ENC-2020-0014
ECONOMIC ANALYSIS AND RISKS OF IMPLEMENTATION OF A DEVICE TO MEASURE THE WORT DENSITY

Simone Ferigolo Venturini
Taís Oliveira da Silva Alfonso
Joana Siqueira de Souza
Federal University of Rio Grande do Sul
sfventurini@gmail.com
taisoalfonso@gmail.com
joana@producao.ufrgs.br

Charles Rech
Federal University of Santa Maria-CS
charles.rech@ufsm.br

Abstract. The Brazilian craft beer market is promising. Taking that into account, in this article, the risks and the economic feasibility of implementing a digital densimeter in the craft brewing process are analyzed. The device serves to measure the wort density in real time during the craft beer fermentation process. For modeling analysis, capital recovery time metrics (Payback), net present value (NPV) and Internal Rate of Return (IRR) were used. The risks were analyzed under two aspects: qualitative analysis method and quantitative analysis method. The internal rate of return, discounting the effects of inflation (Net IRR) was 619,58% and the payback was 2,19 months. The values obtained as results show that the implementation of the project is economically viable. Scenario analysis shows that even in a very pessimistic scenario, the projection is positive.

Keywords: wort density, craft beer, economic analysis, risk analysis, sensitivity analysis.

1. INTRODUCTION

The Brazilian craft beer market has risen considerably in recent years and continues to grow, which creates new opportunities for entrepreneurs (DATASEBRAE, 2019). A study conducted by SEBRAE (Brazilian Micro and Small Business Support Service) mapped this market. This study was the first Brazilian Independent Breweries Census (DATASEBRAE, 2019). The survey had a quantitative nature and showed a prospect of revenue in the order of R$ 360,000.00 per brewery for the year 2019. In addition, it indicated the high level of education of the interviewed: 91% have completed higher education (35%), master's (51%) and doctor degree (5%). This scenario of economic growth combined with the level of education are an opportunity for universities assist micro companies in the development of novel technologies to create and improve their processes.

Among the craft beer production stages, fermentation is the stage that demands great time and risk of contamination, since this must be monitored and measured daily using conventional tools, such as the conventional hydrometer and the portable refractometer. In both cases the evaluation of the fermentation process is done manually by an operator and the measurement of the wort density must be done daily (Kunze, 2014). At this moment, the product is exposed to the risk of contamination by agents external to the process. In this article, it is proposed to analyze the feasibility of risks of implement a continuous digital density meter in the craft beer production processes. This meter does not expose the product and records the values measured over time. However, it is necessary to analyze the risks and economic viability of implementing this new technology in the brewing process. The risk management is a systematic process of defining, analyzing and responding to risk in order to maximize positive events and minimize the consequences of negative events (Damodaran, 2009). For economic feasibility analysis, the metrics Payback, Net Present Value (NPV) and Internal Rate of Return (IRR) were used (Grant; Ireson, 1970). The objective of this paper is to economically analyze the implantation of the technological apparatus (digital densimeter) in microbreweries and perform the risk analysis. This device potentially reduces the risk of product contamination and increases the efficiency of breweries. Thus, an economic analysis is carried out to implement the prototype in a microbrewery with a monthly production of 31,200 liters / year located in the city of Porto Alegre-RS.

2. METHODOLOGY

2.1 System description

Beer is a kind of fermented alcoholic beverage, which has as main ingredients water, malt, hops and yeast (Brasil, 2009). The fermentation process is responsible for to transform wort into beer. Fermentation is the process in which the sugars in the wort are converted to carbon dioxide (CO_2) and ethanol by enzymes in the yeasts (Kunze, 2014; White, 2010).

The digital densimeter is a device to measure the wort density in a real-time and continuous fashion (Venturini et al., 2019). The device is composed of two pressure sensors that measure pressure values in different positions inside the fermentation tank. The result is converted into wort density that varies during fermentation.

The measurement and data of the wort density is important for the control of the evolution of the fermentation of craft beer. In addition, that, the original wort gravity (OG) and the final wort gravity (FG) are used to calculate parameters that specify craft beer (Kunze, 2014).

2.2 Hydrostatic analysis

In a vessel with homogeneous fluid, according to Stevin's Law, the pressure is dependent on the height of the fluid column, since the density and gravitational acceleration are constant.

The digital densimeter uses the principle of measuring hydrostatic differential pressure between two points separated by a fixed distance to accurately calculate the wort density and concentration of the liquid. Consequently, the evolution of the fermentation process is calculated from the measurement of the wort density variation over time.

