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Organics to You - Optimization of Produce Bins

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Organics to You - Optimization of Produce Bins

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1. Executive Summary

Organics to You (www.organicstoyou.org) [1] is a produce delivery company that focuses on bringing organic local food from local farms straight to the homes, schools, and businesses of its clients. Each week a "Small Bin" is created using different varieties of local produce from various farms. Customers receive a bin that contains 12-14 varieties of produce with 2-6 "servings" of each variety (e.g., 1 melon, 4 apples, 1 head of lettuce, 2 lbs potatoes, etc).

Our objective is to optimize the contents of the "Small Bin". The decision we want to make is how much of each variety do we include in the bin while minimizing capital costs, thus maximizing profits. Constraints will aim to keep each variety within the appropriate "servings" range in order to ensure a well rounded bin and avoid overloading customers with too much of one thing, i.e. we cannot just give everyone twenty pounds of potatoes as cheap as that might be.

2. Introduction

This project is a proof of concept to show Organics to You's management team there is an opportunity to minimize capital cost when it comes to picking and choosing produce for the bins. Currently the company is offering 12 different sizes of produce bins. Due to the time constraint, our team will only focus on the "Small Bin" for this project. In order to test our concept, we started with the Add-On option, that has a smaller selection of categories and products.

From Organics to You's website, a "Small Bin" is ideal for a couple or small family. The bin contains a mixture of 12 to 14 varieties of fruits and veggies, and it cost $38 per bin to the customers. The capital cost to the company for a "Small Bin" is standing at about $18-$22. To maximize company profit, we will build a model to minimize the capital cost while keeping the number of bin mixture unchanged to ensure minimal impact for our customers.

Organics to You also offers produce add-ons. Add-ons are small additional "packages" that customers can add on to their order (in case a Small Bin is too small or customers want to add on specific items). Add-ons are roughly half the size of a full bin, so they offered a convenient way to test our model with smaller quantities. We started testing our model with the Fruit Add-on, which consist of 6 varieties of fruit. By beginning with this smaller product, we were able to refine our model before easily scaling up to the larger model with all the options and variables of the Small Bin.

3. Project Objective

We started out with extensive research on similar market for ideas and references. Several articles and models were found for the diet research which help give us a start. We have the participation and support of several of the company's staff members to get details on produce, selection process, and pricing. After a few rounds practicing building the data set and model, we finalized our data set to include a list of products, amount of servings per unit, minimum and maximum amount of produce allowed, and capital cost for each item. During the process, we realized production costs are not fixed due to market fluctuation. We approached building our model with the data set for an Add-On option first because the add-on is only 6 items. This greatly reduced our number of variables and helped us work out the kinks before expanding to our larger model.

Excel Solver was the tool we used to build our model. The tool allows us to define our objective, and constraints in return of optimal solution for our problem. With the minimal data set for Add-On option, Solver worked wonderfully. However, when we attempted to run with data set for the Small Bin, we ran into Solver limitation which led us to use Open Solver.

Despite these issues, we achieved our objective of minimizing the produce capital cost for Organics to You. For the Small Bin, produce capital cost range is $18-$22. We found an optimal solution of $15.49 which represents a 14% reduction from the lower bound of the capital cost range, and a 30% reduction from the upper bound of the capital cost range.

4. Literature Research

In many organizations, how to maximize the profit and how to minimize the costs are important concerns for the company. In the team project, the company needs to optimize the contents of the "Small Bin," which means each bin needs to minimize the cost. Meanwhile, each bin needs to be well-rounded, offering a generous array of both fruits and vegetables.

The diet problem is the classic problem for selecting a set of foods that people need for a daily nutritional requirement [2]. The goal is to find a low price, but people can still have a healthy diet. They need to compare the prices of the foods as well as their nutritional value. Also, the diet problem had a concern with the optimal solution not being very "palatable." They used constraints to make sure it had "tasty" items, not just cheap nutritional items. Similarly, we used constraints to ensure variety. To achieve it, it could be an optimization problem that we need to minimize the price while maximizing nutritional value.

The diet problem is similar to our project in some ways. For example, the objective function of the diet problem is to minimize cost and maximize nutritional value. Our goal here was to let our customer have variety food but also minimize our cost. We went through the diet problem to understand the standard of selecting variety food for the meals as we considered how to build our model.

Using the diet problem, we put all our product information in a price list on an Excel spreadsheet. By using this information, we looked up the values of in different categories groups as well as their prices. The optimization problem for this results in how many items and how much we need to put into our product bin. After building the model, we got a great variety foods with a minimizing price as we wanted.

