|  |  |  |
| --- | --- | --- |
| **Production Planning & Control**  **Code: IND 201**  **Answer of forecasting Prob.** | **SS.jpg** | **Benha University**  **Shoubra Faculty of Engineering**  **Industrial Eng. Department**  **Credit Hours System** |

1. Given the following data: prepare a forecast using each of these approaches:
2. The naïve approach
3. A 3-period moving average
4. A weighted average using weights of 0.5, 0.3 and 0.2.
5. Exponential smoothing with a smoothing constant of 0.4.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Period | 1 | 2 | 3 | 4 | 5 |
| Number of complaints | 60 | 65 | 55 | 58 | 64 |

**Solution:**

1. **The Most recent value of the series becomes the next forecast for period 6: 64.**
2. **A 3-period forecast for period 6: MA3= = 59.**
3. **A weighted average forecast for period 6:**

***F* = 0.50(64) + 0.30(58) + 0.20(55) =60.4.**

1. **Exponential** **smoothing forecast**

|  |  |  |  |
| --- | --- | --- | --- |
| **Period** | **Number  of complaints** | **Forecast** | **Calculations** |
| **1 2 3 4 5 6** | **60 65 55 58 64** | **60 62 59.2 58.72 60.83** | **[ Use previous value of series]**  **60 + 0.40 ( 64 – 60 ) = 62**  **62 + 0.40 ( 55 - 62 ) = 59.2**  **59.2 + 0.40 ( 58 – 59.2 ) = 58.72**  **59.72 + 0.40 ( 64 – 58.72 ) = 60.83** |

1. The number of bushels of apples sold at a roadside fruit stand over 12 day period were as follows:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Number sold | 25 | 31 | 29 | 33 | 34 | 37 | 35 | 32 | 38 | 40 | 37 | 32 |

1. If a two moving average has been used to forecast sales, what were the daily forecasts starting with the forecast for day 3.
2. If a four period moving average has been used, what were the forecasts for each day starting with day5
3. Plot the original data and each set of forecasts on the same graph. Which forecast has the greater tendency to smooth? Which forecast has the better ability to respond quickly to changes?

**Solution:**

|  |  |  |  |
| --- | --- | --- | --- |
| Day | Number | (a)  Two period moving average | (B)  Four period moving average |
| **1**  **2**  **3**  **4**  **5**  **6**  **7**  **8**  **9**  **10**  **11**  **12** | **25**  **31**  **29**  **33**  **34**  **37**  **35**  **32**  **38**  **40**  **37**  **32** | **………………..**  **……………….**  **25+31**  **ـــــــــــــــ = 28**  **2**  **29+31**  **ـــــــــــــــــــ = 30**  **2**  **33+29**  **ـــــــــــــــ = 28**  **2**  **34+33**  **ـــــــــــــــ = 33.5**  **2**  **37+34**  **ـــــــــــــــ = 35.5**  **2**  **35+37**  **ـــــــــــــــ = 36**  **2**  **32+35**  **ـــــــــــــــ = 33.5**  **2**  **38+32**  **ـــــــــــــــ = 35**  **2**  **40+38**  **ـــــــــــــــ = 39**  **2**  **37+40**  **ـــــــــــــــ = 38.5**  **2** | **………………………….**  **…………………………..**  **…………………………..**  **…………………………..**  **25+31+29+33**  **= ــــــــــــــــــــــــــــ 29.5**  **4**  **31+29+33+34**  **= ــــــــــــــــــــــــــــ 31.75**  **4**  **29+33+34+37**  **= ــــــــــــــــــــــــــــ 33.5**  **4**  **33+34+37+35**  **= ــــــــــــــــــــــــــــ 37.75**  **4**  **34+37+35+32**  **= ــــــــــــــــــــــــــــ 34.5**  **4**  **37+35+32+38**  **= ــــــــــــــــــــــــــــ 35.5**  **4**  **35+32+38+40**  **= ــــــــــــــــــــــــــــ 36.25**  **4**  **32+38+40+37**  **= ــــــــــــــــــــــــــــ 36.75**  **4** |

Two-period moving average

Four -period moving average

Actual data

* Four period moving average has the greater tendency to smooth
* Two period moving average model has the ability to respond quickly to changes

1. If the exponential smoothing with α = 0.4 has been used to forecast daily sales for apples in problem 2, determine what the daily forecasts would have been. Then plot the original data, the exponential forecasts, and a set of naïve forecasts on the same graph. Based on the visual comparison, is the naïve more accurate or less accurate than the exponential smoothing method, or are they about the same?