2.3 Economic analysis

Data collection sought economic, financial and technical information. Economic data was searched on open channels, such as economic journals (DCI, 2019). The economic and technical data were collected through unstructured interviews with a businessman in the brewing area and a professor at a Higher Education Institution. Other information was raised in bibliographic research. Based on this information, economic modeling and identification of the risks inherent to the implementation of the artifact were carried out.

For modeling analysis, capital recovery time metrics (Payback), net present value (NPV) and Internal Rate of Return (IRR) were used.

The risks were analyzed under two aspects: qualitative analysis method and quantitative analysis method. According to Damodaran (2009), the qualitative method prioritizes risks, estimating their probability of occurrence and impact. In turn, the quantitative method measures the probability of the impact of the risks and estimates its implications for the project's objectives, which can be characterized as deterministic or probabilistic. In a deterministic quantitative assessment, it is assumed that the input data of the analysis are known, that is, they are information without variability. With this information, sensitivity analysis and scenario analysis are built (Saul, 1995).

3. RESULTS

The first stage of this work involved the collection of data for modeling, which were extracted from sources such as literature, interviews and market research. The implantation of the digital densimeter occurs in the fermentation stage of craft beer. The equipment in this stage is called fermenter and the product of this stage is beer, which still needs further maturation in barrels or bottles.

The investment values considered for modeling the installation of the digital densimeter were based on the data indicated by Padilha (2016), because it is an equipment that has the same purpose, although the operating principle is different. The values were corrected according to the inflation rate of 4% a.a and were adapted to the reality of the case studied (two fermentation tanks). In addition, since the values were collected in reais, the conversion factor from 1 Brazilian real to 0.2 US dollars was used. Table 1 presents the investment data collected.

Table 1. Project investment.

Description	Value (US$)	Source
Equipment	359,93	
Mechanical Installation	508,31	Padilha, 2016
Electrical Installation	255,24	
Electric material	39,33	
Total	1162,80	

Savings in labor and an increase in the number of batches were considered as project revenues. Since the digital densimeter records the density in real time and uninterrupted, the manual measurement process is not necessary to collect this data. The increase in batches is a consequence of the reduction of fermentation time due to the more effective control of the process. Table 2 summarizes the values calculated for the calculation of the project's revenue.

Table 2. Project revenue values and parameters.

Description	Value	Source
Labor Value (Per-hour)	US$ 2,02	DNA Beer Entrepreneur Interview
Hours Reduction (For 2 fermentation tanks)	22	Professor Interview
Revenue Hours/Year	US$ 533,91	Labor Value (Per-hour) * Hours Reduction * 12 Months
Price (Liter)	US$ 2,60	Market Research (Authors)
Raw Material Cost (Liter)	US$ 0,93	DNA Beer Entrepreneur Interview
Contribution Margin	US$ 1,67	Price (Liter) - Raw Material Cost (Liter)
Increased Production (Batches/Year)	4	Venturini, 2019
Increased Production Revenue	US$ 7996,16	Contribution Margin * Increased Production * 1.200 liters
Total	US$ 8441,08	Revenue Hours/Year + Increased Production Revenue

According to Venturini et al. (2019), it is estimated a reduction of 11 hours of work for each fermentation tank and an increase of 4 batches per year.

Regarding operation and maintenance costs (O&M) a manual density check per month was considered. The estimated labor cost for this activity is US$ 24,20.

The inflation considered in the modeling was 3,70% per year, according to the IPCA trend published by *Diário do Comércio, Indústria e Serviços* (2019). The depreciation of the artifact was not taken into account because it is a brewery registered under the national simple tax regime. In this case, a tax rate of 10% per month was considered, taking into account the revenues of the interviewed company. The life cycle considered for the equipment was 10 years and the minimum acceptable rate of return (MARR) was 17%, according to data obtained in an interview. The modeling of the project is shown in Figure 2.

P	Investment (US$)	Revenue (US$)	Costs (US$)	Tax (US$)	Cash Flow (US$)
0	-1.162,80				-1.162,80
1		8.845,68	-25,17	-1.349,55	7.471,68
2		9.172,97	-26,10	-1.399,48	7.748,13
3		9.512,37	-27,06	-1.451,26	8.034,81
4		9.864,33	-28,07	-1.504,96	8.332,10
5		10.229,31	-29,10	-1.560,64	8.640,38
6		10.607,80	-30,18	-1.618,38	8.960,08
7		11.000,28	-31,30	-1.678,26	9.291,60
8		11.407,29	-32,46	-1.740,36	9.635,39
9		11.829,36	-33,66	-1.804,75	9.991,90
10		12.267,05	-34,90	-1.871,53	10.361,60
				NPV	38.204,86
				IRR	646.21%
				Net IRR	619.58%
				PAYBACK (months)	2.19

Figure 2. Economic modeling of the project.

