VIRGINIA COMMONWEALTH UNIVERSITY

SCMA 669 - Test #1

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03/23/2021

Contents

SCMA 669
Forecasting Methods

Take-at-Home Test
Due no later than class Tuesday, 7:00 PM, March 23, 2021

Instructions:
1. You may not discuss this test or general topics which may significantly apply to the test with anyone except the instructor.

2. You may use any support materials (notes, readings, etc.) you need. The data is realistic but created specifically for this problem. It is not related to real dates so outside national or international economic data will not be of benefit.

3. If you have questions concerning the test call (702-526-8154) or e-mail (swcuster@vcu.edu).

4. ~~4.~~ ***There is additional information not in this case report which will be useful for understanding KJ's sales data, business operations, production and financial circumstances.*** In any forecast you have to make assumptions, but do not make assumptions you do not have to. You can obtain additional information about KJ by asking any of the Jacksons. Asking relevant questions of the Jacksons is part of this test. You will not be graded on your requests for information, but you are expected to have considered information not in this case report when preparing your reports.

5. Additional information can be obtained by asking questions of the Slackbot. Questions should be straightforward with one question per request. Don't ask compound questions. You can ask as many questions as you like. Instruction for assessing the Slackbot are on blackboard under Assignments – Test 1 – Slackbot-StudentDocument 2021.

6. If the BOT doesn't answer your question or the answer is not appropriate for the question email your question to me swcuster@vcu.edu. I will respond within 24 hours.

7. In addition to the completed test, provide a computer file containing all relevant computer outputs, including intermediate tables. **The tables should be clearly labeled and referenced to your test report.** The computer file is *not* part of your reports. The reports should be complete and must show your final forecast. (Not just a plot but actual values) Do not reference the Excel Workbook in your report. The Excel Workbook is back-up and will only be viewed if I need to check your calculations.
Include your name on your report and in the title of all documents.

8. It is assumed you will use Excel for your calculations. If you wish to use other software, talk to me first.

9. **The completed test is due no later than 7:00 PM March 23.** Email your report and Excel Worksheet to swcuster@vcu,edu. Make sure your report is formatted to print the way you want it to print.

KJ Manufacturing

Background Problem:

You have just accepted a position at KJ Manufacturing Company. KJ manufactures and markets circuits for CNC (Computer Numerical Control) machines. Customers are manufactures of the equipment.

Ken Jackson is the owner, general manager, or president (KJ is not big on titles). He started the business 6 years ago after working 20 years as Director of Marketing for a larger competitor. The other key managers are his sons Kevin Jackson and Kyle Jackson, and his daughter, Kim Jackson Blackwell. Kevin manages production, Kyle sales, and Kim the financial functions. Kevin and Kyle have engineering degrees and Kim an MBA.

Several things attracted you to the job. KJ is experiencing remarkable growth. Sales have nearly doubled over the last two years alone. You were very impressed with Kevin, Kyle and Kim. They are bright, have a very good working relationship with each other, and are truly concerned about the long-term well-being of the business. You liked their ideas about where the business should go.

Although the business has done well so far, they feel it has reached a point where more analytical management approaches are required. You were hired to develop and implement better management tools where appropriate.

Since you've been with the company you've found that Ken Jackson does not share his children's' views on the need for more analytical approaches to management. In general, he treats his children as, well children. He listens to them but seldom acts on their suggestions. He allowed them to hire you as a token gesture to get them off his case for a while. Although he doesn't want you to fail, he has no vested interest in your success. You have not done any work directly for him, but have met with him on several occasions and are comfortable with him. He is friendly and outgoing, and, although he may not buy what you are selling, he will not be combative or unpleasant. He will adopt changes if he's convinced it's for the good of the business, but his resistance is high.

Your first opportunity to show your stuff is the annual sales forecast. At the beginning of each calendar year Ken Jackson turns out a forecast of monthly revenues for the coming year. The forecast is based on his judgment and experience. In the past his forecasts have been pretty good, although last year it was a bit overly optimistic. For various reasons this year's forecast worries all three children.

Ken's reply to his children's concerns:
"I understand your concerns and I've taken them into account. This is the most conservative forecast I've ever made. The rate of growth is well *below* our traditional growth rate. If anything, it's not ambitious enough. We all need stretch goals, especially the sales force. And a worse sin than too much inventory is orders we can't fill. We can work off inventory; a lost sale is lost revenue."

a) Discuss the forecasting process at KJ Manufacturing, any relevant factors about the company and industry that are pertinent to your forecast and Ken's forecast. (30% of test grade)

b) Forecast monthly revenues for KJ Manufacturing for the coming year. Use the method(s) you think best. Explain your forecasting approach and support your choice of models and the rational for any parameters selected. Give any other comments you think applicable to your forecast. (50% of test grade)

c) Prepare a report to Ken Jackson explaining/supporting your forecast. The report should describe your forecast so that he understands and accepts it. He is intelligent but has no specific knowledge of quantitative forecasting techniques. Remember: "Managers would rather live with a problem they can't solve than a solution they don't understand." (20% of test grade)

Parts a and b are reports to me your instructor. Part c is a report to Ken Jackson. All parts may be in a single document labeled separately.

KJ's sales history and Ken's forecast for the coming year are on Blackboard under "Assignments" labeled KJ Mfg.

Part A

Historically, Ken's previous forecasts have projected very close to actual sales with the exception of last years. Seasonality plays a big role in sales revenue as well as other cascading effects such as demand patterns, Manufacturing capacity, cash flow, inventory management/production, achieving accurate sales goals and so much more. There are high Fall/Winter sales volume verses lower summer sales (see seasonality chart below). Due to the high demand in winter, they must manufacture products year-round to have inventory on hand.

