4-18-2018

A Comparison of Frankenbrew and Traditionally Manufactured Brewing Equipment

Daniel King
Western Michigan University, dan@2pawsbeer.com

A Comparison of Frankenbrew and Traditionally Manufactured Brewing Equipment

Daniel King

Abstract

Opening a new business can be a daunting task. Between the legal paperwork, securing the best perceived location, hiring new employees, the investment can require the use of a life savings. In the brewing industry, this investment can be amplified by the cost of purchasing production scale brewing equipment. Because of this, many start-up brewing operations have turned to the use of Frankenbrew equipment within their brewing process. The term "Frankenbrew" was coined by Tom Hennessy of Colorado Boy Pub & Brewery. The term refers to any equipment incorporated into a brewery that was not originally intended for that purpose, but has rather been repurposed, modified, or in-house fabricated to be used in the brewing process[1].

Frankenbrew equipment can be created in a seemingly infinite number of ways using sometimes surprising source materials. Hot liquor tanks, used to keep water hot during the brewing process can be made from insulated milk tanks, or from uninsulated stainless-steel vessels with the inclusion of an electric heating element or burner coupled with a thermostat. Mash tuns, used for the mashing step that converts malted grains to fermentable wort are a bit more complex than a hot liquor tank, including a 'sparge arm' which showers the mash with hot water to rinse the extracted wort from the grains and a coarse screen to retain the solid grain material as it is moved into the boil kettle. The mash tun can also be made from many different types of stainless-steel vessels, often incorporating some sort of stainless-steel piping with holes drilled to serve as a sparge head, and screens that can range from a full-bedded drilled stainless steel false bottom with holes drilled, to more stainless piping with holes drilled or slots cut in, to even a network of braided stainless-steel flex piping of the sort which is often found in household appliance plumbing[2].

The idea behind any of these 'Frankenbrew' alternatives to traditionally manufactured brewing equipment is to save money for a small-scale brewing operation, but possibly due to the wide variety in Frankenbrew applications, there is very little literature on how a brewhouse can utilize this equipment, or weighing in on any associated costs vs. benefits. This research seeks to begin filling that gap in information by focusing on both quantitative and qualitative aspects of the potential costs and benefits involving Frankenbrew equipment in comparison to the use of more traditionally manufactured counterparts of similar scale.

To do this, Michigan breweries were visited and/or interviewed about their brewing process using twelve different brewing systems. Five of the ten used a heavy incorporation of Frankenbrew equipment in their brewing process, the other five used primarily more traditional brewhouse designs made up primarily of commercially manufactured brewing equipment that required little or no modification to be used in their brewing process. Quantifiable data came in the form of comparing brewhouse extract efficiency, labor hours involved, cost of installation of one group as opposed to the other. Because of the variation of Frankenbrew equipment, the average and standard deviation of values from each of the two groups were taken for comparison. From a qualitative side, brewhouse owners and personnel were interviewed regarding their overall level of satisfaction with the equipment by touching on shortcomings, advantages, whether they planned on replacing the equipment soon, and whether, in hindsight, they would have employed the same equipment if they were to start over. In the interest of keeping potentially private business practices confidential, all company names and personnel remained anonymous for this research.

---

[1] Billy B, "A Homebrewer Gets to Brew on a Big Boy System," *Brilliant Drinks*, 2017, http://homebrewacademy.com/factotum-brewhouse/.

[2] Hennessy, Tom, *Brewery Operations Manual: 3 Steps to Open and Run a Successful Brewery,* (Montrose Colorado: Tom Hennessy, 2015), 54-60.

Brewing Research

Since the early 1980's, the craft beer brewing industry has been experiencing steady growth in the United States. In 2016, craft beer represented a $23.5 billion industry shared by 5,234 regional breweries, microbreweries, and brewpubs according to Smith (2017). Plentiful research in brewing chemistry, yeast microbiology, and market demographics has formed over this time, but research on how different brewing equipment affects these factors has not been as prevalent. Specifically, there is little mention of the "Frankenbrew" phenomenon that has become so common as small-scale breweries and brewpubs rapidly open. Frankenbrew involves using equipment that has been repurposed, modified, and/or completely fabricated in house to mitigate the cost of installing a traditional, commercially manufactured brewing system. The term was coined by Tom Hennessy of Colorado Boy brewing who produced a video, held classes, and later wrote a book on how to build a craft brewing operation with minimal aid from investment.

The objective of this study is to begin to evaluate differences between breweries using Frankenbrew-based systems and breweries using traditionally manufactured systems. Five Frankenbrew systems and seven traditionally manufactured brewing systems of varying scale were evaluated in Michigan to compare their brewhouse efficiency, installation cost, ease of use, and other less quantifiable data.

Methods

Twelve brewing systems from ten Michigan breweries were evaluated via interview with a brewer familiar with that system. The smallest system had a hot-side capacity of 1/2bbl (beer barrel - equal to 31 U.S. gallons), and the largest had capacities of 50bbls. Though the target capacity was initially in a much narrower range (3-15bbls), limited response necessitated this large deviation.