The project is a linear programming (LP) problem. Baker's (2015) book is our textbook[3], and we used it as a guidebook to go through our team project especially Chapter 3 (LP problem), Chapter 6 (Binary), and Chapter 7(big M) are helpful for building the project model. On the other hand, Ragsdale(2001) gave many detail example of these theory that we can try on[4]. We will talk about more how we use these constraints in our team project later, and how we find the solution for our problem to help the company optimize the cost of the product bins.

5. Data Gathering

Data was gathered by collecting and reviewing current invoices at Organics to You. Data was collected in raw form and needed to be cleaned up to fit into the model. Prices were listed on primitive invoice sheets, and they can fluctuate from week to week. All prices are listed on Appendix A. Prices for our project's purpose are listed as a simple value in our model as we adjusted variables and worked out kinks in the model. In order to use the model properly, we would link the price values in the model to a price sheet which would be easy to update on a weekly or even daily basis. The prices used in our model however are realistic and allow our team to consider the accuracy of any results given by the model. By understanding what a normal bin would look like in terms of servings, we can better understand how accurate of a solution our model delivers. Organics to You bins are focused not just on variety and price, but also volume and weight. While those variables are hard to depict in the model, assigning items to categories helped to assure that customers would receive some light but fluffy items (kale, lettuce, etc.) as well as dense but heavy items (carrots, potatoes, etc.).

Produce is purchased by the case in most cases and by bulk bin in others. While some items are charged by the weight, others are charged by the count. Therefore, we defined item units in terms of either pounds (lbs) or count (ct). In order to compare the value of counted items versus the value of weighted items, we assigned a servings per unit value for each item. This allowed us to see that a head of lettuce is worth four servings while a whole apple is only two servings. By using this method, we know that a head of lettuce is roughly equal to two apples in terms of the meal servings the bin can provide for a customer.

Appendix B shows a sample scanned invoice. We used the prices listed but then had to break them down to the cost per unit. By collecting prices over the course of a few weeks, we were able to obtain realistic prices for our model. This allowed us to have a good understanding of our results, and we were able to tell if the results were sensible.

6. Mathematical Formulation and LP Model Development

Mathematical Formulation

Assumptions:

Add-on fruit (initial test model)

1. Each category cannot be selected beyond 1 item.
2. Each add-on has to have at least 6 categories.
3. Amount of each selected item must be grather than or equal minimum amount , and no more than maximum amount of that item.
4. Each order has to have at least 30 serving unts.

Small bin (final model)

1. Each category cannot be selected beyond 1 item.
2. Each bin must have at least 12 categories.
3. Amount of each selected item must be grather than or equal minimum amount, and no more than maximum amount of that item.
4. Each box has to have at least 60 serving unts.

Parameters:

x_i : amount of item i $\quad i \ \varepsilon \ \{1, 2, 3, ..., 46\}$

$y_i = \{1 \ \textit{if i is selected}, \ 0 \ \textit{otherwise} \} \ y_i \ \varepsilon \ \textit{binary}$

c_i : cost of item i in $/unit

k : category $\quad k \ \varepsilon \ \{1, 2, 3, ..., 18\}$

s_i : amount of serving unit of item i

Decision variables:

x_i : amount of item i $\quad i \ \varepsilon \ \{1, 2, 3, ..., 46\}$

$y_i = \{1 \ \textit{if i is selected}, \ 0 \ \textit{otherwise} \}$

Objective:

To minimize cost of the small bin

$$\text{Min} \ \sum_{i=1}^{46} c_i \, x_i$$

Constraints:

Each category cannot be selected beyond 1 item.

$$\sum_{i=1}^{k} y_i \leq 1 \quad \text{for } k = \text{cat 1, cat 2,..., cat 18}$$

By putting our items in 18 categories, we were able to ensure that customers did not get more than one of several similar produce items. For instance, we would only want to include one type of hardy green. Therefore our model will only include at most one of the following: kale, chard, or bok choy.

Each box has to have at least 12 categories.

$$\sum_{i=1}^{46} y_i \geq 12$$

After putting similar items in categories, we required at least 12 of the 18 categories to be included in the bin so as to ensure that each bin had some fruit, some greens, some root vegetables, etc.

Amount of each selected item must be greater than or equal minimum amount of that item.

$$x_i - m \bullet y_i \geq 0 \quad m : \text{minimum amount of the item}$$

This is our linking constraint for little m. This logical constraint was needed to enforce that the minimum amount of an item was included, but that this rule was only enforced if the item was included in the bin at all.

Amount of each selected item must be less than or equal maximum amount of that item.

$$x_i - M \bullet y_i \leq 0 \quad M : \text{maximum amount of the item}$$

This is our linking constraint for Big M. This logical constraint was needed to enforce that the maximum amount of an item was never exceeded, but that this rule was only enforced if the item was included in the bin at all.

