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Undergraduate Review

Volume 11 Article 23

2015

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Janice Bowen
Bridgewater State University

Rebecca Uboldi
Bridgewater State University

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Recommended Citation

Bowen, Janice and Uboldi, Rebecca (2015). Selection of Inflatable Bounce Houses Using Data Envelopment Analysis. *Undergraduate Review*, 11, 126-130.
Available at: http://vc.bridgew.edu/undergrad_rev/vol11/iss1/23

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Selection of Inflatable Bounce Houses Using Data Envelopment Analysis

JANICE BOWEN & REBECCA UBOLDI

Introduction

Inflatable bounce houses were first introduced in Shreveport, Louisiana in 1959. John Scurlock, a mechanical engineer, had an idea while watching his employees bounce on an inflatable tennis cover he had recently designed. When he saw how much fun his employees were having, Scurlock created an inflatable floor for recreational purposes. Scurlock's idea evolved into a company called "Space Walks." Originally, the space walks were basically inflatable mattresses, but the design soon evolved into a bounce type structure complete with walls and circulating air for inflation. The structures were referred to as Moonwalks and became quite popular during the Space Race in the 1960's. Soon after, safety regulations were passed in the United States and the United Kingdom, and the industry of inflatable structures was born (2012, May 30).
The popularity of moonwalks developed the inflatable rental industry, which includes such inflatable structures as slides, obstacle courses, games and more. Inflatable house rentals are popular items for birthday parties, fundraising events, and festivals. The price to rent an inflatable bounce house for one day in the southeastern region of Massachusetts ranges from $125 to $295, depending on the size of the structure. The rental price often includes delivery and set up, but additional charges may be incurred for deliveries made outside of the rental company's delivery area. The cost to purchase a bounce house ranges from $50 to $500 depending on the size and features. As a result of the price to rent an inflatable house for one day, many parents and potential renters find it more economical to purchase an inflatable bounce house rather than rent multiple times.

Consumers may have a difficult time deciding on an inflatable bounce house to purchase because, in addition to cost, a variety of features, such as structure size, weight capacity, weight of product, customer ratings, and number of customer ratings must be compared. A customer may be concerned with the size of the structure, while a different customer looks strictly at price. The purpose of this paper is to use Data Envelopment Analysis to determine which inflatable bounce house is most efficient. In this study, twelve inflatable bounce houses have been compared. The input variable is the cost of the inflatable house. The output variables are customer ratings, number of customer ratings, product size, product weight, and weight capacity. The product weight is viewed as a negative output because a heavier bounce house may be more difficult for the consumer to transport and set up, which would not be a positive feature.

Literature Review

To our knowledge, there are no academic research papers directly using the Data Envelopment Analysis (DEA) model to assist in the selection of inflatable bounce house. However, there are published papers that compare and select various consumer products using the DEA model to, such as smartphones (Mustafa and Peaw, 2005), notebook personal computers (McMullen and Tarasewich, 2000), and automobiles (Papahristoudoulou, 1997).

DEA Model

DEA is a non-parametric approach to relatively evaluate the performance of a homogeneous set of entities referred to as Decision Making Units (DMU's) in the presence of multiple weight inputs and multiple weight outputs. DEA was first initiated by Charnes, Cooper and Rhodes (CCR) (Charnes et al. 1978) to compare the efficiency of multiple service units that provide similar services by considering their use of multiple inputs in order to produce multiple outputs. DEA can incorporate multiple inputs and multiple outputs into both the numerator and the denominator of the efficiency ratio without the need for conversion to a common dollar basis. As a result, the DEA measure of efficiency accounts for the mix of inputs and outputs and is more reliable than a set of operating ratios or profit measures.

DEA is a linear programming model that attempts to maximize a DMU's efficiency, expressed as a ratio of outputs to inputs, by comparing a particular unit's efficiency with the performance of a group of similar service units that are delivering the same service (Charnes et al. 1978). In the process, some units achieve 100 percent efficiency and are referred to as the relatively efficient units. The units that have efficiency ratings of less than 100 percent are referred to as inefficient units. The DEA linear programming model is formulated according to Charnes, Cooper, and Rhodes, and is referred to as the CCR Model, which is described below.

Definition of Variables:

Let Ek, with k = 1, 2, …,K, be the efficiency ratio of unit k, where K is the total number of units being evaluated.

Let uj, with j = 1, 2, …, M, be a coefficient for output J, where M is the total number of output types considered. The variable u is a measure of the relative decrease in efficiency with each unit reduction of output value.

Let vi, with I = 1, 2, …, N, be a coefficient for input I, where N is the total number of input types considered. The variable vi is a measure of the relative increase in efficiency with each unit reduction of input value.

Let Ojk be the number of observed units of output j generated by service unit k during one time period.

Let Iik be the actual units of input I used by service unit k during one time period.