A questionnaire was sent via e-mail to each brewery including the questions and tables that would be asked about in the interview. Also included was a disclaimer that no information given by a brewery would be directly linked with their brand. All but two system questionnaires (for the two largest systems) were followed up by interviews in person.

Brewers were asked to describe their system using a series of prompts intended to produce similarly formatted answers. The bulk of the questions asked for quantitative information. Brewers were asked about the capacity of their hot-side brewing system in beer barrels (bbls), the number and sizes of fermenters and brite tanks in their cellar, how frequently they brew beer and in what volume. To obtain brewhouse efficiencies independent of variations in recipe design, brewers were asked to provide the efficiency of a beer with a starting gravity near 1.060 with minimal use of adjuncts in the grain bill. Finally, a table was provided asking for descriptions of various pieces of brewhouse equipment in terms of manufacturer or (lack thereof), relevant modifications, time required for use, and cost of installation.

Upon beginning to collect data, the focus of the quantitative section was narrowed to comparing brewhouse extract efficiency, time required to brew a single batch of beer, and the installation cost per bbl of system capacity. From each of these data sets, a two-tailed independent t-test was performed, and a box plot created to determine if the two system types gave statistically or visibly dissimilar results. A scatter plot was also created for each of the three variables to graph them as functions of brewhouse capacity. Another scatter plot was created to graphically display the relationship between the time taken to brew a single bbl of wort and increasing brewhouse capacity.

In a second section, brewers were asked open-ended questions to obtain qualitative answers and anecdotal information about their systems. This section included questions about the reasoning behind the system design, perceived advantages and disadvantages of their system compared to others, planned upgrades, and any changes that they would have made if given the choice to start over.

Observations

The questionnaire was written with a broad spectrum of questions with the intention of narrowing focus once the early stages of data collection had begun. It became quickly apparent that comparing brewing schedules to determine frequency and volume would not yield useful data due to the variations in product type, market needs, and stage of development for each brewery studied. While the original document planned for the possibility of comparing systems component-by-component, this also proved unreasonable due to a common occurrence of components included in certain systems that had no direct counterpart in other systems. Instead, the brewing system was looked at as a whole in terms of brewhouse extract efficiency, cost of installation and time required for operation.

Determining which breweries belonged in the Frankenbrew category was not an exact science since none of the breweries visited used Frankenbrew equipment exclusively. Fermentation and conditioning vessels were commercially manufactured with only two exceptions, and so the focus of the deviation between the two categories was trained on the hot-side brewing equipment, defined as any equipment a brewer would use in the brewing process up until knockout of a beer to a fermenter. From here, it was easier to segregate breweries which used predominantly Frankenbrew equipment from those which used little or no Frankenbrew components.

One of the traditionally manufactured brewing systems in the study was not part of a production brewery, but rather a custom-built, scaled-down brewing system for use in an education setting. Because of the nature of the system, its cost of installation was a definite outlier compared with the rest of the data. Because of this, a t-test, box plot, and scatter plot was created both with and without this data point.

Data

Frankenbrew Systems						
Brewery	Hotside bbls	Brewhouse Efficiency (%)	Labor Hours/batch	Labor Hours/ Double Batch	Total install cost (USD)	System cost per bbl of capacity
F1	3	70%	3.75	7.5	$ 50,000.00	$ 16,666.67
F2	7	80%	6		$ 50,400.00	$ 7,200.00
F3	5	82%	6	10	$ 40,000.00	$ 8,000.00
F4	7	77%	4.5	9	$ 130,000.00	$ 18,571.43
F5	3	75%	5		$ 12,000.00	$ 4,000.00
Mean	5	77%	5.05	8.833333333	$ 56,480.00	$ 10,887.62
Standard Deviation	2.0	5%	0.975	1.26	$ 43,972.17	$ 6,360.32
Relative Standard Deviation	40.0	6.07%	19.3	14.24	$ 77.85	$ 58.42
n	5	5	5			5
Variance		0.22%	0.95			$ 40,453,623.58

Table 1: Quantitative Data from Frankenbrew Systems

Commercially Manufactured Systems						
Brewery	Hotside bbls	Brewhouse Efficiency (%)	Labor Hours/batch	Labor Hours/ Double Batch	Total install cost (USD)	System cost per bbl of capacity
T1	15	80%	5.0	10.0	$ 350,000.00	$ 23,333.33
T2	1.17	88%	6.0	11.0	$ 190,000.00	$ 162,393.16
T3	2.5	72%	5.0		$ 33,350.00	$ 13,340.00
T4	0.5	84%	3.5	7.0	$ 8,000.00	$ 16,000.00
T5	7	82%	7.0		$ 70,000.00	$ 10,000.00
T6	50	95%	3.5	7.0	$ 3,215,000.00	$ 64,300.00
T7	50	94%	5.0	10.0	$ 581,500.00	$ 11,630.00
Mean	18.0	85%	5.0	9.0	$ 635,407.14	$ 42,999.50
Standard Deviation	22.4	8%	1.3	1.9	$ 1,155,627.38	$ 55,941.92
Relative Standard Deviation	124.2	9.43%	25.2	20.8	$ 181.87	$ 130.10
n	7	7	7			7
Variance		0.64%	1.58			$ 3,129,497,917