Each box has to have at least 60 serving units.

$$\sum_{i=1}^{46} s_i \geq 60$$

This ensures that each bin has a significant amount of meal or snack servings. Some items must be included as a whole item (melons, apples, etc.), but a melon would provide more servings than an apple. This constraint takes that into consideration and requires the bin to include enough substance to be satisfactory to the customer.

Non-negativity

$$x_i \geq 0$$

There is no such thing as a negative mushroom so we must assume non-negativity.

Binary

$$y_i \ \varepsilon \ \textit{binary}$$

This allows our logical constraints to determine whether or not a particular item is included in the bin at all.

Integrality (for items in ct)

$$x_5, x_6, x_7, x_{12}, x_{13}, x_{15}, x_{16}, x_{17}, x_{18}, x_{19}, x_{20}, x_{21}, x_{22}, x_{23}, x_{29}, x_{30}, x_{32}, x_{33}, x_{34}, x_{35}, x_{36}, x_{38}, x_{43} \ \varepsilon \ \textit{Integer}$$

These items (such as melons, apples, heads of lettuce, etc.) must be included as an integer in the model. That means they will be included as whole items in a bin.

Linear Programming Excel Model

The mentioned parameters can be expressed as following:

- The number of all item is 46
- The number of all category is 18
- The total serving unit is 60
- Total number of variables is 92 (Half of them are binary variables)

According to the gathering data, there are 46 product items (x_i) in 18 categories (k). The small bin must have at least 12 items, but each item needs to be in different category as shown in Table 1. Therefore, we need to apply binary variables (y_i) to the excel model. If item i is selected then y_i is 1; otherwise, y_i is 0. The selected items are shown in Table 1. Each category can have no more than one selected item, so we add constraints to keep the condition which is summation of y_i in each category less than or equal 1 as shown in Table 2.

Moreover, we have maximum amount of all items in order to prevent too much amount in the cheap selected items. As the minimized model and non negativity, we need to prevent 0 amount of selected items by adding minimum amount of all items. Hence, we need to add efficient numbers to link between x_i and y_i into constraints. The efficient numbers are M (big M) and m (little m) in case of the maximum amount and the minimum amount, respectively.

There are 23 items in pound unit (lbs) and 23 items in count unit (ct). The count unit items must be integer as shown i (little i symbol) in the row of x_i in Table 1. We also consider the serving unit that has to be at least 60 serving units in the small bin as shown in Table 2.

We computed the objective with all constraints by Solver in Excel, but we could not find the optimal solution. Solver showed limitation of 200 variables and 100 constraints. Hence, we used OpenSolver which provides more range of variables and constraints [5].

Table 1 - The optimal solution

Category (k)	Item number (i)	Item	Unit	Price per unit	Amount of units to be included (Xi)	Binary (Yi)	Servings per unit (Si)	Sum Serving	little m Min (units)	Big M Max (units)	Logical constraint (little m) x-my>= 0	Logical constraint (Big M) x-My<= 0
1	1	Squash - Delicata	lbs	$0.74	0	0	3	0	1	2	0≤ 0	0≥ 0
	2	White Potatoes	lbs	$0.70	3	1	3	9	1	3	2	0
	3	Sweet Potatoes	lbs	$1.20	0	0	2	0	1	3	0	0
2	4	Banana	lbs	$0.70	2	1	3	6	0.5	2	1.5	0
	5	Mango	ct	$2.80	0	0	2	0	1	2	0	0
3	6	Cantaloupe	ct	$2.44	0	0	4	0	1	1	0	0
	7	Watermelon	ct	$2.50	0	0	4	0	1	1	0	0
4	8	Blueberries	lbs	$2.19	0	0	4	0	0.5	1	0	0
	9	Strawberries	lbs	$2.25	0	0	3	0	1	2	0	0
	10	Kiwiberries	lbs	$5.00	0	0	6	0	0.5	1	0	0
5	11	Grapes	lbs	$1.89	0	0	4	0	0.5	2	0	0
	12	Pomegranate	ct	$1.24	0	0	2	0	3	4	0	0
6	13	Pears - Red Bartlett	ct	$0.42	4	1	2	8	3	4	1	0
	14	20th Century Pears	lbs	$1.00	0	0	2	0	3	4	0	0
7	15	Apples - Honeycrips	ct	$0.60	0	0	2	0	3	4	0	0
	16	Apples - Gala	ct	$0.36	0	0	2	0	3	4	0	0
	17	Apples - Fuji	ct	$0.34	4	1	2	8	3	4	1	0
8	18	Grapefruit	ct	$1.56	0	0	2	0	1	2	0	0
	19	Orange	ct	$0.63	4	1	2	8	2	4	2	0
9	20	Bunch Parsley	ct	$0.83	1	1	4	4	1	1	0	0
	21	Bunch Cilantro	ct	$0.90	0	0	4	0	1	1	0	0
10	22	Bunch Chard	ct	$1.00	1	1	3	3	1	1	0	0
	23	Bunch Kale	ct	$1.10	0	0	3	0	1	1	0	0
	24	Baby Bok Choy	lbs	$1.50	0	0	3	0	0.5	1.5	0	0
11	25	Green Peppers	lbs	$1.20	0.5	1	2	1	0.5	1.5	0	-1
	26	Red/Gold Peppers	lbs	$1.25	0	0	2	0	0.5	1.5	0	0
12	27	Yellow Onions	lbs	$0.63	2	1	3	6	0.5	2	1.5	0
	28	Red Onions	lbs	$0.90	0	0	3	0	0.5	2	0	0
	29	Green Onions	ct	$0.67	0	0	4	0	1	1	0	0
13	30	Red Leaf Lettuce	ct	$1.25	1	1	3	3	1	1	0	0
	31	Salad Mix	lbs	$3.98	0	0	4	0	0.5	1	0	0
14	32	Bunch Radish	ct	$1.37	0	0	3	0	1	1	0	0
	33	Bunch Beets	ct	$1.33	0	0	3	0	1	1	0	0
	34	Bunch Carrots	ct	$1.58	0	0	3	0	1	1	0	0
15	35	Fennel	ct	$1.50	0	0	3	0	1	1	0	0
	36	Celery	ct	$1.58	0	0	3	0	1	1	0	0
	37	Cucumber	lbs	$1.50	0	0	3	0	1	2	0	0
	38	Avocado	ct	$1.60	0	0	2	0	1	3	0	0
	39	Eggplant	lbs	$1.75	0.5	1	4	2	0.5	1.5	0	-1
	40	Mushrooms - Crimini	lbs	$2.70	0	0	4	0	0.25	0.5	0	0
16	41	Tomatoes on the vine	lbs	$2.00	0	0	3	0	0.5	2	0	0
	42	Tomatillos	lbs	$2.00	0	0	4	0	0.5	1.5	0	0
17	43	Lemon	ct	$0.65	1	1	2	2	1	2	0	-1
	44	Lime	lbs	$1.45	0	0	2	0	0.5	1	0	0
18	45	Garlic	lbs	$4.67	0	0	8	0	0.25	0.75	0	0
	46	Ginger	lbs	$6.00	0	0	8	0	0.25	0.75	0	0