Last year sales did not meet plan, as a result they ended the year with about $750,000 excess in inventory (enough to meet January's forecast). When speaking to Ken, his thought process on seasonality this year (December specifically) seemed to be on an upward trend when historically has not increased. He claims: "By putting more of the growth in December we will be on or close to our goals through November and then get an extraordinary effort in December to meet our yearly goals.". I suggest he use a Holt's Forecast to have similar growth expectations and a more fitted projection to seasonality without over expectations in December.
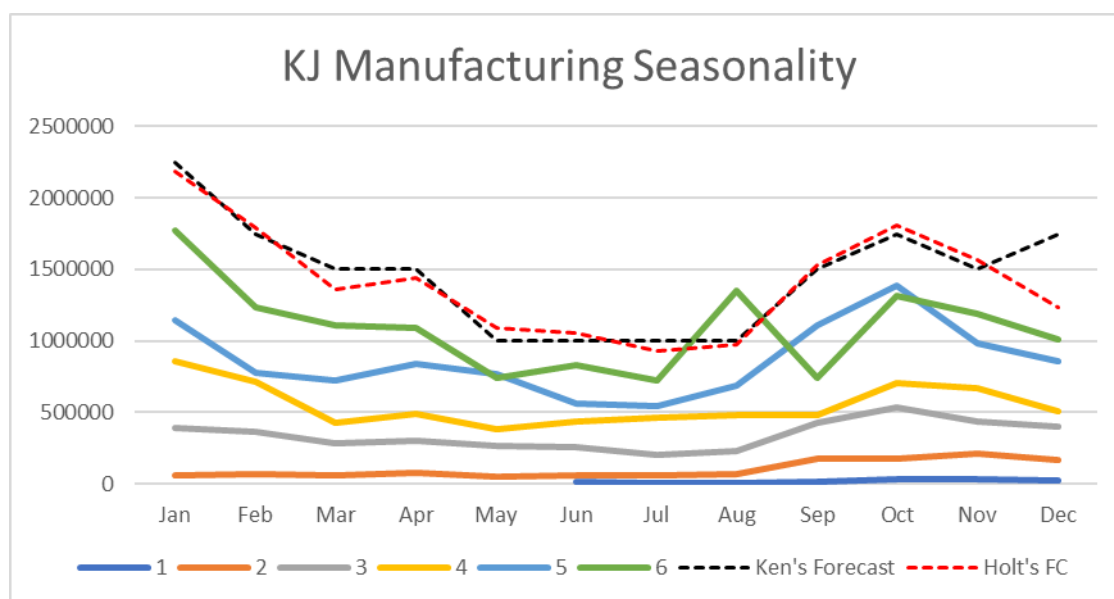
Ken prepared his forecast by using "judgment and experience in addition to what I feel is the growth that is necessary for the business to meet our goals". It does not appear a mathematical approach was used to create this forecast. He has predicted a sales growth increase by an average of 23% over the course of year 7 from the previous year. As mentioned, this is well below the traditional growth rate (34% actual growth in Year 6 from year 5 and 37% in year 5 from year 4) as multiple sources are claiming new growth in customers as well as industry growth are slowing therefore, sales are beginning to level off. KJ instituted a major price increase in year 5, and competitive pressures will not allow another one this year.

The objective is to not forecast too much causing the potential loss of important salespeople, an excess in supply, and more expected cash flow while also not forecasting too little to cause a shortage in supply or salespeople to not reach their full potential.

For simplicity, I've listed important factors that depend on the sales forecast:

- Attractive Sales goals / Retaining salespeople
  - After last year's ambitious sales forecast, very few salespeople qualified for their bonus/compensation therefore, a large concern is forecasting or creating goals unattainable to where sales representatives get intimidated (fear they will not reach their goals) and leave the company.
- Inventory management
  - They manufacture to inventory/forecast and then sell from stock in order to maintain short customer lead-times.
  - Inventory workload is balanced over the year by building inventory during the summer when demand is weak in anticipation of heavy orders in the fall and winter. If demand doesn't materialize as planned, he'll have extra inventory.
  - Last year's forecast led them to $1,750,000 of inventory – about $750,000 too much. A large inventory hangover at the end of this year could create "a cash flow crisis."
- Cash flow: planned expenditures
  - There are healthy profits but cash profits and then some have been put back into the business to finance growth
  - "We have considerable debt but servicing the debt will not be a problem if next year's sales are close to the forecast I created."
  - Extra cash is needed this year to finance new equipment.
  - The debt is dependent on anticipated business.
- Manufacturing capacity
  - This year's production requirements will require extra cash for more people and additional equipment. It takes 3 to 4 months to hire and train new operators and at least 6 months and usually longer, for new equipment (causing slower inventory production)
  - As for the physical plant, no need to expand facilities currently - physical plant is adequate for any realistic growth
- Industry trends:
  - A leading trade journal for their industry, estimates that the job shop CNC industry grew at 7% to 10%/year over the last few years. "I think this may be a little overly optimistic, and if anything, the industry is on the low side of that estimate and flatting"
- Marketing or Organizational changes:
  - They do not plan on any major changes to marketing or organization in year 7

Part B:

I suggest Ken use Holt's linear model forecast to have similar growth expectations and exponential smoothing with trend to project seasonality without unrealistic expectations in December. I chose this method to put emphasis on the fact that more recent years have declining sales in December. A variety of other models were considered (see below) but I believe to receive buy in from Ken this model with higher growth would be more willingly accepted.