Table 2: Quantitative Data from Commercially Manufactured Brewing Systems

t-tests		Efficiency	Labor hours	Installation per bbl Brewhouse Capacity
mean-mean		8%	0.05	32111.88034
A		0.04721643	13.3	18938801997
B		10	10	10
C		12	12	12
D		35	35	35
A/B		0.00472164	1.33	1893880200
C/D		0.34285714	0.342857143	0.342857143
(A/B)*(C/D)		0.00161885	0.456	649330354.2
Squrt (A/B)*(C/D)		0.04023492	0.675277721	25481.96135
D.F.		10	10	10
T test		2.00785063	0.07404361	1.260180875

Table 3: t-tests for comparison of Frankenbrew and Commercially Manufactured Systems

T Test	Efficiency		T Test	Labor Hours/Batch		T Test	System Cost/bbl		T Test	System Cost/bbl	
t-value =	2.0078506		t-value =	0.07404361		t-value =	1.260180875		t-value =	1.259429511	
Frankenbrew = Commercial?	95% Confidence Critical T = 2.228	Accept	Frankenbrew = Commercial?	95% Confidence Critical T = 2.228	Accept	Frankenbrew = Commercial?	95% Confidence Critical T = 2.228	Accept	Frankenbrew = Commercial?	95% Confidence Critical T = 2.228	Accept
	90% Confidence Critical T = 1.812	Reject		90% Confidence Critical T = 1.812	Accept		90% Confidence Critical T = 1.812	Accept		90% Confidence Critical T = 1.812	Accept
	80% Confidence Critical T = 1.372	Reject		80% Confidence Critical T = 1.372	Accept		80% Confidence Critical T = 1.372	Accept		80% Confidence Critical T = 1.372	Accept
	50% Confidence Critical T = 0.700	Reject		50% Confidence Critical T = 0.700	Accept		50% Confidence Critical T = 0.700	Reject		50% Confidence Critical T = 0.700	Reject

Table 4: t-test Interpretation for Comparing Frankenbrew and Commercially Manufactured Brewing Systems

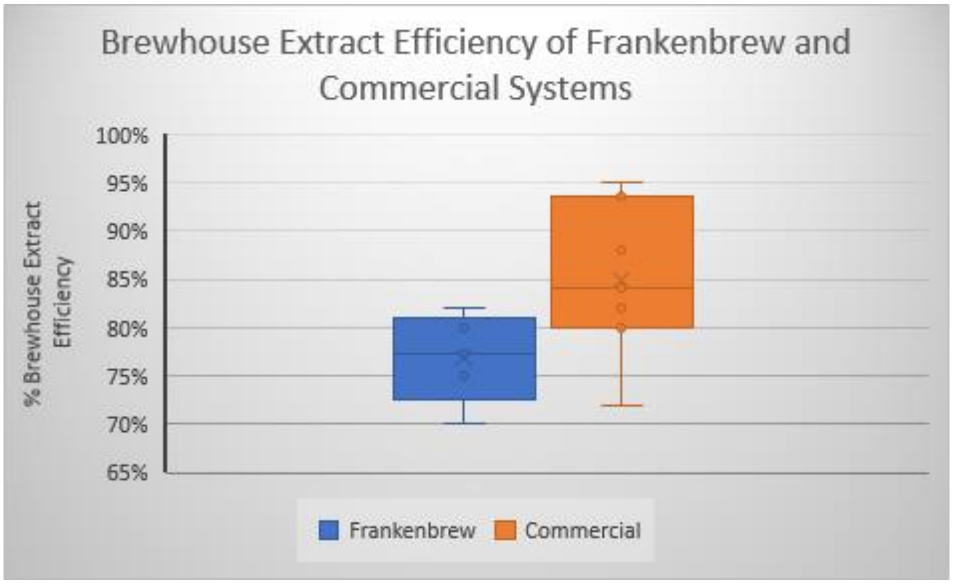


Figure 1: Boxplot Comparison of Brewhouse Extract Efficiency Between Frankenbrew and Commercially Manufactured Systems