Table 2 - The objective and constraints

Category 1	1	<=	1
Category 2	1	<=	1
Category 3	0	<=	1
Category 4	0	<=	1
Category 5	0	<=	1
Category 6	1	<=	1
Category 7	1	<=	1
Category 8	1	<=	1
Category 9	1	<=	1
Category 10	1	<=	1
Category 11	1	<=	1
Category 12	1	<=	1
Category 13	1	<=	1
Category 14	0	<=	1
Category 15	1	<=	1
Category 16	0	<=	1
Category 17	1	<=	1
Category 18	0	<=	1
All	12	>=	≥ 12

Servings Total	60	>=	≥ 60
Objective	min 15.4931		

Table 3 - The optimal solution of Add-on option

Category (k)	Item number (i)	Item	Unit	Price per unit	Amount of units to be included (Xi)	Binary (Yi)	Servings per unit (Si)	Sum Serving	little m Min (units)	Big M Max (units)	Logical constraint (little m) x-my>= 0	Logical constraint (Big M) x-My<= 0
1	1	Banana	lbs	$0.70	2	1	3	6	0.5	2	1.5	0
	2	Mango	ct	$2.80	0	0	2	0	1	2	0	0
2	3	Cantaloupe	ct	$2.44	0	0	4	0	1	1	0	0
	4	Watermelon	ct	$2.50	0	0	4	0	1	1	0	0
3	5	Blueberries	lbs	$2.19	0	0	4	0	0.5	1	0	0
	6	Strawberries	lbs	$2.25	0	0	3	0	1	2	0	0
	7	Kiwiberries	lbs	$5.00	0	0	6	0	0.5	1	0	0
4	8	Grapes	lbs	$1.89	0.5	1	4	2	0.5	2	0	-1.5
	9	Pomegranate	ct	$1.24	0	0	2	0	3	4	0	0
5	10	Pears - Red Bartlett	ct	$0.42	4	1	2	8	3	4	1	0
	11	20th Century Pears	lbs	$1.00	0	0	2	0	3	4	0	0
6	12	Apples - Honeycrips	ct	$0.60	0	0	2	0	3	4	0	0
	13	Apples - Gala	ct	$0.36	0	0	2	0	3	4	0	0
	14	Apples - Fuji	ct	$0.34	4	1	2	8	3	4	1	0
7	15	Grapefruit	ct	$1.56	0	0	2	0	1	2	0	0
	16	Orange	ct	$0.63	2	1	2	4	2	4	0	-2
8	17	Lemon	ct	$0.65	1	1	2	2	1	2	0	-1
	18	Lime	lbs	$1.45	0	0	2	0	0.5	1	0	0

