delay the project

The strategic Black-Scholes and binomial real options value of the investments project is calculated as:

\[
\text{NPV}_s = \text{NPV}_t + \text{OV}
\]

where:
- \( \text{NPV}_s \)—strategic value of the real option (EUR),
- \( \text{NPV}_t \)—the traditional value of project investment,
- \( \text{OV} \)—option value
3. Results

As mentioned, the methodology of CB analysis and two real options models were applied to evaluate the efficiency of a milk farm. The first part of this chapter presents the results of the analysis related only to milk production as a primary and sole product.

The discount rate is equalized with the interest rate of the Investment Development Bank of the Republic Srpska on the loans for agriculture ($d = 3.6\%$) [34].

Non-discounted net cash-flow of the milk farm for the 14 years is negative and has a value of (EUR $-14,898$) (Table 2). Net cash-flow discounted with a rate of 3.6% is also negative, $\text{NPV} = \text{(EUR} - 33,373). The financial outflow in the milk production consists from the following: operational and services costs with a share in the total cost of 20% (the cost of small inventory, electricity, water, diesel, veterinary services, milk analysis, foria for silage, press rope (baler), maintenance of agricultural machinery, maintenance of milking parlors and freezers and tractor registration costs); feed production costs with a share of 31% in total cost (corn, barley, oats, hay, corn silage, buying feed); gross salaries, which amount to 26% (paying for farm manager (owner) salary and seasonal workers) and depreciation cost (24% of total costs). The revenue is generated from the following: milk sales with a share of 54%, calf and manure sales with a share of 26%, subsidies for milk with a share of 19% and fuel subsidy with a share of 1% of the total income.

Table 2. Farm NPV of producing only milk (EUR).

<table>
<thead>
<tr>
<th>Year of the Project Lifetime</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net cash-flow (non-disc.)</td>
<td>−88,873</td>
<td>5280</td>
<td>5280</td>
<td>5280</td>
<td>5280</td>
<td>5280</td>
<td>−14,720</td>
<td>5280</td>
<td>3280</td>
<td>5280</td>
<td>5280</td>
<td>5280</td>
<td>32,617</td>
<td>−14,898</td>
<td></td>
</tr>
<tr>
<td>Present value net cash-flow</td>
<td>−85,784</td>
<td>4919</td>
<td>4748</td>
<td>4583</td>
<td>4424</td>
<td>4270</td>
<td>−11,093</td>
<td>3840</td>
<td>3707</td>
<td>2223</td>
<td>3454</td>
<td>3334</td>
<td>19,880</td>
<td>−33,373</td>
<td></td>
</tr>
</tbody>
</table>

Source: author’s calculation.

Due to negative NPV, the internal rate of return was also negative and does not necessitate interpreting it in this paper. The payback period is longer than the project period.

Table 3 shows the results of the cheese production analysis, which starts in the fourth year of the traditional milk production project. The investment in a mini cheese factory involves investing in the following assets: duplicator, molds, cooling chamber, cheese tables, vacuum cleaner, libra, pick up, pasteurizer, space for cheese production and air-conditioner. Present value of all long-term assets is EUR 27,735 in the fourth year of project.

Table 3. Farm NPV of producing cheese option (EUR).

<table>
<thead>
<tr>
<th>Year of Project</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash inflow</td>
<td>59,320</td>
<td>49,735</td>
<td>49,735</td>
<td>49,735</td>
<td>49,735</td>
<td>49,735</td>
<td>49,735</td>
<td>49,735</td>
<td>49,735</td>
<td>49,735</td>
<td>49,735</td>
</tr>
<tr>
<td>Cash outflow</td>
<td>61,234</td>
<td>29,284</td>
<td>29,284</td>
<td>29,284</td>
<td>29,284</td>
<td>29,284</td>
<td>29,284</td>
<td>29,284</td>
<td>29,284</td>
<td>29,284</td>
<td>29,284</td>
</tr>
<tr>
<td>Discounted net cash-flow</td>
<td>−1661</td>
<td>17,136</td>
<td>16,541</td>
<td>15,966</td>
<td>15,411</td>
<td>15,097</td>
<td>14,764</td>
<td>14,459</td>
<td>14,193</td>
<td>13,962</td>
<td>12,913</td>
</tr>
<tr>
<td>Present value of the optional investment (S)</td>
<td>155,607</td>
<td>31,950</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investment expenditure</td>
<td>27,735</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: author’s calculation.