First, I plotted the data and Ken's forecast. The missing data (in Orange) was filled in by taking year 4 total revenue ($6,600,000) minus the current year 4 sum equals $961,490. This was then used to fill in the gap by dividing by two to disperse the leftover revenue between the month August and September. The black line is Ken's forecast for year 7 and I later went back in and added the Holt's Forecast to compare.
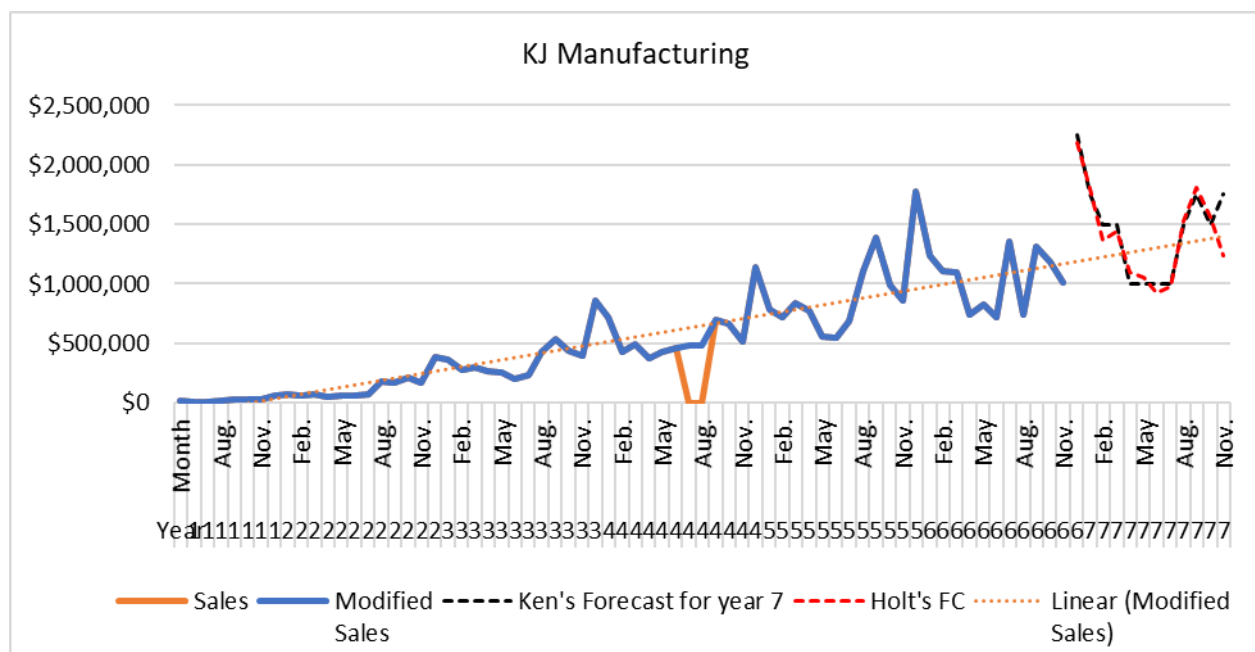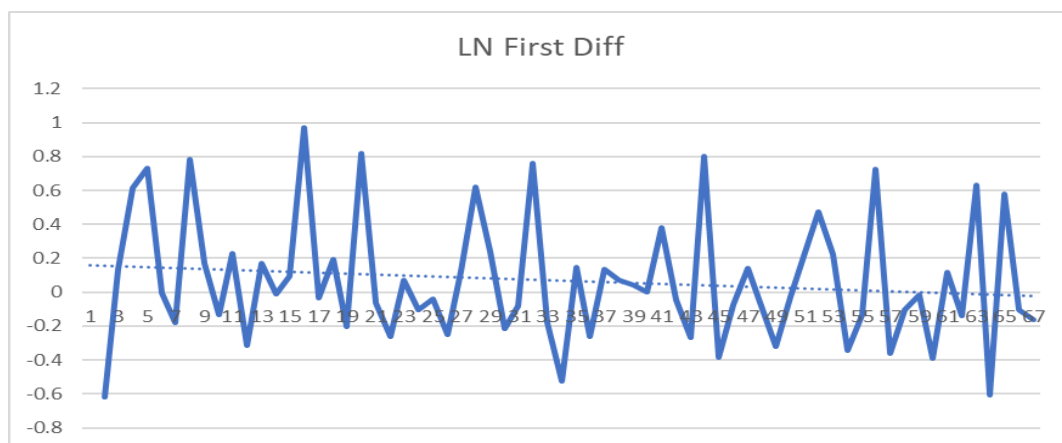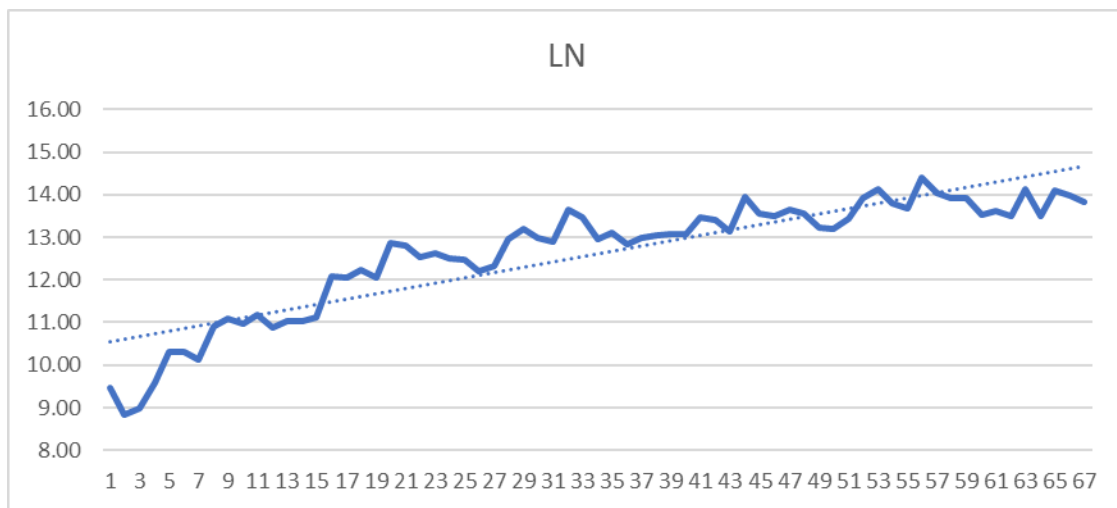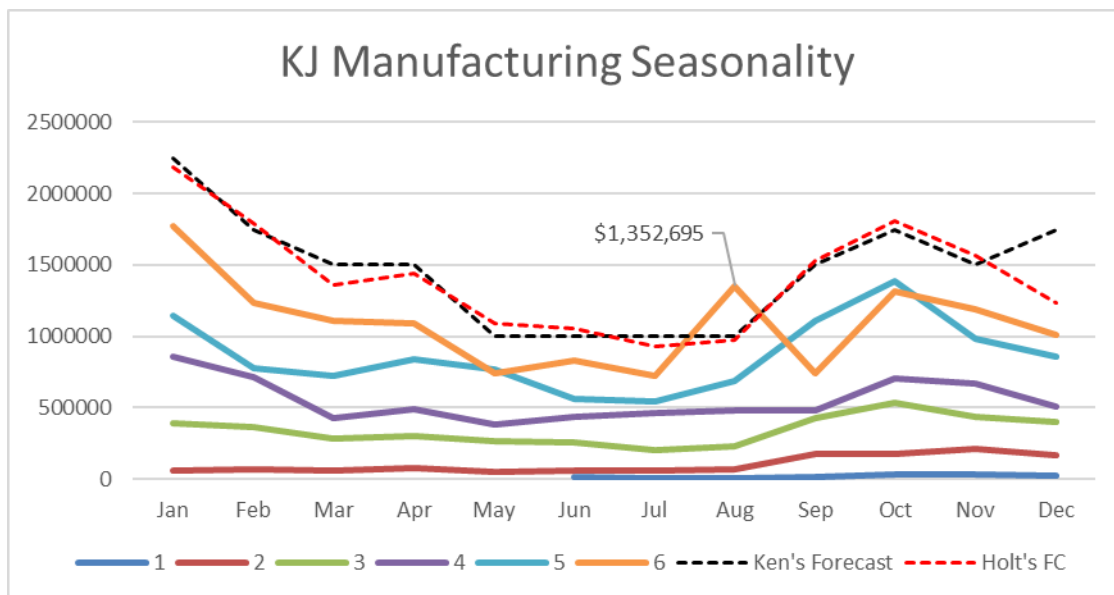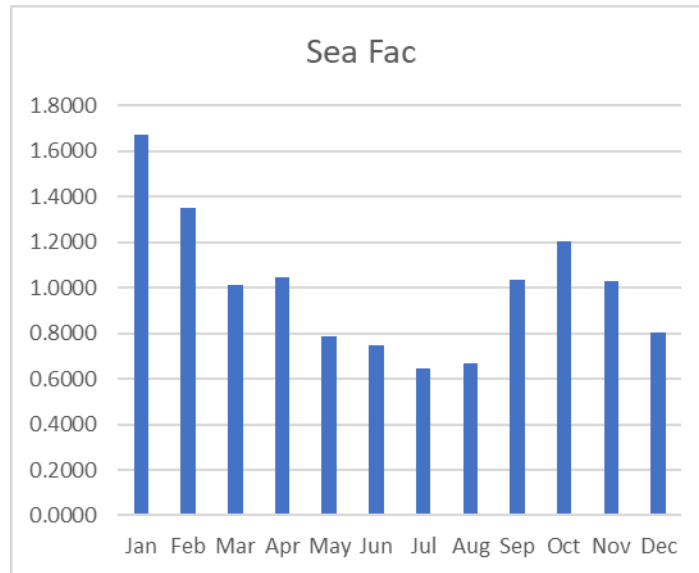
Using the difference, variability continues to increase.
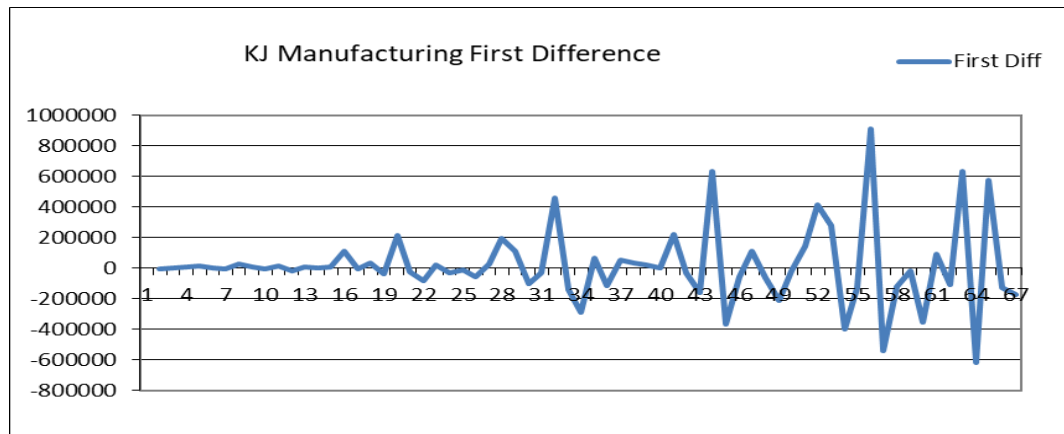
Taking the LN confirms the skepticism of sales "leveling off" and increasing at a slower rate along with the decreasing trend line of the LN Difference.
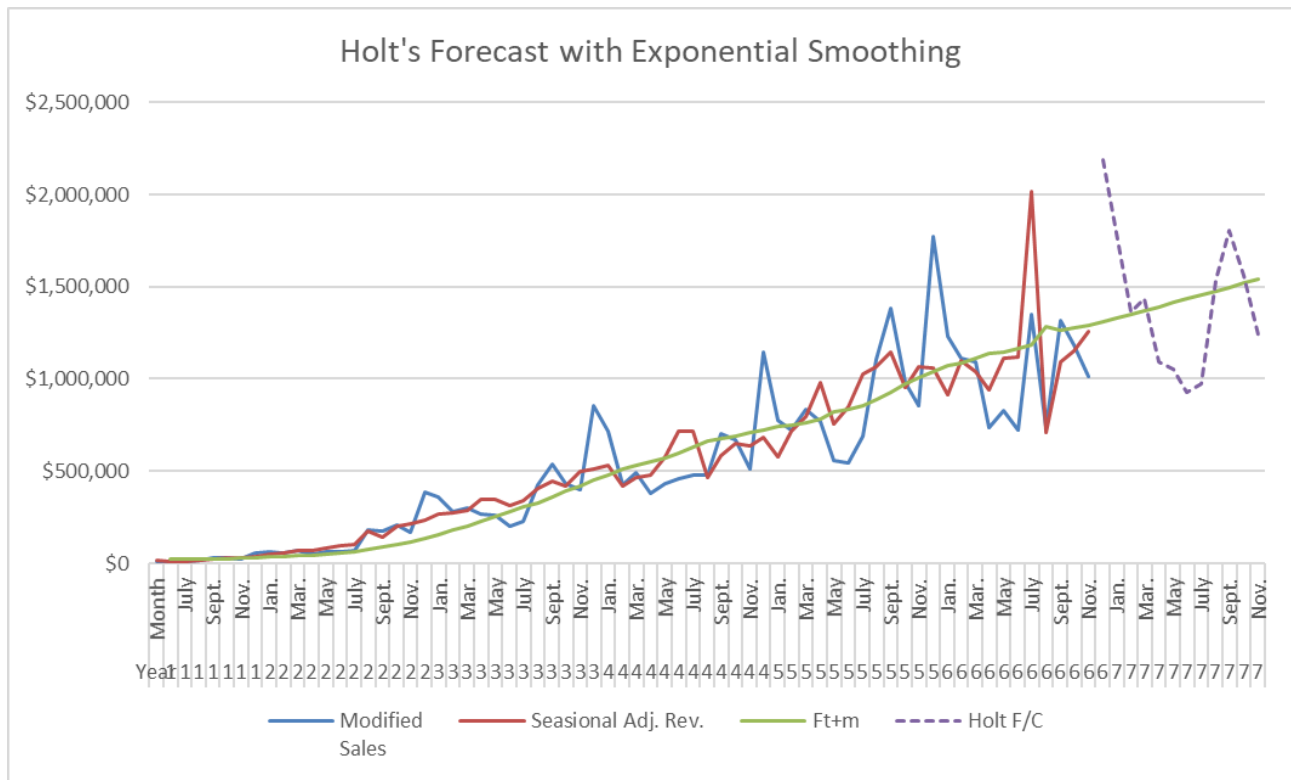
As previously mentioned, seasonality was accounted for.