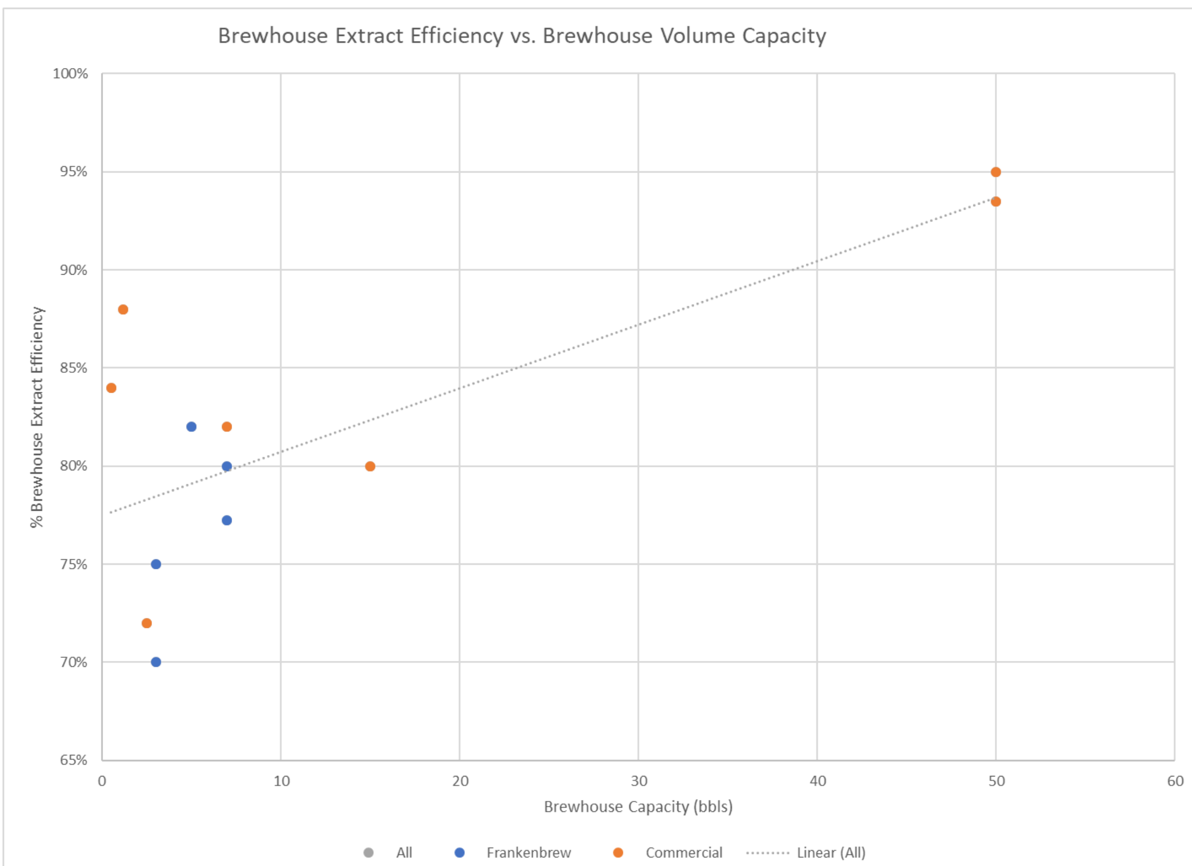


Figure 2: Scatter Plot of Brewhouse Extract Efficiency as a Function of Brewhouse Capacity

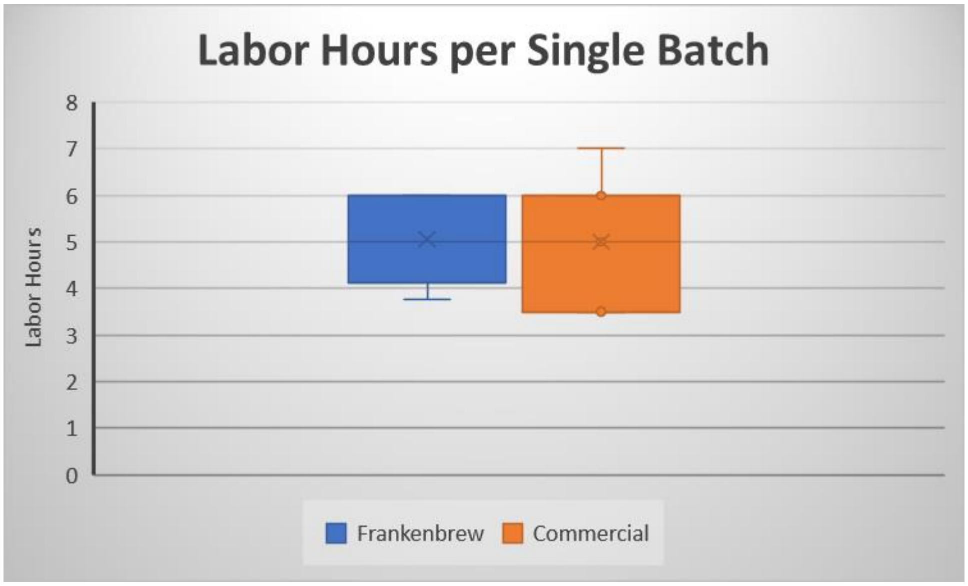


Figure 3: Boxplot Comparison of Labor Hours Required to Brew a Single Batch of Beer on Frankenbrew and Commercially Manufactured Brewing Systems. Breweries which most commonly brewed double batches were represented here by taking 1/2 their double batch time.

