



Little Green Entrepreneurs: An Integrated Case Study of Sleepy Hollow Rag Rugs

Background

Sleepy Hollow Rag Rugs (SHRR) is about as green as it gets. For more than 30 years Diane and Wally O'Brien have been weaving rugs from fabric that was once clothing or household linens. The small shop housing looms, supplies and retail space shares walls with the kitchen and barn of a 200 year old farmhouse near the Maine coast. The business began when Wally purchased the first loom to provide an outlet for his bright, creative wife Diane who was going stir crazy raising their three sons. In the early years, custom rugs for affluent people summering nearby and Gant Shirt's Manhattan stores were welcome commissions. After the business helped put the boys through college, custom work was discontinued with rare exception.

The Process

The time required to create a rug from scratch varies depending upon several factors. The basic steps are as follows:

1. Wash fabric (if necessary)
2. Cut fabric into strips
3. Create a ball of strips for each fabric used
4. If the warp thread is not the desired color, rethread the loom
5. Weave the rug
6. Finish the ends

Larger rugs take significantly more time at every stage except threading the loom.

Note: Videos of steps 2-6 will be available in late June 2012.

Seasonal Sales

The rag rug business is highly seasonal as are most businesses on the Maine coast. Summer people and tourists make the overwhelming majority of purchases during the season spanning mid-June to Labor Day. Traditionally, the O'Briens worked through the winter to build inventory in preparation for two and one half months of summer. After many years of lessons learned, they have a feeling for what is likely to sell during the next season.

The 21st Century

Technology is consumed carefully in the O'Brien household where television viewing was limited to dad's baseball games when the boys were young. Along the way a satellite dish appeared and wireless internet access was installed. Diane's writing projects (including two published books on local history) have funded a Mac workstation with 24" monitor that stands in her office off the living room. Their daughter-in-law, an artist, designed a website showcasing their wares in an online store (www.sleepyhollowragrugs.com). They are also on Facebook.

Sleepy Hollow uses Apple technology to manage sales transactions including credit card swiping and receipts with embedded photos of purchased items.

The online store has dampened the seasonality of demand to an extent but the bulk of Sleepy Hollow's sales are still made during the summer months.

LP Optimization

In 2010 Sleepy Hollow Rag Rugs opened an online store to expand their retail presence. At first, sales in the online store were mainly to former visitors to the brick and mortar store. Starting last fall, new customers comprise a growing percentage of those who purchase rugs online.

The O'Briens are concerned that online rug demand will grow to a level that will outstrip what they are able to supply. They understand the risk of low inventory levels and try to keep a wide variety of rugs available at all times.

To ensure they are able to scale up their operation they have begun to enlist the help of local weavers and apprentices. Information about these weavers is shown next. To ensure retention of weavers and continued development of apprentices, minimum weekly hours have been negotiated. The productivity of each level of worker refers to how much time it takes them to perform work relative to a skilled weaver. For example, if a rug takes 10 hours, an apprentice with 80% productivity will need $10/80\% = 12.5$ hours to complete the rug.

Weaver	Maximum Hours / day	Minimum Hours / week	Wages \$/hour	Productivity (%)	Role
Scott	4	2	\$7.50	80	Apprentice
Elizabeth	4	2	\$7.50	80	Apprentice
John	6	2	\$7.50	80	Apprentice
Annie	6	4	\$7.75	90	Jr. Weaver
Mary	8	4	\$8.00	95	Weaver
Helen	8	4	\$8.25	100	Skilled Weaver

Because the shop and looms are adjacent to their home, the O'Briens would like to limit weaving activity in the shop during certain times of the day. They have set maximum hours as 6 hours per day Monday through Friday, 4 hours on Saturday and no weaving on Sunday. They also know a minimum amount of weaving must be done each week in order to meet current demand. They believe they need at least 20 hours of weaving in total each week and have set a minimum of two hours per day Monday through Friday to ensure the work is spread out throughout the week.

Note: only one worker is able to weave at a time.

Ignoring productivity, what schedule of workers would have the lowest weekly cost?

Assuming workers only work full hours (i.e., integer solution) and ignoring productivity, what schedule of workers would have the lowest weekly cost?

What schedule of workers has the lowest weekly cost when worker productivity is considered? Hint: Only skilled weavers could do the work in 20 hours. Other weavers and apprentices would need more time.

Part 2

Based on signals indicating increased demand for SHRR's products, the O'Briens want to investigate an alternative optimization problem. Rather than the lowest weekly wage cost, they want to find out the lowest blended hourly rate they can obtain while still meeting all other conditions.