1	2	3	4	5	6
	$55,192	$386,973	$856,169	$1,142,226	$1,770,530
	$65,478	$362,910	$715,785	$777,921	$1,232,578
	$57,249	$279,726	$424,179	$723,705	$1,110,182
	$71,854	$299,549	$490,141	$834,815	$1,091,672
	$52,341	$269,184	$377,359	$770,839	$738,216
$12,786	$62,227	$258,781	$430,992	$560,906	$828,809
$6,892	$61,702	$201,075	$461,459	$545,198	$720,396
$7,890	$67,667	$228,050	$480,745	$689,041	$1,352,695
$14,601	$178,373	$423,168	$480,745	$1,105,173	$737,335
$30,313	$172,037	$537,014	$701,897	$1,384,091	$1,315,334
$30,161	$208,343	$433,058	$669,285	$983,006	$1,185,351
$25,183	$170,317	$399,299	$511,244	$858,011	$1,010,338

August of year 6 seemed to have a great year for sales (see Seasonality chart above). Because August is usually one of the lowest months in sales, the seasonally adjusted revenue put emphasis on this outlier of a month.

This was noticed but taken accounted for with exponential smoothing.

After experimenting with different variations, I used excel solver to optimize alpha and beta (0.08 and 0.21, respectively) to minimize the mean squared error. When looking at our exponential smoothed green line, the relatively low alpha has removed most all the noise however it does slightly lag due to being so low. The MSE is minimized the most when changing the starting values to a 6-month average when compared to 12 and 3 months after optimizing with solver.

| MSE	
23592240708	6 month avg
23598040971	12 month avg
23893685000	3 month avg

Other models that were considered:
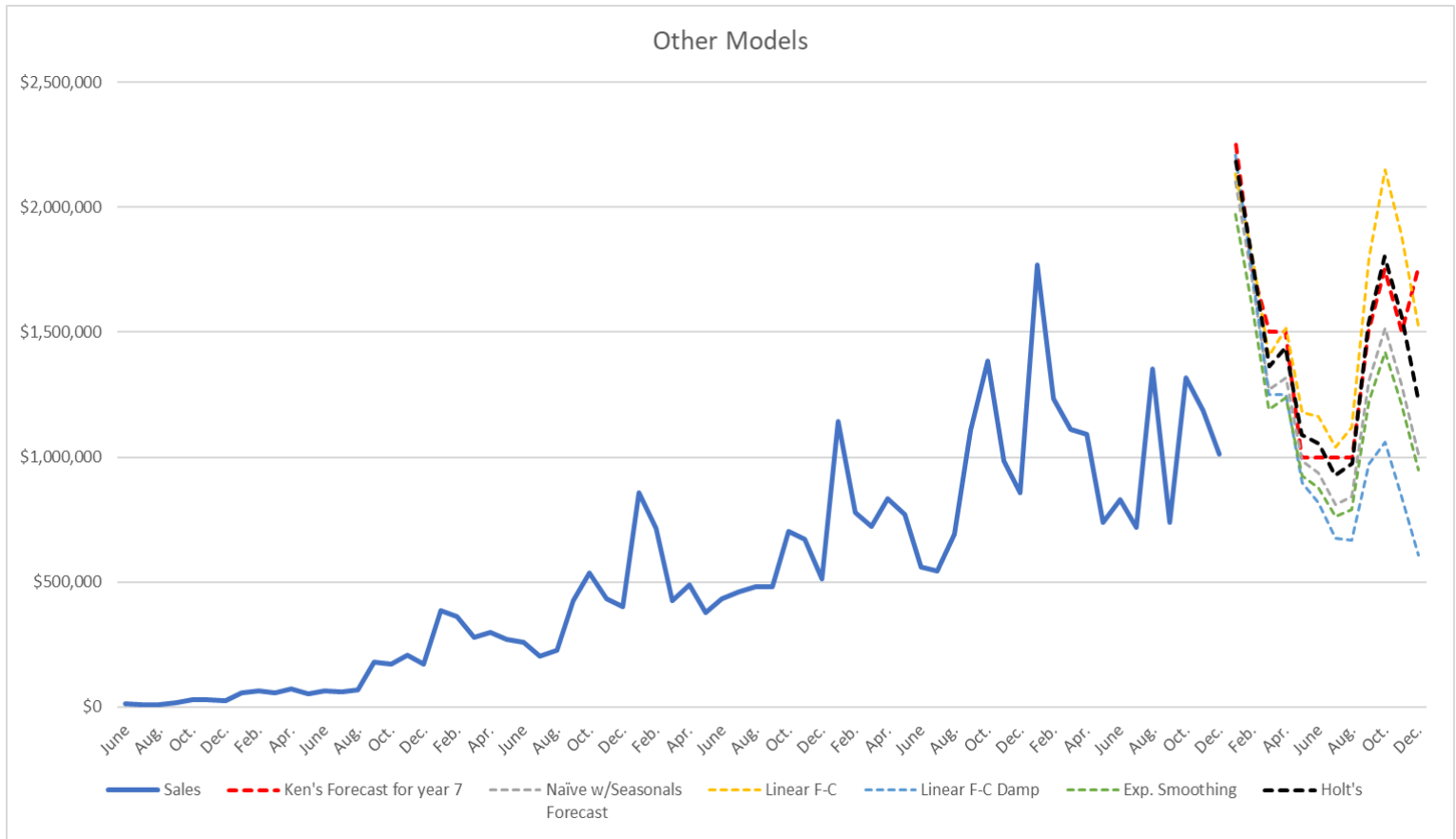
Naïve w/Seasonal, Linear F-C, Exponential Smoothing and Linear F-C Dampening models were compared to Holt's and Ken's forecasts. Below are the percentages each model is projected to grow from year 6 as well as the averages per month – Holt's being on the slightly ambitious side.