Servings Total	30	>=	≥ 30

Category 1	1	<=	1
Category 2	0	<=	1
Category 3	0	<=	1
Category 4	1	<=	1
Category 5	1	<=	1
Category 6	1	<=	1
Category 7	1	<=	1
Category 8	1	<=	1
All	6	>=	≥ 6

Objective (min): 7.28214

7. Findings & Analysis

The optimal solution from our model contains the following items:

- 3 lbs - white potatoes
- 1 ct - parsley
- 1 ct - bunch chard
- 0.5 lbs - green peppers
- 2 lbs - yellow onions
- 1 ct - red leaf lettuce
- 0.5 lbs - eggplant
- 2 lbs - bananas

- 4 ct - pears (red bartlett)
- 4 ct - apples (fuji)
- 4 ct - oranges
- 1 ct - lemon

Total cost = $15.49

This model accomplishes our objectives of reducing the cost of the Small Bin, while maintaining variety and quantity of servings. Compared to the lower bound of the original cost range ($18), the optimal solution of $15.49 represents a 14% reduction. If compared to the upper bound of the original cost range ($22), the optimal solution represents almost 30% reduction.

As our original model contains integers (to maintain integrality of items in count), sensitivity analysis was not available. For the purposes of this project, we did further analysis by using the LP relaxation, which ultimately had the same result (since our upper and lower bounds, big M and little m, were integers, the integrality was preserved). The following table contains an analysis of the items chosen in the optimal solution:

Table 4 - Analysis of chosen products

Cells	Name	Final Value	Reduced Costs	Objective Value	Allowable Increase	Allowable Decrease
F4	White potatoes	3	0	0.7	0.121107694	1E+100
F6	Banana	2	0	0.703947368	0.273661377	1E+100
F15	Pears - Red Bartlett	4	0	0.42	0.231739155	1E+100
F19	Apples - Fuji	4	0	0.336283186	0.023716839	1E+100
F21	Orange	4	0	0.625	0.026739155	1E+100
F22	Bunch Parsley	1	0	0.833333333	0.066666767	1E+100
F24	Bunch Chard	1	0	1	0.1000001	0.022391404
F27	Green Peppers	0.5	0	1.2	0.042997812	0.003478461
F29	Yellow Onions	2	0	0.625	0.034202949	1E+100
F32	Red Leaf Lettuce	1	0	1.25	0.00173923	0.272391354
F41	Eggplant	0.5	0	1.75	0.10173933	0.446521789
F45	Lemon	1	0	0.65173913	0.014927603	0.00173923

This analysis helps decision-makers identify how much the price of the items selected can vary without affecting the optimal solution. The allowable increase column shows the upper-bound on the item price, for example, the slightest increase (anything over $0.0017) in the price of Red Leaf Lettuce would change the optimal solution. Meanwhile, the price per pound of bananas could increase up to $0.26 and they would still be included in the optimal bin.

The following table contains the analysis performed on the LP relaxation of the items not chosen in the optimal model:

Table 5 - Analysis of products not chosen

Cells	Name	Final Value	Reduced Costs	Objective Value	Allowable Increase	Allowable Decrease
F3	Squash - Delicata	0	0	0.742857143	0.234751603	0.181661541
F5	Sweet Potatoes	0	0.54826087	1.2	1E+100	0.54826087
F7	Mango	0	1.8741304	2.8	1E+100	1.874130435
F8	Cantaloupe	0	0.86683575	2.444444444	1E+100	0.866835749
F9	Watermelon	0	0.9223913	2.5	1E+100	0.922391304
F10	Blueberries	0	0.33576087	2.1875	1E+100	0.33576087
F11	Strawberries	0	0.99826087	2.25	1E+100	0.99826087
F12	Kiwiberries	0	2.4965217	5	1E+100	2.496521739
F13	Grapes	0	0.042997712	1.894736842	1E+100	0.042997712
F14	Pomegranate	0	0.49217818	1.235294118	1E+100	0.492178176
F16	20th Century Pears	0	0.34826087	1	1E+100	0.34826087
F17	Apple - Honeycrisps	0	0	0.5995	0.052239155	0.263216839
F18	Apple - Gala	0	0	0.36	0.291739155	0.023716839
F20	Grapefruit	0	0.63506793	1.5609375	1E+100	0.635067935
F23	Bunch Cilantro	0	0	0.9	0.403478361	0.066666767
F25	Bunch Kale	0	0	1.1	0.138804398	0.1000001
F26	Baby Bok Choy	0	0.2776087	1.5	1E+100	0.277608696
F28	Red/Gold Peppers	0	0.05	1.25	1E+100	0.05
F30	Red Onions	0	0	0.9	0.077608746	0.240797151
F31	Green Onions	0	0	0.666666667	0.481594303	0.068405897
F33	Salad Mix	0	2.1350725	3.983333333	1E+100	2.135072464
F34	Bunch Radish	0	0.12117754	1.372916667	1E+100	0.121177536
F35	Bunch Beets	0	0.081594203	1.333333333	1E+100	0.081594203
F36	Bunch Carrots	0	0.32951087	1.58125	1E+100	0.32951087
F37	Fennel	0	0.29913043	1.5	1E+100	0.299130435
F38	Celery	0	0.38246377	1.583333333	1E+100	0.382463768
F39	Cucumber	0	0.29913043	1.5	1E+100	0.299130435
F40	Avocado	0	0.728125	1.603125	1E+100	0.728125
F42	Mushrooms - Crimini	0	0.50347826	2.7	1E+100	0.503478261
F43	Tomatoes on the vine	0	0.47413043	2	1E+100	0.474130435
F44	Tomatillos	0	0.14826087	2	1E+100	0.14826087
F46	Lime	0	0.79562929	1.447368421	1E+100	0.795629291
F47	Garlic	0	0.96318841	4.666666667	1E+100	0.963188406
F48	Ginger	0	2.2965217	6	1E+100	2.296521739