In addition to costs in milk production, there are also certain costs in cheese production, such as cost of maintenance of cheese-making equipment and pick-up vehicle for the delivery, vehicle registration, fuel, vacuum bags and labels for cheese packages, spices for cheese and depreciation for fixed assets in a mini cheese factory. In cheese production, more than 80% of the total income comes from cheese sales. The other income arises from calf, manure and fuel subsidy. For the eleven years, the present value of the optional investment reaches a value of EUR 155,607.

The identified alternatives for cheese production are evaluated using a simulation of Black–Scholes and binomial models in the Microsoft Excel software program. The final results are shown in the table below.
After the discounting of investment expenditure and cash-flow, the next phase is to calculate the option value of the alternative project using the Black–Scholes model. The parameters that are included in the model are shown in Table 4. The risk-free rate of 8% and variance (risk) of the optional project of 30% were fixed deterministically [4,7,8]. All the other parameters are calculated through the model (d1, d2, N(d1), N(d2)). The call option value according to the Black–Scholes model for the analyzed project has a value of EUR 144,155.

Table 4. Cheese production Black–Scholes model evaluation (EUR).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present value of the optional investment (S)</td>
<td>155,607</td>
</tr>
<tr>
<td>Present value of investment expenditure (X)</td>
<td>27,735</td>
</tr>
<tr>
<td>Exponential function</td>
<td>2.71828</td>
</tr>
<tr>
<td>Risk-free rate (r)</td>
<td>8.00%</td>
</tr>
<tr>
<td>Period of investment expiry (t)</td>
<td>11</td>
</tr>
<tr>
<td>Variance (risk) of investment’s project (v)</td>
<td>30%</td>
</tr>
<tr>
<td>Black–Scholes option evaluation</td>
<td></td>
</tr>
<tr>
<td>d1</td>
<td>3.115</td>
</tr>
<tr>
<td>d2</td>
<td>2.120</td>
</tr>
<tr>
<td>Lognormal distribution N (d1)</td>
<td>0.999</td>
</tr>
<tr>
<td>Lognormal distribution N (d2)</td>
<td>0.983</td>
</tr>
<tr>
<td>Call option value of cheese production</td>
<td>144,155</td>
</tr>
</tbody>
</table>

Source: author’s calculation.

For the binomial model of real options evaluation, the same parameters as the Black–Scholes model are used. To calculate the value of an optional project using this model, additionally, it is necessary to determine the values of up factor (u) and down factor (d), which further affect the values of risk-neutral probability p and 1-p (Table 5). These parameters determine the values in the binomial tree for the value of the underlying asset and the binomial tree for the call option to delay the project.

Table 5. Cheese production real option binomial model evaluation (EUR).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present value of the optional investment (S)</td>
<td>155,607</td>
</tr>
<tr>
<td>Present value of investment expenditure (X)</td>
<td>27,735</td>
</tr>
<tr>
<td>Exponential function</td>
<td>2.71828</td>
</tr>
<tr>
<td>Risk-free rate (r)</td>
<td>8.00%</td>
</tr>
<tr>
<td>Period of investment expiry (t)</td>
<td>11</td>
</tr>
<tr>
<td>Variance (risk) of investment’s project (v)</td>
<td>30%</td>
</tr>
<tr>
<td>Binomial model of option evaluation</td>
<td></td>
</tr>
<tr>
<td>Up factor (u)</td>
<td>1.350</td>
</tr>
<tr>
<td>Down factor (d)</td>
<td>0.741</td>
</tr>
<tr>
<td>Risk neutral probability (p)</td>
<td>0.562</td>
</tr>
<tr>
<td>Risk neutral probability (1-p)</td>
<td>0.438</td>
</tr>
</tbody>
</table>

Source: author’s calculation.