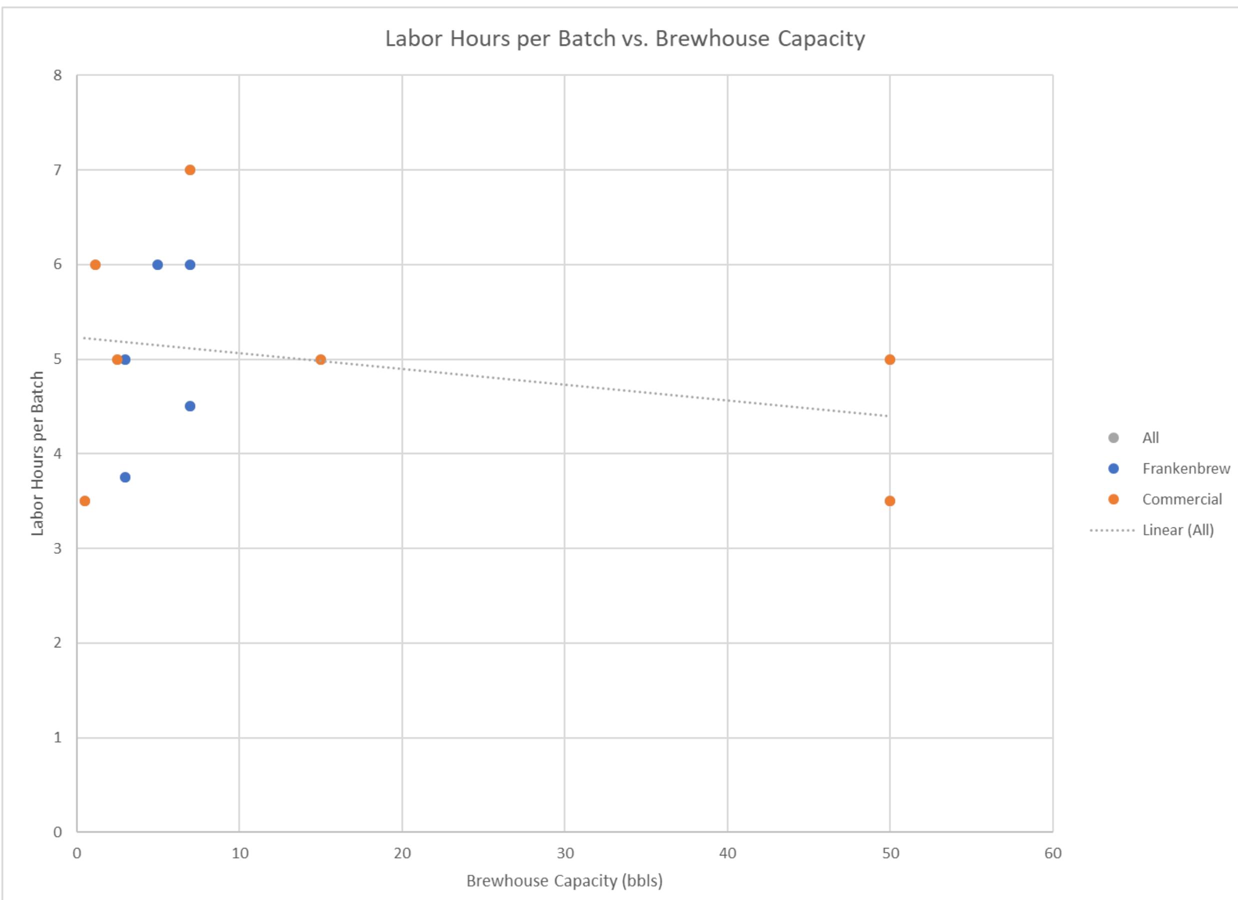
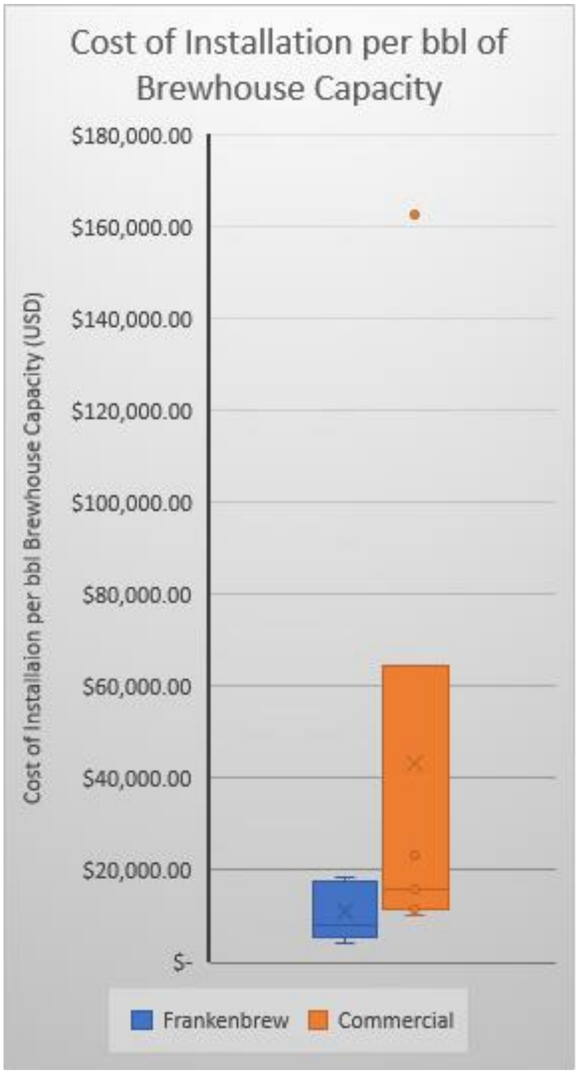