This analysis provides information about how much the prices of these items would have to decrease in order for them to be in the optimal solution. Any decrease larger than the value indicated in the allowable decrease column would cause the product to be selected. This means, for example, that Kiwi Berries would have to cost about $2.50 less per pound to be included, which is 50% of their initial price.

Finally, qualitative analysis of the optimal solution might also lead decision-makers to make adjustments. For example, maybe 4 pears, 4 apples, and 4 oranges all in one bin are not exactly what their clients are looking for, so a constraint could be added to prevent this situation. Similarly, if part of the organization's objective is to be seen as more premium when compared to their competitors, a new constraint or category could be added to make sure that at least one premium product (such as mushroom or avocado) is selected. However, it must be noted that adding constraints will make the objective function to increase. Our hope with this project is that having these models and analysis available will allow decision-makers to be more strategic when it comes to these trade-offs. By mathematically creating the best offer within initial constraints, we can more easily and effectively manage trade-offs, while measuring results.

8. Conclusion

The model gave one optimal solution as is outlined above. The solution yields a good size produce bin and is on point with what a usual Small Bin from Organics to You would be. In fact, it is a little larger than usual while the cost is lower than the usual cost at Organics to You. This model would be very helpful in deciding which items to put in the bins as Organics to You goes through their daily operations. The projected 14-30% savings is a significant amount and would offer considerable additional profit.

We feel confident in this conclusion and these findings as well because on top of the analyses we outline above, we also ran the model several times with different prices. In the produce industry, things can change fast, and prices can change quickly depending on availability. Organics to You is often able to find farmers who would like to sell produce albeit at a discounted rate, so management was curious how different pricing could affect the results. When we run the model with different price points, we still generate a bin with a good variety of fruits and veggies and one that is comparable in size to what is currently in a Small Bin.

With this solution and this model in general, Organics to You realized not only was there opportunity for savings, but they could instead choose to increase the size amounts of their bins overall while keeping costs at current levels. Our model is constrained to only 12+ categories, but we could increase that minimum to 14 or even 15 categories and still stay under the current average cost of weekly bins. This means heavier, fuller boxes and consequently happier customers. Customer satisfaction leads to further growth for this business.

9. Limitations & Future Research

Limitations

Some items may not always be available to scale up to full order numbers. The model assumes that, if the price is right, there is enough supply of each item that we could include the determined amount in every small bin Organics to You makes. Some days that is as much as 200 bins, so it is impossible to guarantee there will always be enough of each item. Management is usually aware of this, and perhaps additional constraints could be introduced to address the issue.

Costly items will always get left off the list. While this sounds beneficial, consider that Organics to You customers appreciate the rare, local treat every now and then. Oregon strawberries for instance are very desirable and Organics to You likes to bring those good to their customers. Since the model does not include the strawberries, constraints could be adjusted to force strawberries (or some type of berries) to be included.

Categories are subjective, and perhaps management would want to rearrange categorical assignments. The categories the team designated aim to provide a healthy variety of produce selections. Items could be reassigned, and perhaps customer input could help to determine the most desired items and categories for each variety.

It may seem obvious but only items in the model can be considered. The nature of the business often means that new items can become available and sometimes last minute changes are made.

Future Research

Items were valued by their serving amount. The volume and density was not considered. While the categorical assignments helped to ensure a bin would contain a good variety of all types of produce items, density of items could be considered in future research to better pinpoint the variable and ensure that the bins looked voluminous upon delivery.