As maintained before, the binomial model comprises two underlying tree generation aspects: asset and option value tree.

The Figure 3 indicates the possible project values after 11 years of optional production. Depending on favorable or unfavorable business environments, the values can be from EUR 5739 to EUR 4,218,906. The next phase in the binomial model option evaluation is the determination of the expected option value on the terminal nodes and backward induction to the first node. The binomial tree for the call option to delay the project (option value lattice) is shown in the next figure.
Figure 3. The binomial tree for the value of the underlying asset (project value).

The binomial model of option evaluation determined that the option value of the cheese production investment project in Bosnia and Herzegovina is EUR 149,052 (Figure 4), which is almost EUR 5000 more than the option value calculated in the Black–Scholes model valuation (about 3.2%).

Figure 4. The binomial tree for the CALL option to delay the project.
Table 6 shows the comparison between the traditional NPV calculated by applying CB analysis and two models of real options evaluation.

Table 6. Comparison of traditional and real option appraisal.

<table>
<thead>
<tr>
<th>Method</th>
<th>NPV\textsubscript{traditional}</th>
<th>Option Value</th>
<th>NPV\textsubscript{strategic} (NPV\textsubscript{traditional} + OV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black–Scholes</td>
<td>−33,373</td>
<td>144,155</td>
<td>110,783</td>
</tr>
<tr>
<td>Binomial</td>
<td>−33,373</td>
<td>149,052</td>
<td>115,679</td>
</tr>
</tbody>
</table>
| Real option appraisal confirmed that additional investment in on-farm milk processing in Bosnia and Herzegovina’s market is a financially effective option. This is also a sustainable solution for milk farms since traditional CB analysis showed that milk production based on ten milk cows does not ensure a positive NPV according to the achieved milk yield and purchase and sales prices. Moreover, a traditional CB analysis of cheese production on a milk farm, for 14 years, confirmed the economic justification of this investment. The internal rate of return (IRR) of the cheese processing project is 9.9%. The undiscounted return period of the investment in cheese production on the farm is 9.4 years.

4. Discussion

Milk production in Bosnia and Herzegovina is one of the most important agricultural industries [35]. However, with market liberalization and the abolition of import duties and quotas, it is increasingly difficult for domestic producers to remain competitive. The agricultural sector in developing countries and less-developed countries is a source of employment and livelihood for the majority of the population, a major foreign exchange earner and supplier of raw materials to local industry and has important potential for the economic development of those countries [36]. The milk sector in BiH has largely survived thanks to high subsidies [37], which have been criticized by other producers and for which reduction is necessarily within the harmonization of agricultural policy to the Common Agricultural Policy of the EU. This statement was also confirmed by the result of the applied analysis, with a negative NPV in milk production.

The decrease in the number of small milk farms and consolidation of the milk sector in Bosnia and Herzegovina is evident. The highest growth was for milk farms with five to ten cows [35]. In such a situation, the perspective for small farms is the processing of milk into products with higher added value; otherwise, it will be difficult to survive in relation to the competition of large farms and import of milk products. The option of a switch to on-farm milk processing for local sales and green markets instead of selling milk to dairies was identified as one of four options for small milk farms in the FAO sector strategy for milk and meat in BiH ten years ago [38]. It has been identified as an option in many other cases, especially in emerging countries. In some countries, this is due to the absence of the milk industry and the purchase of raw milk [39,40], and in others due to resisting the competition of large farms and filling out a market niche for traditional and other products of special origin [41].