Objective Function:

The objective is to find the set of coefficient u's associated with each output and of v's associated with each input that will give the service unit being evaluated the highest possible efficiency.

$$\text{Max } E_e = \frac{u_1 O_{1e} + u_2 O_{2e} + \ldots + u_M O_{Me}}{v_1 I_{1e} + v_2 I_{2e} + \ldots v_N I_{Ne}}$$

where e is the index of the unit being evaluated. This function is subject to the constraint that when the same set of input and output coefficients (u_j's and v_i's) is applied to all other decision making units being compared, no DMU will exceed 100 percent efficiency or a ratio of 1.0.

Constraints:

$$\frac{u_1 O_{1k} + u_2 O_{2k} + \ldots u_M O_{Mk}}{v_1 I_{1k} + v_2 I_{2k} + \ldots v_N I_{Nk}} <= 1.0 \quad k = 1, 2, \ldots, K$$

where all coefficient values are positive and non-zero.

To solve this fractional linear programming model using standard linear programming software requires a formulation. Note that both the objective function and all constraints are ratios rather than linear functions. The objective function is restated as a linear function by scaling the inputs for the unit under evaluation to a sum of 1.0.

$$\text{Max } E_e = u_1 O_{1e} + u_2 O_{2e} + \ldots + u_M O_{Me}$$

Subject to the constraint that:

$$v_1 I_{1e} + v_2 I_{2e} + \ldots v_N I_{Ne} = 1$$

For each service unit, the constraints are similarly reformulated:

$$(u_1 O_{1k} + u_2 O_{2k} + u_M O_{Mk}) - (v_1 I_{1k} + v_2 I_{2k} + vNINk) <= 0$$
$$k = 1, 2, \ldots, K$$

where:

$$u_j >= 0 \qquad j = 1, 2, \ldots, M$$
$$v_i >= 0 \qquad i = 1, 2, \ldots, N$$

Recommended sample size: K>= 2 (N + M)

Data and Preliminary Data Analysis

Our output variables include the following dimensions: 1) customer rating, which is based on a scale of one to five, with five being the highest rating; 2) number of customer ratings; 3) product size (in cubic feet); 4) product weight in pounds (excluding shipping weight); and 5) the weight capacity in pounds for each bounce house. Considering the challenges of transportation, consumers would prefer the lighter bounce house. Therefore this study treats the product weight as a negative output. This negative output needs to be treated differently because normally one would increase the output value to make the unit more efficient, but in this case, increasing the product weight would make the unit less efficient. As a result, the negative output has been treated as an input (Seiford & Zhu, 2002). The input variable is the price of the bounce house. Shipping prices were not evaluated because shipping could be free depending on whether or not the consumer has a Prime membership with Amazon. For the purposes of evaluating the most popular bounce houses, the data for the above inputs and outputs for each bounce house are shown in Table 1. All of the information contained in the data table was taken from the Amazon.com web site.

Results

This study employed the DEA model to formulate the entire problem, which was then solved through the Excel 2010 Solver. Twelve bounce houses were evaluated, and seven of them were found to be efficient using the DEA model. Bounce houses with scores of 1.00 are efficient when compared to the others evaluated. Bounce houses with scores of less than one are inefficient. Efficiency scores of all of the bounce houses that were evaluated are shown in Table 2.

Recommendations

Shadow price is the solution of the dual problem of the linear programming. In DEA models, shadow price provides the extent to which inefficient DMU's refer to efficient DMU's in order to become efficient. Recommendations for making the less efficient units more efficient are shown in Table 3.The results of Table 3 are summarized as follows:

•Little Tikes Triangle: To improve efficiency, the number of customer ratings should increase from 41 to 64; the product weight should decrease from 29.8 to 25.03; and the price should decrease from \$185 to \$138.81.

•Little Tikes Shady Jump 'n Slide: To improve efficiency, the customer rating should increase from 4.5 to 4.6; the product weight should decrease from 38.3 to 35.97; and the price should decrease from $239 to $224.44.

•Cloud 9 Mini Crayon: To improve efficiency, the number of ratings should increase by from 27 to 28; the weight capacity should increase from 300 to 309; the product weight should decrease from 51 to 45.32, and the price should decrease from $249 to $236.41.

•Cloud 9 Tunnel Course: To improve efficiency, the customer rating should increase from 1 to 2.94; the number of ratings should increase from 1 to 22; the weight capacity should increase from 300 to 327; the product weight should decrease from 46 to 42.5; and the price should decrease from $358 to $306.53.

•Bounceland Dream Castle: To improve efficiency, the number of ratings should increase from 20 to 52; the product weight should decrease from 45 to 37.11; and the price should decrease from $398 to $234.12.

Conclusion

Data Envelopment Analysis was used to compare twelve inflatable bounce houses in order to determine the most efficient. This simple tool can help the consumer compare the many different models of bounce houses that are available on the market. The results of this research showed that seven bounce houses were found to be efficient when compared to the others. Although the results cannot identify the best one for the consumer to purchase, they can narrow down the choices by ignoring the inefficient ones. As a result, the consumer can make a final decision according to personal needs, for example, choosing the one that best fits in their yard. Therefore, they can optimize their final decision.