**Solution:** The exponential smoothing with α = 0.4🡺

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Exponential smoothing = 0.4 | | Naïve method | |
| Period | Actual demand | Forecasted | Error | Forecasted | Error |
| 1 | 25 | --- | --- | --- | ---- |
| 2 | 31 | 25.00 | 6.00 | 25 | 6 |
| 3 | 29 | 27.40 | 1.60 | 37 | -8 |
| 4 | 33 | 28.04 | 4.96 | 21 | 12 |
| 5 | 34 | 30.02 | 3.98 | 45 | -11 |
| 6 | 37 | 31.61 | 5.39 | 23 | 14 |
| 7 | 35 | 33.77 | 1.23 | 51 | -16 |
| 8 | 32 | 34.26 | -2.26 | 19 | 13 |
| 9 | 38 | 33.36 | 4.64 | 45 | -7 |
| 10 | 40 | 35.21 | 4.79 | 31 | 9 |
| 11 | 37 | 37.13 | -0.13 | 49 | -12 |
| 12 | 32 | 37.08 | -5.08 | 25 | 7 |

Exponential smoothing forecasting

Actual demand

Naïve approach

* From the graph we can see that the exponential forecasting is more accurate than the naïve approach

1. Apple’s Citrus fruit farm ships boxed fruit anywhere in the continental United States. Using the following information forecast shipments for the first four mouths. The monthly forecast equation being used is: y= 402+3t where: t0 January of last year and y is the number of shipments. Determine the amounts of shipments for the first four months of the next year: January t=24; February t=25 etc.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Month | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
| Seasonal relative | 1.2 | 1.3 | 1.3 | 1.1 | 0.8 | 0.7 | 0.8 | 0.6 | 0.7 | 1.0 | 1.1 | 1.4 |

**Solution:**

* **Determine trend amounts for the first four months of next year: January, t = 24; February t = 25; etc. Thus,**

**First forecast the monthly demand by the given trend equation**

**Then multiply the gotten value by the month seasonal index**

**y*jan* = 402 + 3(24) = 474 🡺 SI of Jan = 1.2 🡺 474(1.2) = 568.8**

**y*feb* = 402 + 3(25) = 477 🡺 SI of Feb = 1.3 🡺477(1.3) = 620.1**

**y*Mar* = 402 + 3(26) = 480** 🡺 **SI of Mar = 1.3 🡺 480(1.3) = 624.0**

**y*Apr* = 402 + 3(27) = 483** 🡺 **SI of Apr = 1.1 🡺 483(1.1) = 531.3**

1. Develop a linear trend line for the following data. Plot the line and the data on a graph, and verify visually that a linear trend line is appropriate. Then use the equation to predict the next two values of the series.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Demand | 44 | 52 | 50 | 54 | 55 | 55 | 60 | 56 | 62 |

**Solution:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Period (t) | Demand (Y) | t\*y | t2 |
|  | 1 | 44 | 44 | 1 |
|  | 2 | 52 | 104 | 4 |
|  | 3 | 50 | 150 | 9 |
|  | 4 | 54 | 216 | 16 |
|  | 5 | 55 | 275 | 25 |
|  | 6 | 55 | 330 | 36 |
|  | 7 | 60 | 420 | 49 |
|  | 8 | 56 | 448 | 64 |
|  | 9 | 62 | 558 | 81 |
| Sum | 45 | 488 | 2545 | 285 |