	Linear F-C	Ken's Forecast for year 7	Holt's	Naïve w/Seasonals Forecast	Exp. Smoothing	Linear F-C Damp	
Jan.	2132909.28	$2,250,000	2185164.86	2101957.155	1971702.908	2207617.772	
Feb.	1798384.837	$1,750,000	1792848.57	1697088.185	1591922.891	1726948.008	
Mar.	1403795.81	$1,500,000	1363911.78	1270804.101	1192054.812	1249861.679	
Apr.	1515439.279	$1,500,000	1436995.56	1318214.9	1236527.654	1249647.189	
May	1177406.548	$1,000,000	1091035.99	985625.6248	924548.2981	897830.334	
June	1160968.407	$1,000,000	1052552.95	936611.5586	878571.5394	816982.4745	
July	1041639.003	$1,000,000	924966.48	810926.9606	760675.3746	674664.5863	
Aug.	1120938.199	$1,000,000	975918.22	843148.4327	790900.1439	666028.9319	
Sept.	1792573.487	$1,500,000	1531569.88	1304230.154	1223409.517	973075.0019	
Oct.	2150576.945	$1,750,000	1804756.59	1515137.991	1421247.8	1061159.893	
Nov.	1893075.282	$1,500,000	1561653.01	1292769.342	1212658.909	843779.0181	
Dec.	1524923.243	$1,750,000	1237493.37	1010338.136	947729.4227	609198.7991	
Sum	18712630.32	17500000	16958867.3	15086852.54	14151949.27	12976793.69	
%different							Average/month
Jan.	17%	21%	19%	16%	10%	20%	17%
Feb.	31%	30%	31%	27%	23%	29%	28%
Mar.	21%	26%	19%	13%	7%	11%	16%
Apr.	28%	27%	24%	17%	12%	13%	20%
May	37%	26%	32%	25%	20%	18%	26%
June	29%	17%	21%	12%	6%	-1%	14%
July	31%	28%	22%	11%	5%	-7%	15%
Aug.	-21%	-35%	-39%	-60%	-71%	-103%	-55%
Sept.	59%	51%	52%	43%	40%	24%	45%
Oct.	39%	25%	27%	13%	7%	-24%	15%
Nov.	37%	21%	24%	8%	2%	-40%	9%
Dec.	34%	42%	18%	0%	-7%	-66%	4%
Average	29%	23%	21%	10%	5%	-11%	

KJ Manufacturing Sales Forecasting Models

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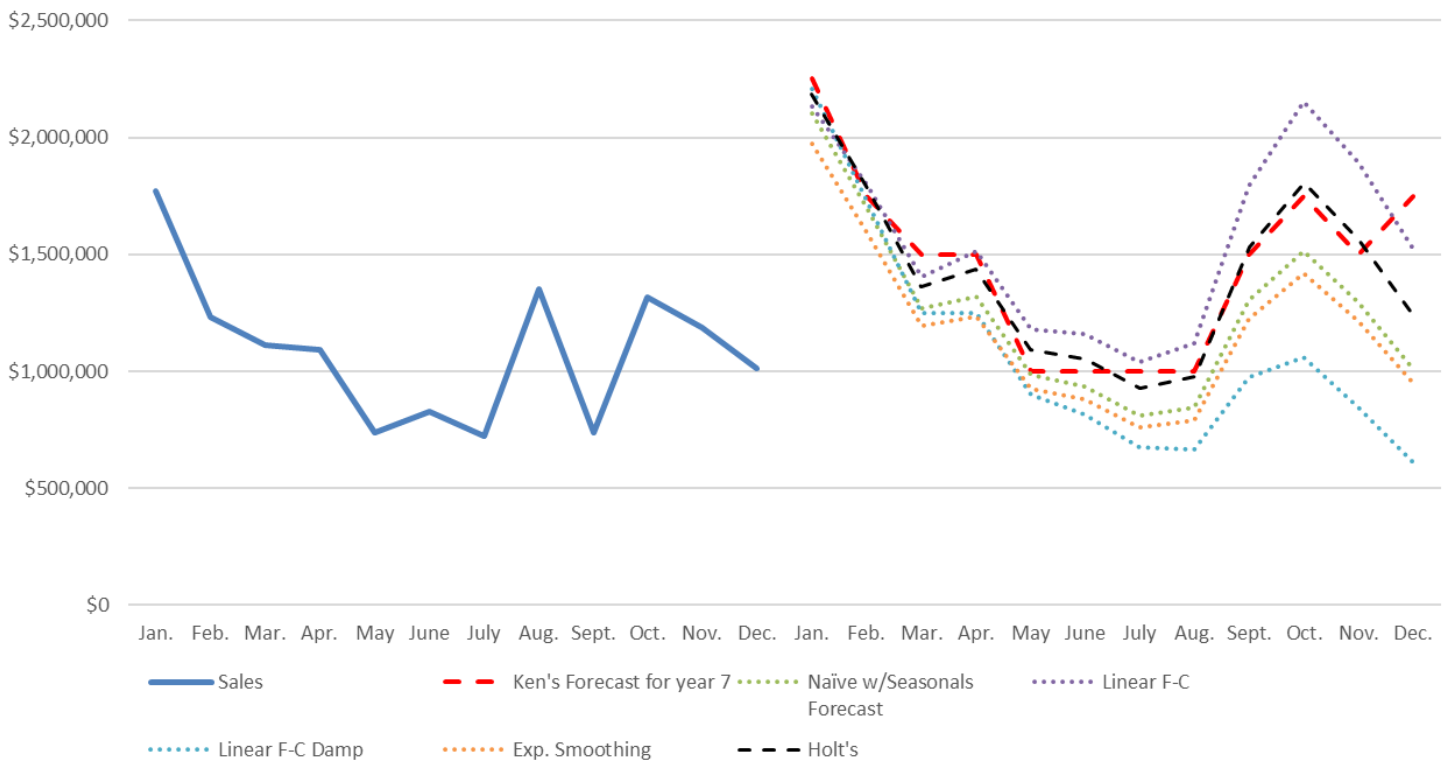
Part C:

KJ Manufacturing Sales Forecast

Mr. Jackson, I have put together a variety of forecasts using historical data and simple mathematical forecasting techniques to optimize the accuracy of your sales predictions. As you know, KJ Manufacturing heavily relies on sales revenue forecasts so that the rest of your business has enough cash to operate and plan. We want to create the growth that is necessary for the business to meet your business goals while minimizing risk of not bringing in enough revenue.

Because your data has a trend, I propose you use a Holt's Linear Forecast to have similar growth expectations (21%) as your own forecast (23%) while having a more tailored fit to the typical seasonality. Seasonality plays a big role in sales revenue as well as predicting other cascading effects such as demand patterns, Manufacturing capacity, cash flow, inventory management/production, achieving accurate sales goals and so much more. Overshooting expectations in (such as December) could cause damage to multiple departments and cashflow. For example, your forecast is projecting a 42% increase in the month of December when there is an average of just 26% within the last 3 years. We see no reason to believe this will increase that much without any significant business component change. Historically, December sales have decreased after November due to the holidays. The Holt's model disperses that sales growth throughout the year using a method that puts the greatest emphasis on the most recent years.

This year's forecast is more important than ever due to multiple sources claiming new growth in customers as well as industry growth are slowing therefore, sales are beginning to level off. We do not want to forecast too much causing the potential loss of important salespeople, an excess in supply, and more expected cash flow while also not forecasting too little to cause a shortage in supply or salespeople to not reach their full potential. In addition to this, extra cash is needed this year to finance new equipment.

KJ Manufacturing Seasonality
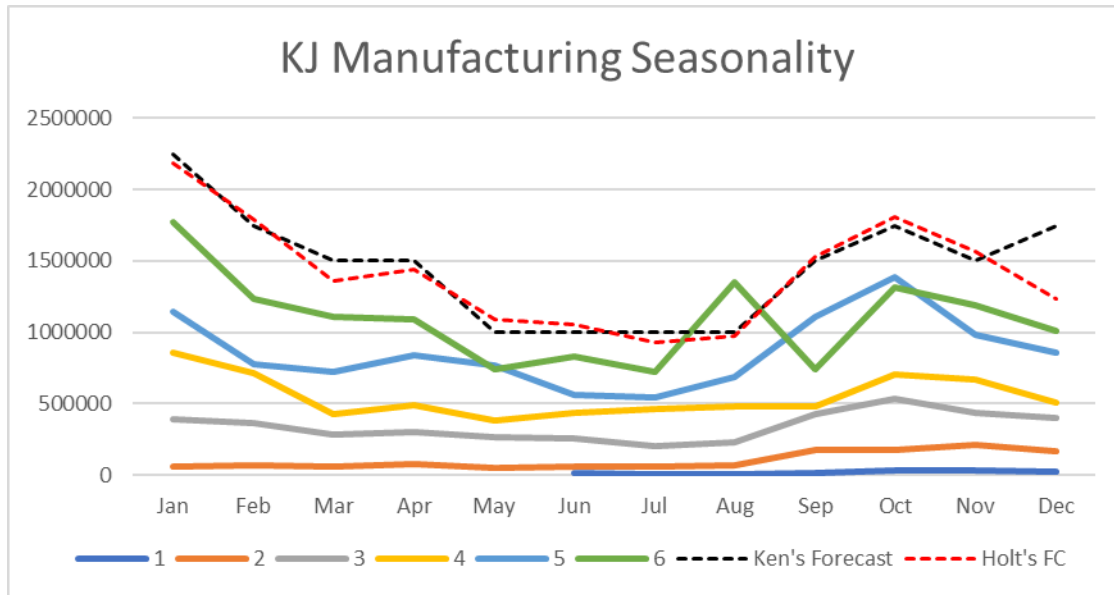
To get this forecast, we basically estimate which months of the year are typically higher or lower and put a numerical value/weight to it, remove that seasonality, calculate the level and slope at which it is and remove all the noise/variation/outliers to get a soft trendline of a 6-month average. From there, we get a "seasonally adjusted series" and can forecast one period ahead. With this, we add the linear trend number and then multiply the seasonality back into the data using the previously calculated seasonal weight.

Steps taken to create forecast
1. Scan the data at a glance
2. Estimate the seasonal component.
3. Seasonally adjust series or de-seasonalized series.
4. Irregular component cannot be estimated: average or smooth it out.
5. Forecast trend-cycle.
6. Reintroduce seasonal components.

Naïve w/Seasonal, Linear F-C, Exponential Smoothing and Linear F-C Dampening models were compared to Holt's and your forecasts. Below are the forecasts – Holt's being on the slightly ambitious side.