The net present value (NPV) calculated for the project was US$ 38.204,86. The internal rate of return, discounting the effects of inflation (Net IRR) was 619,58% and the payback was 2,19 months. The values obtained as results show that the implementation of the project is economically viable.

After the modeling stage, the project's risks were mapped. The identified risks were classified into dimensions and linked to the model variable impacted by its effect. Table 2 presents the risks raised.

Table 2. Risk Mapping.

Risk classification	Risk	Impacted model variable
Process	Batch contamination	Batch
	Product defect	
	Fermentation time	
Technological	Life cycle shorter than expected	Life cycle
Operational	Longer than expected maintenance time	Operational cost
Systemic	Inflation variation over the analysis period	Inflation

The variables impacted by the identified risks were subjected to a sensitivity analysis. The output variable chosen for analysis was the NPV. A variation of 20% more and less for each variable was considered. The 10% plus and minus points were also collected. The Sensitivity Analysis of the variables considering the NPV is shown in Figure 3.
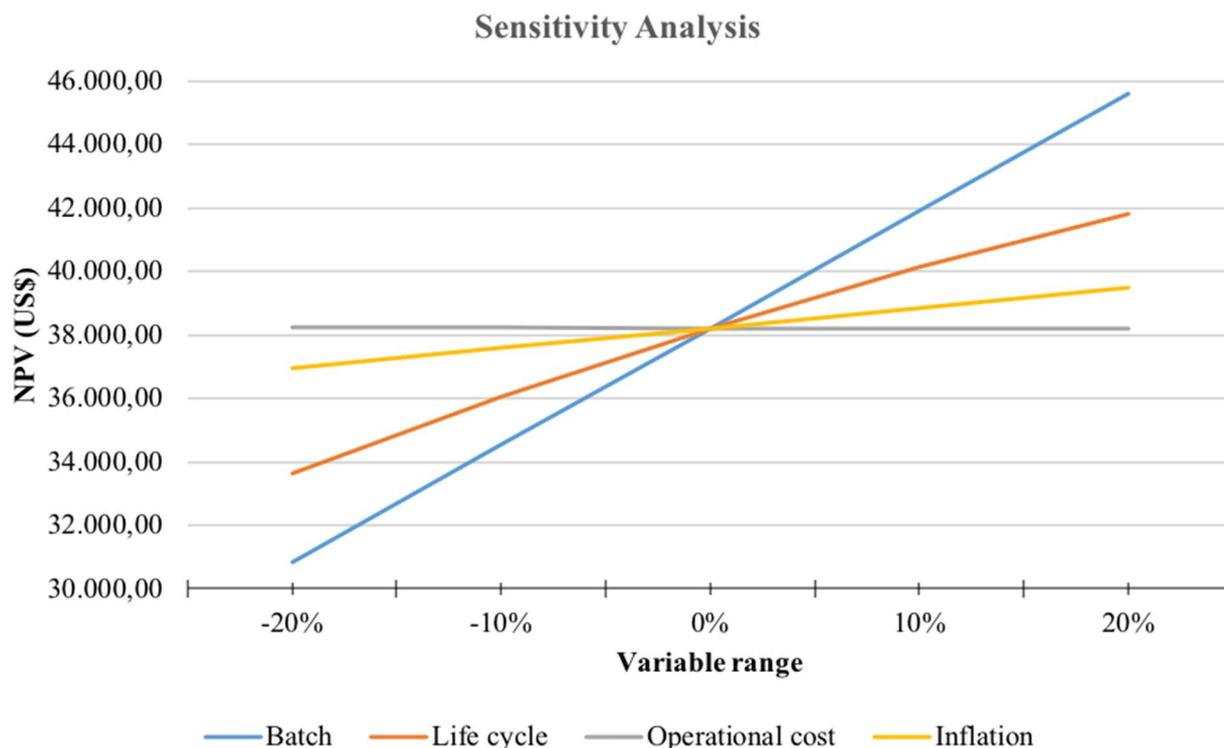

Figure 3. Sensitivity analysis.

The sensitivity analysis of the project showed that the variables number of batches and life cycle of the artifact are representative considering the NPV as the output variable. The O&M cost and inflation variables have little impact. The determining variables for the project, that is, batches and life cycle were subjected to scenario analysis.

In the analysis of scenarios, 4 contexts were considered: pessimistic in relation to the increase in production and life cycle, or very pessimistic; pessimistic only in relation to the increase in production; probable and optimistic. In the very pessimistic scenario, it was considered that in addition to the fermentation time not having been reduced, the batches were contaminated and had their density altered by measurement errors. In addition, another product was launched on the market, reducing the life cycle of the product/project in half. Thus, in this scenario it was considered as an increase in production 1 batch/year and as a life cycle of the project 5 years.