Alter the model to find the lowest blended hourly wage. Restrict your solution to integer values for the hours each weaver works on a given day.

Regression Analysis

Sleepy Hollow's pricing has been done using a straightforward calculation based on rug size with some expert opinion-based tweaking. For example, some rugs are sold at a premium because they are deemed highly saleable due to color, size or other factors. Other rugs may be discounted; these are included in inventory to ensure customers are offered a broad spectrum of choices.

Undergraduate:

1. Use regression to predict rug price based on the forecast shown in the table below.

Run models with:

- a. All data and
- b. Each of the four sizes (Large, Medium, Small and Runner) as its own model

2. Which model in (1) does the

- a. Best job of predicting the price?
- b. Worst job of predicting the price?

Explain your answers.

3. Which rug sizes yield the highest and lowest margins for SHRR?

4. What recommendations would you make for SHRR's pricing structure?

Graduate: Analyze Sleepy Hollow's pricing structure.

Sleepy Hollow Rag Rugs Forecast as of September 4, 2011

Rug #	Size	Time (hours)	Price (\$)	Warp	Date Needed	Priority
1	Medium	15	156	Black	18-Dec	1
2	Medium	12	130	Black	18-Dec	2
3	Medium	13	134	White	18-Dec	2
4	Runner	9	100	Black	18-Dec	1
5	Runner	12	139	Black	18-Dec	2
6	Large	15	153	White	25-Dec	2
7	Medium	14	140	Black	25-Dec	1
8	Medium	11	114	Black	25-Dec	2
9	Medium	13	128	White	25-Dec	1
10	Small	8	84	White	25-Dec	3
11	Large	15	170	White	22-Jan	2
12	Medium	14	156	Black	22-Jan	3
13	Runner	10	114	Black	22-Jan	2
14	Large	16	164	Black	12-Feb	1
15	Large	16	163	White	12-Feb	1
16	Medium	12	120	Black	12-Feb	1
17	Medium	11	120	White	12-Feb	2
18	Runner	10	115	Black	12-Feb	1
19	Small	10	108	White	12-Feb	1
20	Large	14	159	Black	22-Apr	2
21	Medium	15	148	White	22-Apr	1
22	Runner	7	85	Black	22-Apr	3
23	Small	9	101	Black	22-Apr	2
24	Small	10	103	Black	22-Apr	2
25	Small	7	78	White	22-Apr	3
26	Large	18	198	White	27-May	2
27	Large	14	162	White	27-May	3
28	Runner	11	124	Black	27-May	1
29	Small	8	81	White	27-May	1
30	Large	14	159	White	17-Jun	2
31	Runner	16	184	Black	17-Jun	3
32	Small	9	98	Black	17-Jun	3
33	Large	15	164	White	1-Jul	3
34	Runner	12	141	Black	1-Jul	1
35	Small	9	94	Black	1-Jul	2
36	Small	9	103	Black	1-Jul	3

Forecasting

Undergraduate:

Shortly after Sleepy Hollow developed its annual forecast in early September 2011, a popular entertainment news magazine published photos of several celebrities' homes with handmade rag rugs prominently featured as a "hot new trend" in home décor. Within days, Sleepy Hollow's online store experienced a huge uptick in activity and orders and e-mail inquiries jammed the store's inbox. As a result, the O'Briens revised their forecast to reflect an expected increase in business.

The scenarios they used were based on the following summary of the existing forecast by rug size and scheduled production deadlines:

	Large	Medium	Runner	Small	Total
18-Dec	0	3	2	0	5
25-Dec	1	3	0	1	5
22-Jan	1	1	1	0	3
12-Feb	2	2	1	1	6
22-Apr	1	1	1	3	6
27-May	2	0	1	1	4
17-Jun	1	0	1	1	3
1-Jul	1	0	1	2	4
Total	9	10	8	9	36

Considering the possibility that the fad is a passing one, two scenarios altered only December's sales.

Scenario I – 140% increase in sales volume for holiday season sales only

	Large	Medium	Runner	Small
18-Dec	2	4	2	4
25-Dec	2	4	2	4

Scenario II – 100% increase in sales volume for holiday season sales only

	Large	Medium	Runner	Small
18-Dec	1	5	3	1
25-Dec	2	5	1	2

Two other scenarios were based on the assumption that the trend would remain strong throughout the year.

Scenario III – Increase the original forecast by one unit for each size / production deadline combination.

Scenario IV –Double the original forecast for each size / production deadline combination.

Using the average prices for each size rug obtained from the original forecast data from September 4th, what is the impact on total revenue for each of the four scenarios?