KJ Manufacturing Sales Forecasting Models

KJ Manufacturing Sales Forecasting Models
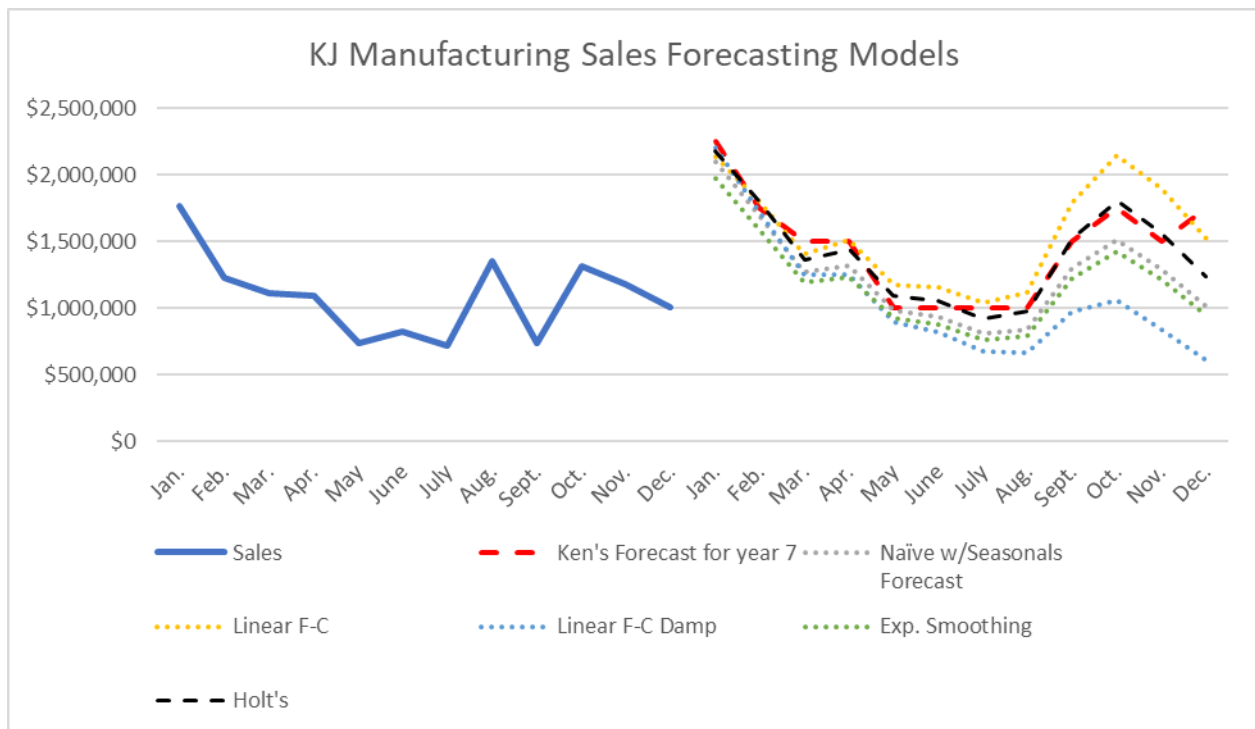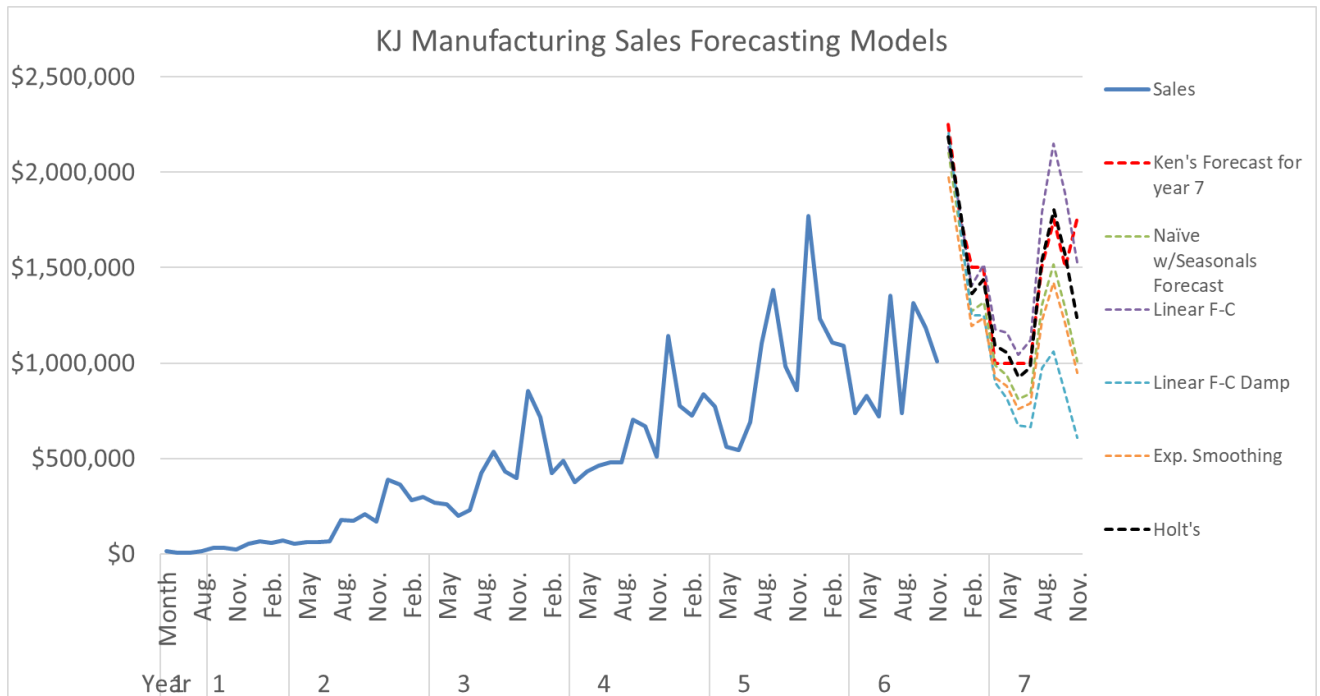
Using a mathematical approach will exponentially benefit KJ Manufacturing in creating a more accurate forecast while minimizing risk.

Holt's Forecast Values:

$2,185,164.86
$1,792,848.57
$1,363,911.78
$1,436,995.56
$1,091,035.99
$1,052,552.95
$924,966.48
$975,918.22
$1,531,569.88
$1,804,756.59
$1,561,653.01
$1,237,493.37

Should you be interested in any of the other forecasts, feel free to let me know and I'll be glad to take a second look. – Bryce Bowles