Future research could also be aimed at other bin types. Organics to You offers juicer bins, all veggie bins, large bins, etc. The model would work for all types but may need to be altered to properly consider the variables and preferences of each type.

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Appendix A - Original Dataset

		Price Sheet for wholesale prices paid by Organics to you									
			Wholesale pricing								
			Data from invoices			Team Calculations for Optimization Pricing					
No.	Category	Item	Quantity in Case	Unit	Price per case	Price per unit	Servings per unit	Min (units)	Max (units)	Min (servings)	Max (servings)
1	1	Squash - Delicata	35	lbs	$26.00	$0.74	3	1	2	3	6
2	1	White Potatoes	50	lbs	$35.00	$0.70	3	1	3	3	9
3	1	Sweet Potatoes	40	lbs	$48.00	$1.20	2	1	3	2	6
4	2	Banana	38	lbs	$26.75	$0.70	3	0.5	2	1.5	6
5	2	Mango	5	ct	$14.00	$2.80	2	1	2	2	4
6	3	Cantaloupe	9	ct	$22.00	$2.44	4	1	1	4	4
7	3	Watermelon	10	ct	$25.00	$2.50	4	1	1	4	4
8	4	Blueberries	16	lbs	$35.00	$2.19	4	0.5	1	2	4
9	4	Strawberries	16	lbs	$36.00	$2.25	3	1	2	3	6
10	4	Kiwiberries	6	lbs	$30.00	$5.00	6	0.5	1	3	6
11	5	Grapes	19	lbs	$36.00	$1.89	4	0.5	2	2	8
12	5	Pomegranate	34	ct	$42.00	$1.24	2	3	4	6	8
13	6	Pears - Red Bartlett	100	ct	$42.00	$0.42	2	3	4	6	8
14	6	20th Century Pears	1247	lbs	$1,247.00	$1.00	2	3	4	6	8
15	7	Apples - Honeycrips	100	ct	$59.95	$0.60	2	3	4	6	8
16	7	Apples - Gala	100	ct	$36.00	$0.36	2	3	4	6	8
17	7	Apples - Fuji	113	ct	$38.00	$0.34	2	3	4	6	8
18	8	Grapefruit	32	ct	$49.95	$1.56	2	1	2	2	4
19	8	Orange	72	ct	$45.00	$0.63	2	2	4	4	8
20	9	Bunch Parsley	30	ct	$25.00	$0.83	4	1	1	4	4
21	9	Bunch Cilantro	30	ct	$27.00	$0.90	4	1	1	4	4
22	10	Bunch Chard	24	ct	$24.00	$1.00	3	1	1	3	3
23	10	Bunch Kale	48	ct	$52.80	$1.10	3	1	1	3	3
24	10	Baby Bok Choy	20	lbs	$30.00	$1.50	3	0.5	1.5	1.5	4.5
25	11	Green Peppers	25	lbs	$30.00	$1.20	2	0.5	1.5	1	3
26	11	Red/Gold Peppers	30	lbs	$37.50	$1.25	2	0.5	1.5	1	3
27	12	Yellow Onions	40	lbs	$25.00	$0.63	3	0.5	2	1.5	6
28	12	Red Onions	40	lbs	$36.00	$0.90	3	0.5	2	1.5	6
29	12	Green Onions	48	ct	$32.00	$0.67	4	1	1	4	4
30	13	Red Leaf Lettuce	24	ct	$30.00	$1.25	3	1	1	3	3
31	13	Salad Mix	3	lbs	$11.95	$3.98	4	0.5	1	2	4
32	14	Bunch Radish	24	ct	$32.95	$1.37	3	1	1	3	3
33	14	Bunch Beets	24	ct	$32.00	$1.33	3	1	1	3	3
34	14	Bunch Carrots	24	ct	$37.95	$1.58	3	1	1	3	3
35	15	Fennel	900	ct	$1,350.00	$1.50	3	1	1	3	3
36	15	Celery	24	ct	$38.00	$1.58	3	1	1	3	3
37	15	Cucumber	20	lbs	$30.00	$1.50	3	1	2	3	6
38	15	Avocado	48	ct	$76.95	$1.60	2	1	3	2	6
39	15	Eggplant	20	lbs	$35.00	$1.75	4	0.5	1.5	2	6
40	15	Mushrooms - Crimini	5	lbs	$13.50	$2.70	4	0.25	0.5	1	2
41	16	Tomatoes on the vine	11	lbs	$22.00	$2.00	3	0.5	2	1.5	6
42	16	Tomatillos	10	lbs	$20.00	$2.00	4	0.5	1.5	2	6
43	17	Lemon	115	ct	$74.95	$0.65	2	1	2	2	4
44	17	Lime	38	lbs	$55.00	$1.45	2	0.5	1	1	2
45	18	Garlic	30	lbs	$140.00	$4.67	8	0.25	0.75	2	6
46	18	Ginger	200	lbs	$1,200.00	$6.00	8	0.25	0.75	2	6