Figure 4: Scatterplot of Labor Hours per Single Batch as a Function of Brewhouse Capacity



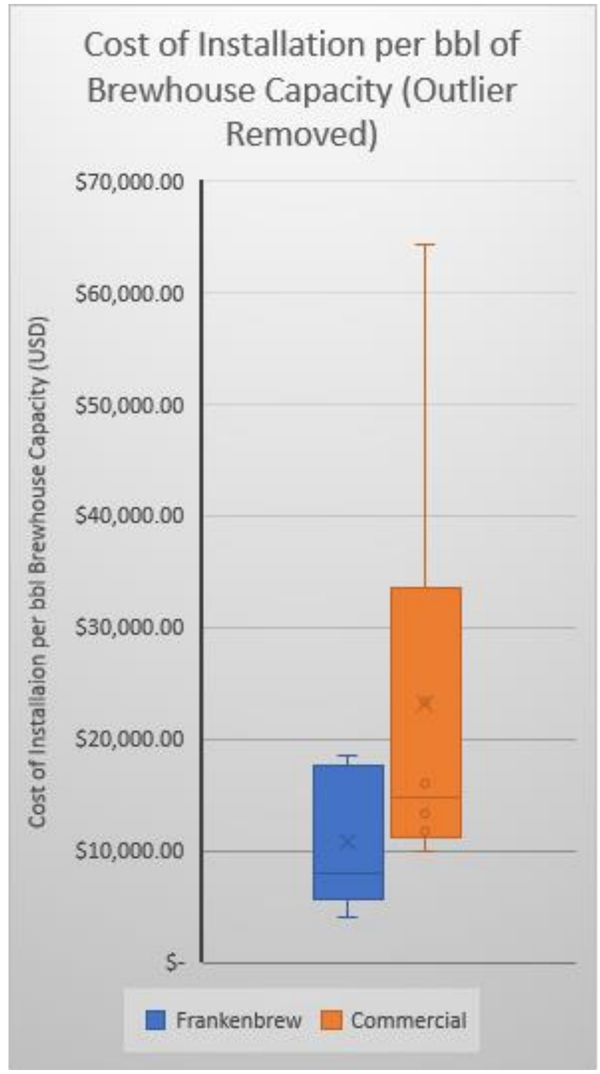


Figure 5 (left): Boxplot Comparison of Cost of Brewhouse Installation between Frankenbrew and Commercially Manufactured Systems

Figure 6 (right): Boxplot Comparison of Cost of Brewhouse Installation between Frankenbrew and Commercially Manufactured Systems with the Educational Brewery Outlier Removed