To capitalize on the fad while it's hot, Sleepy Hollow is considering increasing prices by 10% temporarily. If consumers are willing to pay the higher prices, what is the impact on total revenue for each of the scenarios?

Based on your analysis, what are your recommendations for Sleepy Hollow?

Part 2

Using the minimum blended rate obtained in Part 2 of the LP Optimization problem, calculate the change in the profit margin for each scenario.

Would you alter your recommendations based on the results of this additional analysis?

Graduate:

Shortly after Sleepy Hollow developed its annual forecast in early September 2011, a popular entertainment news magazine published photos of several celebrities' homes with handmade rag rugs prominently featured as a "hot new trend" in home décor. Within days, Sleepy Hollow's online store experienced a huge uptick in activity and orders and e-mail inquiries jammed the store's inbox. As a result, the O'Briens revised their forecast to reflect an expected increase in business.

Perform scenario analysis incorporating considerations such as whether the rag rug craze is just a fad or has staying power, changes to the composition of the forecast with respect to product mix and any other relevant considerations. Use data and results obtained elsewhere within the case and incorporate sensitivity analysis to the extent it contributes to your analysis.

Based on your analysis, outline your recommendations for Sleepy Hollow.

Decision Analysis

The O'Briens have decided to use a payoff table to determine which of three courses of action to pursue: make no change to the initial forecast, increase the forecast by 100% for the holiday season only or increase the entire forecast by 100%.

They believe there are three possible states that could prevail, each mirroring the actions being considered: no discernible change in demand, demand doubles during the holiday season only and demand doubles throughout the year. They are very skeptical of demand doubling for the whole year and have assigned it a likelihood of 5%. Based on the increased activity on the website, including purchases, they are fairly confident that demand will double during the holiday season and have assigned that event a probability of 65%. They are less inclined to believe there will be no change in demand and have assigned a 30% probability to that event.

Based on forecast results found earlier, determine which of the three possible actions is the most profitable using the following decision criteria:

- Maximax
- Minimax
- Minimax Regret

Determine the following:

- Expected payoff
- Expected regret
- Expected value of perfect information

Which option would you choose and why?

Project Management

Note: Microsoft Project is not required. Graphical techniques may be as effective.

Shortly after Sleepy Hollow developed its annual forecast in early September 2011, a popular celebrity news magazine published photos of several celebrities' homes with handmade rag rugs prominently featured as a "new hot trend" in home décor. Within days, Sleepy Hollow's online store experienced a huge uptick in hits and e-mail inquiries jammed the store's inbox. As a result, the O'Briens revised their forecast to reflect an expected doubling of their business.

The revised forecast is summarized in the table below.

	Large		Medium		Small		Runner	Total		
	Black	White	Black	White	Black	White	Black	Black	White	All
18-Dec	0	0	3	2	0	0	4	7	2	9
25-Dec	2	1	2	2	0	2	0	4	5	9
22-Jan	1	1	4	0	0	0	2	7	1	8
12-Feb	2	2	2	2	1	1	2	7	5	12
22-Apr	1	0	1	1	2	2	3	7	3	10
29-Apr	1	1	1	2	2	0	0	4	3	7
27-May	0	2	2	2	0	3	2	4	7	11
17-Jun	1	2	1	1	2	1	2	6	4	10
1-Jul	1	2	0	0	2	0	1	4	2	6

The average time to complete each rug using only skilled weavers with 100% productivity is:

Size	Hours
Large	14
Medium	12
Runner	10
Small	8

The time required to change the warp thread is 3 hours. This must be done by one of the O'Briens who prefer to schedule rethreading the loom to be done over a weekend. Ideally, the warp thread would only need to be changed once each year but that may not be realistic.

Given the workforce shown in the LP Optimization section, will it be possible to complete all the work on schedule and meet the revised forecast?

If the decision is made to change the warp thread only once in the coming year, what would be the optimal sequencing of the work: Black first or White first? Consider the impact on net profit from work that may not be completed on schedule.

Little Green Entrepreneurs: An Integrated Case Study of Sleepy Hollow Rag Rugs

Teaching Note

Introduction

This case involves the operations of a small family-owned business that uses discarded fabric to create handmade rugs. The five modules are well-suited to quantitative methods courses and incorporate concepts and techniques from operations management, project management, finance and marketing including:

- Worker scheduling
- Pricing strategy
- Production forecasting
- Scenario analysis
- Sensitivity analysis
- Model selection

The five modules (linear programming optimization, regression analysis, forecasting, decision analysis and project scheduling) can be used individually or in combination. Some modules refer to solutions or information presented in other modules, reinforcing the interconnectedness of organizational decision making. Each module includes problems for different student ability levels; several modules include different approaches for undergraduate and graduate students.