Appendix B - Sample Invoice

Organically Grown Company

Bill To
Organics To You
14107 NE Airport Way
Portland, OR 97230

503-236-6490

Make payment to:
20078 NE Sandy Blvd
Portland, OR 97230
Main Line 503-907-3600
Email:
Fax (503) 495-0477

Ship to: Organics To You
14107 NE Airport Way
Portland, OR 97230

503-236-6490

Invoice #	Delivery Date		
01527885	11/27/17		
Customer #	Page	Clk	Chrd By
OG2U	1		

CUSTOMER COPY

Special Instructions	Terms	Due Date	Salesperson/Assistant	P.O. #	Route	Stop
	7 Days	12/04/17	Elissa Ruddy	Monday	PD8	2

Qty Rst	Reason	RTI	Ordered	Shipped	Unit	Item #	Brand	Description	Origin	Unit Price	Amount
			2.00	2.00	100 Ct	APLF100SRR.C	Starr Ranch	Apple, Fuji	US	29.00	58.00
			7.00	7.00	48 Ct	AVOHS48AVM.C	Aveproduce Mexico	Avocado, Hass	MX	62.00	434.00
			13.00	13.00	38 #	BAN...OGUOC	Organics Unlimited	Banana G.R.O.W.	EC	26.75	347.75
			1.00	1.00	20# bulk	BKYB20.LSD.C	Lakeside	Bok Choy Baby	US	23.00	23.00
			14.00	14.00	14 Ct	BRC14..FOX.C	Foxy	Broccoli	US	24.00	336.00
			15.00	15.00	45#	CABG...SSF.C	Siri & Son Farms	Cabbage, Green	US	28.00	420.00
			7.00	7.00	50# Box	CRTCT..HWF.C	Hoppwell Farm	Carrot, Cliptop	US	48.00	336.00
			12.00	12.00	25 # Bag	CLC....SSF.C	Siri & Son Farms	Celeriac	US	27.00	324.00
			8.00	8.00	30 Ct	CLR....JTF.C	JTF Organics	Cilantro	US	21.00	168.00
			10.00	10.00	24 Ct	KALI...CAG.C	Cal Organic	Kale, Italian	US	30.00	300.00
			3.00	3.00	19 # v/f	KWI36VFWRV.C	Wild River	Kiwi size 36	US	36.00	108.00
			10.00	10.00	24 Ct	LFROM.DFF.C	Deardorff Family Far	Leaf, Romaine	US	24.00	240.00
			3.00	3.00	72 Ct 38 #	NAV72..TOG.C	Tomorrow's Organics	Navel Orange	US	49.00	147.00
			1.00	1.00	40# Box	ONRJ..AND.C	Andersen Organics	Onion, Red Jmb	US	33.00	33.00
			10.00	10.00	70 Ct	PERD70.DSG.C	Daisy Girl	Pear, D Anjou	US	42.00	420.00
			1.00	1.00	25# v/f	PRG25.COVI.C	Covilli	Pepper, Green Bell FT	MX	40.00	40.00
			1.00	1.00	40 48 Ct	PRSF4..RVY.C	Rainbow Valley Orcha	Persimmon, Fuyu 2 Layer	US	40.00	40.00
			3.00	3.00	24 Ct	POM24..VLP.C	Valley Pride Fruit	Pomegranate 2 Layer	US	45.00	135.00
			2.00	2.00	50 # Box	POTRS70OGR.C	Organically Grown	Potato, Russet 70 Ct	US	30.00	60.00
			2.00	2.00	25# v/f	SAT...VLP.C	Valley Pride Fruit	Satsuma	US	45.00	90.00

All products USDA certified organic unless indicated otherwise.

"The perishable agricultural commodities listed on this invoice are sold subject to the statutory trust authorized by section 5(c) of the Perishable Agricultural Commodities Act, 1930 (7 U.S.C. 499e(c)). The seller of these commodities retains a trust claim over these commodities, all inventories of food or other products derived from these commodities, and any receivables or proceeds from the sale of these commodities until full payment is received."

ALL CLAIMS MUST BE MADE WITHIN 24 HOURS OF RECEIPT OF MERCHANDISE

Container Quantity X
Driver Signature
CONT Total Gross Ship Weight CONT
Total Cube CONT

A SERVICE CHARGE OF 1.5% PER MONTH (18% ANNUAL) WILL BE APPLIED TO PAST DUE ACCOUNTS

X
Received By
BUYER'S AUTHORIZED SIGNATURE PLEASE SIGN LEGIBLY

Pay This	$1
Amount	Tax

Reusable Plastic Containers
IN: | OUT:

$

NVG780001010152788500001