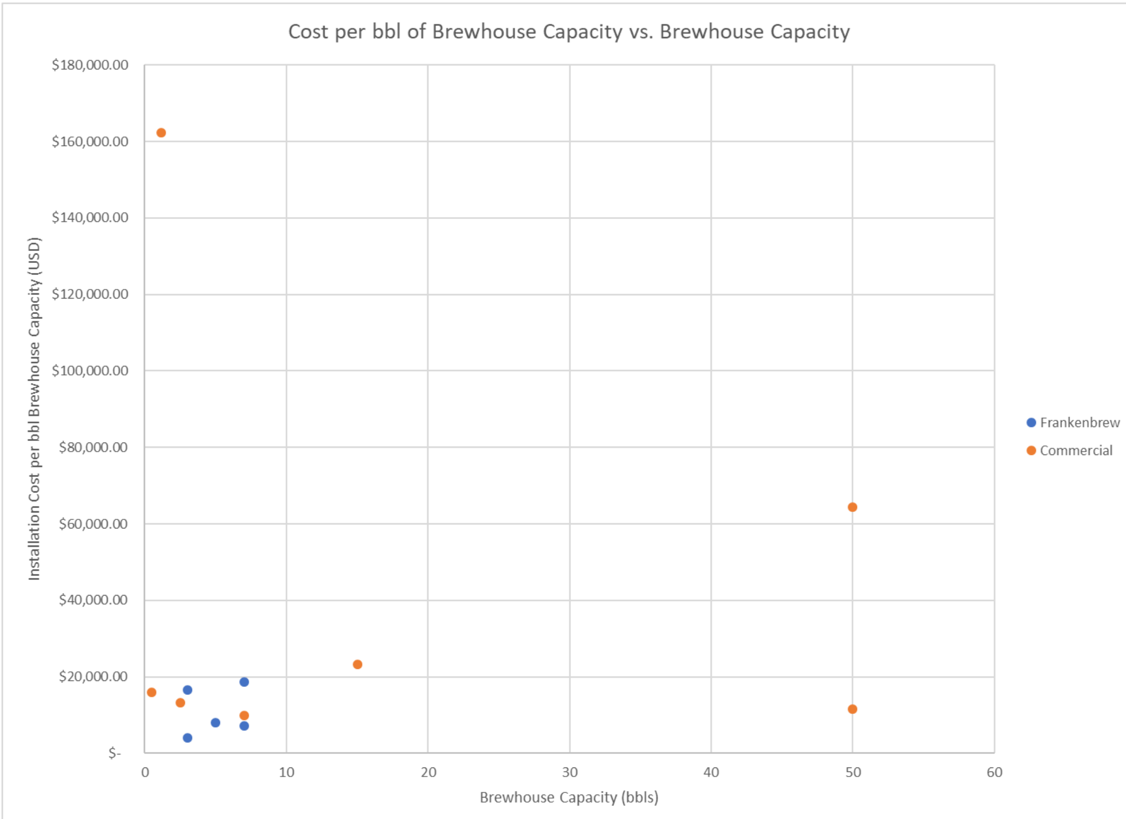


Figure 7: Scatterplot of Installation Cost per Barrel of Brewhouse Capacity as a Function of Brewhouse Capacity

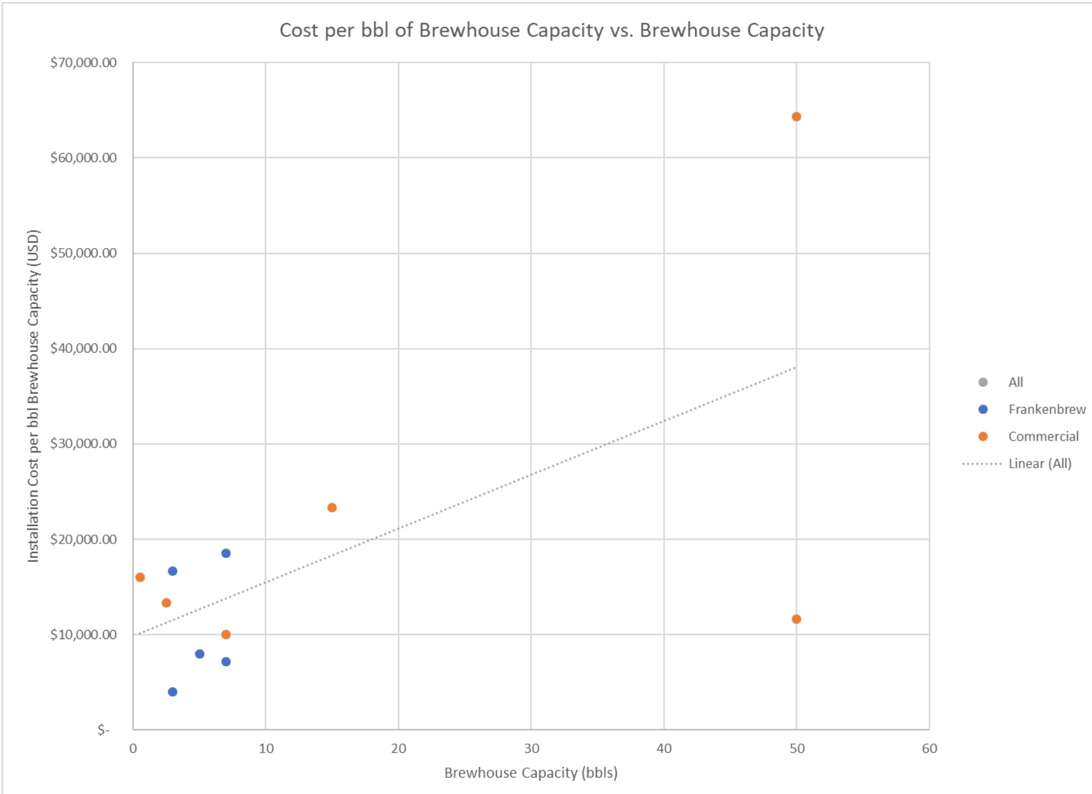


Figure 8: Scatterplot of Installation Cost per Barrel of Brewhouse Capacity as a Function of Brewhouse Capacity with the Educational Brewery Outlier Removed

Figure 9: Scatterplot of Time Required to Brew 1bbl of Wort as a Function of Brewhouse Capacity

Discussion

Quantitative

The box plot and t-test comparing brewhouse extract efficiency revealed that statistical difference exists at a 90% confidence interval between Frankenbrew and Commercially manufactured systems. The scatter plot of brewhouse extract efficiency showed only a very weak correlation between increasing brewhouse capacity and increasing extract efficiency.