The level of income/cow/year has been influenced by marketed milk, milk price, culled cow weight and price per kg live weight, calf live weight and related prices in each country [42]. This study shows how important it is for farmers to pay more attention to the increase in milk yield to improve financial results, which is the main goal of farmers. Becker et al. (2007) calculated the economic efficiency of milk processing on 50- or 500-cow farms in the USA [41]. They stated that investment in raw milk production had a substantially negative NPV, while investment in yogurt milk plants and cheese processing generated a positive NPV. In the case of orientation to cheese production, a small cheese plant has a negative NPV, and larger cheese plants have a positive NPV. This indicates that the extent of the capacity for on-farm milk processing is also important in the case of the analyzed farm in BiH: an increase in the number of cows would probably result in more favorable economic returns.
In this work, the authors have upgraded the traditional CB analysis with the method of valuation of real options. Tubetov et al. (2012) listed the advantages of the real options approach (ROA), which asserts that an investor might increase returns by postponing an irreversible investment decision instead of investing instantly despite the fact that it has a positive NPV. Moreover, they consider that, in order to realize an investment project, the investment trigger according to the ROA is significantly higher than those according to the NPV criterion [10]. Differences between ROA and alternative theories also vary in terms of their focus on cost efficiency and the role of knowledge, learning and decision flexibility [43]. They also submit that ROA draws on all these factors in a comprehensive way and, hence, carries considerable integration potential with other theories focusing on aspects of firm investment and decision-making under uncertainty.

The analyzed model and the results presented in this paper confirmed the feasibility of that option in the case of Bosnia and Herzegovina. A similar conclusion was reached by Xavier et al., 2020 that the expansion and processing of the milk produced can ensure the success of agricultural activity [11]. The research results of Chetroiu et al. [44] showed that the size of farms and the level and value of milk production are directly correlated with profitability, and the unit cost is inversely correlated with it. Moreover, Imadi et al. thought that sustainable approaches can only be employed by smaller farms [22]. Comparing the traditional CB analysis indicators, the decision to process milk into cheese is economically a much better option than selling raw milk.

The transition from milk production to cheese production implies the appearance of certain uncertainties, both production and market uncertainties. Of the production uncertainties, there are risks in cheese processing, preservation and storage. Market risks include a possible insufficient demand for these products, the appearance of competing farms and imported cheese products, an increase in the prices of inputs for cheese processing, etc. Moreover, a shortage represents a possible lack of knowledge for processing, and the loss of subsidies per liter of milk would be because there are no subsidies for cheese production in BiH. In addition to these, there is also the risk of loans and additional allocation of financial resources needed for additional investment. Likewise, the required quality standards are much stricter in relation to milk production.

5. Conclusions

High competition of imported milk, high feed production costs, depreciation of assets and machinery and high participation of labor costs are some of the factors that influence the lack of profitability of milk production.

- The price of raw milk and complementary products is not enough to cover the high costs of this production. Certainly, direct payments enable milk farms to survive, but their long-term sustainability is threatened without subsidies.
- The conducted research confirmed that raw milk production with the farm size of ten cows is not financially viable.
- Based on this case study, taking into account milk yield and other parameters in the model, after 14 years of the project effectuation, a negative NPV (EUR $-33,373$) was recorded, which imposes two possibilities for the producer. The first is to leave milk production, and the second possibility would be to start dealing with milk on-farm processing. The second option is analyzed as the processing of raw milk into cheese at the same farm.
- By applying Black–Scholes and binomial methods, strategic NPV was calculated. According to the Black–Scholes model, the value of the option is EUR 144,155, and the strategic NPV has a value of EUR 110,783. Based on the binomial model, the option value is EUR 149,052 and the strategic NPV is EUR 115,679.
- Additional investment and workforce employment, despite the increase in costs, bring much higher revenue due to adding value to the milk and returning a positive strategic NPV to the farm. Moreover, conversely, the calculated values of the key indicators
confirmed the research hypothesis that it is economically valuable to diversify a milk business into on-farm cheese processing.

In future research, the sample for analysis such as this could be larger in order to consist of data for small, medium and large farms in BiH and to compare them, as well as to evaluate and extrapolate the movements of inputs in the future for the production of milk and cheese and the selling price of cheese. Another possibility could be to take into account different discount rates in the evaluation that would refer to risks in this production.

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