In the pessimistic scenario, it was considered that the fermentation time was not reduced as expected and some batches were contaminated. However, the life cycle of the product/project was as designed. Thus, an increase in production of 2 batches/year and a Project Life Cycle of 10 years were considered.

In the probable scenario, it is estimated that the project will have the projected result and that the variables will behave according to the defined parameters. In the optimistic scenario, it was considered that there were no significant technological changes in the market, increasing the product/project life cycle by 20%. In this last scenario, an increase in production was considered 4 batches/year and the Project Life Cycle 12 years. The studied scenarios are summarized by Figure 4.

Scenario summary	Current values:	VERY PESSIMISTIC	PESSIMISTIC	PROBABLE	OPTIMISTIC
Variable cells:					
BATCHES/YEAR	4	1	2	4	4
LIFE CYCLE	10	5	10	10	12
Células de resultado:					
NPV (US$)	38.207,91	6.408,46	19.769,15	38.207,91	41.811,85
Net IRR	619,58%	183,31%	329,41%	619,58%	619,58%
PAYBACK (months)	2,19	7,35	4,11	2,19	2,19

Figure 4. Scenario analysis.

Scenario analysis shows that even in a very pessimistic scenario, the projection is positive. In this scenario, it is still possible to obtain NPV of US$ 6,408.46 and a payback of 7.35 months. Thus, it appears that the project is economically viable, even in a scenario of strong technological change (which would cut the product life cycle in half) and with only 25% of the expected production increase. However, given that despite the economic results, adherence to this type of technology is low, it is suggested to understand that other tools would be necessary to convince the target public.

4. CONCLUSIONS

The aim of this work was to economically analyze the implementation of a digital densimeter in a microbrewery and perform an analysis of the risks of this implementation. Thus, an economic modeling was performed based on data collected from the literature, interviews and market indexes. The new technology is economically viable. Based on this scenario, the project's risk was surveyed and the model variable impacted by each risk. The variables identified were submitted to a sensitivity analysis. It was found that the most impactful variables for NPV were number of batches per year and life cycle of the equipment. These variables were submitted to a scenario analysis. It was observed that, even in a very pessimistic scenario, the project is economically viable.

For future studies, given the economic viability of the project, it is suggested to understand what other techniques would be necessary to convince the target public of the technology. In addition, a more comprehensive mapping of the costs involved in the project is required, which can change the results of the modeling. Finally, the mapping in the risk identification phase can be expanded by inviting a brainstorming session to project stakeholders.

5. REFERENCES

DCI, 2019. "IPCA para 2019 passa de 3,31% para 3,33%, aponta Focus" Diário Comércio Indústria. 15 Oct. 2019 <https://www.dci.com.br/economia/ipca-para-2019-passa-de-3-31-para-3-33-aponta-focus-1.840230>>.

Damodaran, A., 2009. *Gestão estratégica do risco*. Bookman, São Paulo.

Datasebrae, 2019. "Cervejarias Independentes Brasileiras" DataSebrae. 20 Jul. 2019 <https://datasebrae.com.br/cervejarias-independentes-brasileiras/#Noticia)>>.

Datasebrae, 2019. "1º Censo das Cervejas Independentes Brasileiras" DataSebrae. 20 Jul. 2019 <https://datasebrae.com.br/wp-content/uploads/2019/10/Censo-cerveja-geral2-v3-1.pdf>.

Grant, E. L. and William G. I., 1970. Principles of engineering economy. MacMillan, New York.

Kunze, W., 2014. Technology of Malting and Brewing. Berlim, Alemanha, 5th edition.

Padilha, G. L., 2016. Análise de Viabilidade Econômica para Medição de Grau Plato Durante o Processo de Fermentação da Cerveja. Repositório de Relatórios-engenharia Elétrica.

Saul, N., 1995. Análise de Investimentos: critérios de decisão e avaliação de desempenho nas maiores empresas do Brasil. Unisinos, Porto Alegre, 2nd edition.

Brasil, 2009. Decreto nº 6.871, de 4 de junho de 2009. Regulamenta a Lei no 8.918, de 14 de julho de 1994, que dispõe sobre a padronização, a classificação, o registro, a inspeção, a produção e a fiscalização de bebidas. Diário Oficial da União, Brasília, DF, 05 jun. 2009, Seção 1, p. 20.

Venturini, S. F., Rech, C., Schneider, P. S., Kunst, R. and Drehmer, L. R. C. "Real Time Density Measurement of Alcoholic Fermentation of Craft Beer". *In Proceedings of the 25nd International Congress of Mechanical Engineering - COBEM 2019*. Uberlândia, Brazil.

6. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.