The box plot and t-test comparing labor hours to brew a single batch of wort showed no statistical difference except at the 50% confidence interval and below. The corresponding scatter plot of labor hours as a function of brewhouse capacity showed little to no evidence that increasing brewhouse capacity decreases labor hours. However, figure 9 graphically shows the (intuitive) trend of decreasing the number of hours required to brew 1bbl of beer. This should make sense, because if the length of a brew day isn't significantly changing with an increase in brewhouse capacity, that increased capacity itself means that a brewer can produce a significantly larger volume of beer in the same amount of time.

Finally, the cost of installation per bbl of capacity was determined not significantly different between Frankenbrew and Commercially manufactured systems by the t-test except at the 50% confidence interval. However, the box plot comparison visually illustrates that commercially manufactured systems have a much greater deviation of installation cost that extends far above the Frankenbrew cost data. While removal of the outlying data point from the custom-built educational brewing system has little effect on the result of the t-test, the commercially manufactured data still seems to have a greater cost potential based on visual analysis of the boxplot. If more data points were available, this may prove to have significant difference statistically.

The scatter plot Figure 8 seems to show a weak correlation between increasing brewhouse capacity and increasing the cost per barrel of installation once the outlying educational brewery data point is removed. It may at first seem counterintuitive that increasing scale would also increase the cost of installation, but increasing capacity is often paired with purchase of more technologically advanced equipment that in some way affects the quality of the product or increases automation. These benefits can be weighed to offset an increase in installation cost.

In the case of both extract efficiency and cost of installation, it would be advantageous to obtain more data points to evaluate the impact of brewhouse capacity, since both cases seemed to suggest a trend that may skew the comparison of Frankenbrew vs. Commercially manufactured systems data.

Qualitative

When asked about the research involved in selecting or creating a brewing system, nearly every brewer said that they spent a significant amount of time talking to other brewers beforehand. Every brewer except one indicated that they preferred the idea of installing a commercially manufactured brewing system to a Frankenbrew system. That Frankenbrew was the only economically feasible option at the time was the reason given for the installation of Frankenbrew equipment on every account.

Positive comments about Frankenbrew involved a personal preference for specific traits of the brewing system. Two brewers expressed pride in their Frankenbrew systems' lack of automation, "This system allows brewers to learn from the ground up. If you're learning how to drive, you're not given the keys to a Lambo…this system makes it so we have to pay attention to things that a button controls on other systems," said one.

Brewers indicated multiple concerns that they associated with the use of Frankenbrew equipment. One brewer said that his Frankenbrew system was initially selected for its low-cost relative to commercially manufactured options, but went on to say that it was continually becoming less cost effective as various updates and repairs needed to be made. He maintained that a new traditional system would have required less maintenance, and in the long run would not have been much more expensive. Frankenbrew was perceived as less safe than traditional equipment by one brewer, who cited a design flaw he had once dealt with that resulted in a low-level carbon monoxide build up in his production facility. Even proponents of Frankenbrew admit that the performance of the equipment deal directly with the competence of the person or people who design, build and use the system. One brewer, for instance noted a flaw in a previous Frankenbrew design he had owned that limited the grain bill capacity and therefore styles of beer he could make.

In trying to find why the cost of installation for Frankenbrew systems was not significantly lower than the commercially manufactured systems researched, other cost cutting methods employed by brewers of traditionally manufactured systems were noted. First, brewing on a very small scale (1bbl or less) allowed for a low investment means of starting a brewery. Second, as other breweries close or update, used equipment can become available for purchase at a discounted rate. Third, some manufacturers have begun to specialize in small-scale brewing equipment that targets the upstart brewpub on a budget. Likewise, manufacturers of equipment in foreign countries such as China have become increasingly competitive in their pricing, at an acceptably lower quality.

Overall

While there is not strong enough quantitative evidence to say that implementation of Frankenbrew is definitively better or worse than using commercially manufactured equipment, this research did yield some interesting information to consider. Namely, Frankenbrew equipment does correlate with a slight drop in brewhouse efficiency, and there was a hint that Frankenbrew equipment may correspond with a slightly lower installation cost, even though this was not confirmed statistically. Use of Frankenbrew equipment does not seem to have a significant effect on brew time, but some brewers described it as more hands-on due to the absence of automation seen in some commercial equipment. More research on the factor of differing brewhouse capacity could reinforce these findings by assessing whether it affects any of the variables independently. From the findings of this study alone, it seems that besides the benefit of low cost, deciding whether to install a Frankenbrew system may ultimately be most influenced by a brewer's personal preference.

Resources

B, Billy. "*A Homebrewer Gets to Brew on a Big Boy System." Brilliant Drinks*, 2017, http://homebrewacademy.com/factotum-brewhouse/.

Hennessy, Tom. *Brewery Operations Manual: 3 Steps to Open and Run a Successful Brewery.* Montrose Colorado: Tom Hennessy, 2015.

Smith, Sylvia; Farrish, John; McCarroll, Matthew; and Huseman, Elizabeth (2017) "Examining the Craft Brew Industry: Identifying Research Needs," International Journal of Hospitality Beverage Management: Vol. 1 : No. 1 , Article 3. http://scholars.unh.edu/ijhbm/vol1/iss1/3