Preparation

The underlying philosophy of Sleepy Hollow Rag Rugs is similar to that of the “lifestyle business” characterized by founders who establish a certain income level and work only as needed to maintain it, reserving more time for leisure or other pursuits. The instructor may have students research these businesses and bring examples to class discussion.

To gain an understanding of the business and its products students should view the videos showing fabric preparation, loom threading, weaving and finishing.

Students may also benefit from an understanding of the creative workforce:

- Caves, R. E. 2000. Creative Industries: Contracts Between Art and Commerce: Harvard University Press.
- Florida, R. L. 2002. The Rise Of The Creative Class: And How It's Transforming Work, Leisure, Community And Everyday Life: Basic Books.

LP Optimization

Students should understand how to solve linear programming optimization problems. Several levels of questions are included to accommodate a range of student ability levels: non-integer and integer solutions; integer solutions incorporating worker productivity differences; and alternative objectives.

Regression Analysis

Undergraduate students should be able to run and analyze the results of regression models, understand the concept of profit margin and be able to compare models.

Graduate students need to be able to analyze a product's pricing structure.

Forecasting

Undergraduate students must be able to augment forecasts, calculate averages and revenue and compare scenarios. The second part of the question is optional; it requires the solution to Part 2 of the LP optimization problem. Alternatively, the instructor could provide a rate.

Graduate students need to be able to develop reasonable scenarios and perform analysis to assess the potential impact of an increase in demand that may or may not materialize.

Decision Analysis

Students will need to be able to find the best solution for a 3X3 payoff table using minimax, maximax and minimax regret decision criteria and calculate expected payoff, regret and value of perfect information.

Project Management

Students will need to be able to use graphical or other techniques to determine whether a particular production schedule can be met given the workforce constraints detailed in the LP optimization module.

The conditions on the first question are posed as "prefer" and "ideally" which require careful reading and interpretation.

Teaching Approach

Introducing the case

To introduce the case, assign students research on lifestyle businesses, work-life balance, family owned businesses and the creative class.

In the classroom, guide the discussion to focus on the motivation of Sleepy Hollow Rag Rugs' founders. One possible question to get things started:

“Why would anyone start a business that is unlikely to ever make enough money to attract investor interest?”

Answers will vary but generally include:

- Independence / control
- Desire to be available to family
- Money only one of many motivators
- Creative outlet

Next ask students to share what they have learned through their research beyond what they have already shared while answering the question. As the discussion winds down or 20-25 minutes before the end of class, survey the students by asking if they would ever consider such a path. Note whether there appear to be any differences by surface level diversity metrics such as gender, age, traditional vs. non-traditional students, etc.

Introduce Sleepy Hollow by either summarizing the background or having students read it. Then view the videos and, if time allows, briefly browse the website.

Teaching to undergraduates

The modules appear in the order in which they would ideally be assigned. Modules may be skipped depending upon student ability and background.

LP Optimization

The questions are ordered by level of difficulty with the non-integer question first, followed by the integer solution, incorporation of worker productivity and, as Part 2, an alternative objective. If the first question is too challenging, some of the constraints can be ignored (e.g., minimum and maximum hours per worker, per day and in total).

Regression Analysis

If the multiple runs are overly challenging, have students simply run the model with all data and discuss the results.

Forecasting

The summary table at the beginning of the module can be omitted; students would need to compose it from the forecast provided in the Regression Analysis module.

For Part 2, a rate could be provided to students.

Decision Analysis

Students could be provided with the payoff table and a subset of the calculations assigned.

Project Management

Students will need to be creative in developing techniques to organize the information. One possibility is to use Excel as shown next.

Date															12/18
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cumul min hr	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
Cumul max hr	26	52	78	104	130	156	182	208	234	260	286	312	338	364	390
Color	B	B	B	B	B	B	B	B	B	B	B	Through Jan 22			
												W	W	W	W

Teaching to graduate students

For each module, graduate students should prepare a written summary of their analyses and recommendations.

Regression Analysis

Graduate students should incorporate the priority data which is not explicitly discussed in the case.

Forecasting

The summary table at the beginning of the module should be omitted.

Graduate students should incorporate the priority data in a reasonable way, e.g., different demand increases for each priority, analyses of priority by date/rug size/warp color/price, etc.

Graduate students must support their choice of scenarios and may include research on fads, general economic conditions, retail sales, etc.

Sensitivity analysis should include a sufficient range to show profit levels that are lower than those with no increase in demand. To achieve this, hourly wages and rug prices can be manipulated.

Project Management

Graduate students should incorporate priority data although it may have no bearing on the final solution.