Manufacturers of inflatable bounce houses also benefit from this study, especially those who produce inefficient ones. Using results of DEA models, manufacturers can improve the features of the current inflatable bounce houses or implement new strategies to improve customer evaluations. In addition, the information here can aid in the design of next generation products in order to gain a better share of the market.

Limited by the data resources, this study does not include some factors that might be important for customers when they select inflatable bounce houses. For example, the durability of the product, measured by the length of usage, could be an interesting dimension to investigate. Meanwhile, although this study treats the weight of the product as a negative output, a subset of customers might argue that they would prefer a heavier bounce house because of durability and safety concerns. Future research would address the above concerns. Based on the application to inflatable bounce houses selection, the DEA model also can be applied to other purchasing decision making processes.

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Table 1. Bounce House Data Table

Bounce House)		Customer Rating (Scale of 1 to 5	Number of Customer Ratings	Product Size (Cubic ft.)	Weight Capacity (pounds)	Product Weight (pounds)	Price (US $)
Intex Jump O Lene Castle Bouncer	DMU_1	3.5	51	146	120	13.2	50
Intex Jump O Lene Transparent Ring	DMU_2	4	65	71	200	15.2	69
Intex palyhouse Jump O Lene	DMU_3	3.5	150	120	120	19	44
Little Tikes Triangle	DMU_4	4.5	41	374	250	29.8	185
Little Tikes Shady Jump 'n Slide	DMU_5	4.5	261	648	250	38.3	239
Little Tikes Jump 'n Slide Dry	DMU_6	4.5	365	648	250	37.5	257
Cloud 9 Mini Crayon	DMU_7	5	27	850	300	51	249
Cloud 9 Tunnel Course	DMU_8	1	1	1084	300	46	358
Cloud 9 Princess	DMU_9	4.5	18	867	300	45	239
Bounceland Castle with Hoop	DMU_{10}	4.5	334	756	250	40	259
Bounceland Dream Castle	DMU_{11}	4.5	20	803	300	45	398
Bounceland Pop Star	DMU_{12}	4.5	33	1658	500	65	469

Table 2. Bounce House Efficiency Results

			Shadow Price											
DMU	Name of Bounce House	Eff Val.	DMU 1	DMU 2	DMU 3	DMU 4	DMU 5	DMU 6	DMU 7	DMU 8	DMU 9	DMU 10	DMU 11	DMU 12
1	Intex Jump O Lene Castle Bouncer	1.00	1	0	0	0	0	0	0	0	0	0	0	0
2	Intex Jump O Lene Transparent Ring	1.00	0	1	0	0	0	0	0	0	0	0	0	0
3	Intex Playhouse Jump O Lene	1.00	0	0	100	0	0	0	0	0	0	0	0	0
4	Little Tikes Triangle	0.84	.3771	.6079	0	0	0	0	0	0	0	0	0	.1663
5	Little Tikes Shady Jump 'n Slide	0.93	.1736	.1427	0	0	0	0	0	0	0	.7232	0	.0397
6	Little Tikes Jump 'n Slide Dry	1.00	0	0	0	0	0	1	0	0	0	0	0	0
7	Cloud 9 Mini Crayon	0.94	.2145	0	0	0	0	0	0	0	.9443	0	0	0
8	Cloud 9 Tunnel Course	0.92	0	0	0	0	0	0	0	0	0	0	0	.6538
9	Cloud 9 Princess	1.00	0	0	0	0	0	0	0	0	1	0	0	0
10	Bounceland Castle with Hoop	1.00	0	0	0	0	0	0	0	0	0	1	0	0
11	Bounceland Dream Castle	0.82	.7327	.0122	0	0	0	0	0	0	0	0	0	.4193
12	Bounceland Pop Star	1.00	0	0	0	0	0	0	0	0	0	0	0	1

Table 3. Recommendations to Improve Efficiency

	Customer Rating (1-5)	Number of Ratings	Product Size (cubic feet)	Weighr Capacity (lbs)	Product Weight (lbs)	Price (US $)
Little Tikes Triangle	4.5	64	374	250	25.03	138.81
Little Tikes Shady Jump 'n Slide	4.61	261	648	250	35.97	224.44
Cloud 9 Mini Crayon	5	28	850	309	45.32	236.41
Cloud 9 Tunnel Course	2.94	22	1084	327	42.5	306.63
Boumceland Dream Castle	4.5	52	803	300	37.11	234.12

About the Authors

Janice Bowen and Rebecca Uboldi worked together to develop a study that would assist consumers in selecting and purchasing an inflatable bounce house through the use of Data Envelopment Analysis. Their project was completed in the fall of 2014 under the mentorship of Dr. Xiangrong Liu (Management). Janice will graduate in the spring of 2015 with a bachelor's degree in General Management at BSU. She works for the Department of Counselor Education at BSU. Rebecca will also be graduating in the spring of 2015. She is majoring in Accounting and Operations Management and minoring in Actuarial Science..