**n = 9**

**∑t = 45**

**∑t \*y= 2545**

**∑(t^2) = 285**

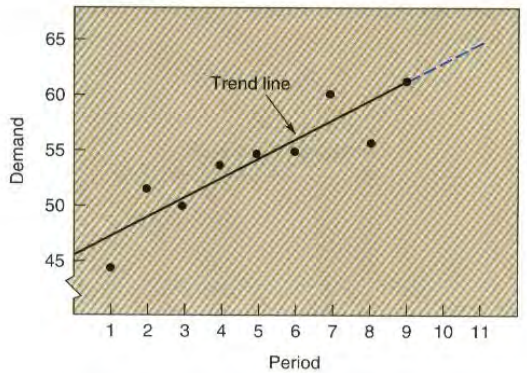
b==  
  
a=

**Thus, the linear trend equation is *yt =*45.47 + 1.75t. The next two forecasts are:**

***y*10 = 45.47 + 1.75(10) = 62.97**

***y*11 = 45.47 + 1.75(11) = 64.72**

**A plot of the data indicates that a linear trend line is appropriate**:



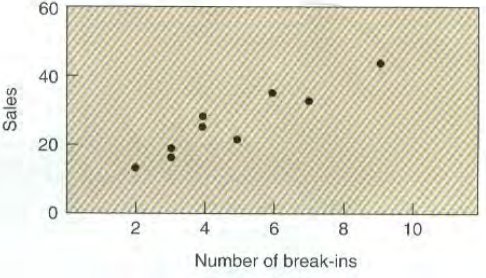
1. The owner of a small hardware store has noted a sales pattern for window locks that seems to parallel the number of break-ins reported each week in the newspaper. The data are:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| sales | 46 | 18 | 20 | 22 | 27 | 34 | 14 | 37 | 30 |
| Break-ins | 9 | 3 | 3 | 5 | 4 | 7 | 2 | 6 | 4 |

1. Plot the data to determine which type of equation is appropriate
2. Obtain a regression equation for the data
3. Estimate sales when the number of break-ins is five

**Solution:**

* 1. **Plot the data to determine which type of equation is appropriate:**



From the scatter plot of the data the linear relation is clear between sales and the number of break-ins thus the linear regression is appropriate model

* 1. **the computations for a straight line are :**

|  |  |  |  |
| --- | --- | --- | --- |
| Break-ins  ***x*** | Sales  y | ***x y*** |  |
| 9 | 46 | 414 | 81 |
| 3 | 18 | 54 | 9 |
| 3 | 20 | 60 | 9 |
| 5 | 22 | 110 | 25 |
| 4 | 27 | 108 | 16 |
| 7 | 34 | 238 | 49 |
| 2 | 14 | 28 | 4 |
| 6 | 37 | 222 | 36 |
| 4 | 30 | 120 | 16 |
| 43 | 248 | 1354 | 245 |

b==  
  
a=

**Thus, the equation is *yx* = 7.129 + 4.275x.**

* 1. ***x* = 5, *yx*= 7.129 + 4.275(5) = 28.50.**

1. National mixer, Inc., sells can openers. Monthly sales for a seven-month period were as follows:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Month | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. |
| Sales (1000 units) | 19 | 18 | 15 | 20 | 18 | 22 | 20 |

1. Plot the monthly data on a sheet of graph paper
2. Forecast September sales volume using each of the following:
3. A linear regression
4. A five-month moving average
5. Exponential smoothing with a smoothing constant equal to 0.2, assuming a March forecast of 19000 units
6. The naive approach
7. Aweighted average using 0.6, 0.3, and 0.1 wieghts
8. Which method seems least appropariate? Why?

**Solution :**

1. **Plot the monthly data**
2. **Forcasting the septamper value using :**

**1. linear regrission :**

|  |  |  |  |
| --- | --- | --- | --- |
| **Month ( t )** |  | **Sales ( Y )** | **Ty** |
| ---- | --- | ---- | 0 |
| Feb. (2) | 4 | 19 | 38 |
| Mar. (3) | 9 | 18 | 54 |
| Apr. (4) | 16 | 15 | 60 |
| May (5) | 25 | 20 | 100 |
| Jun. (6) | 36 | 18 | 108 |
| Jul (7) | 49 | 22 | 154 |
| Aug (8) | 64 | 20 | 160 |
| 35 | 203 | 132 | 674 |
| = 1225 | ∑ = 203 |  |  |

|  |  |
| --- | --- |
| ***Yt* = a + bt**  **where**  t = specified number of time periods from t=0  ***Yt* = forecast for period t**  a=value of ***Yt*** at t=0  b=slope of the line | b=  a=  n=number of periods = 7  y=value of time series |



**2. a five month moving average** :

MAn =**where**

i="Age" of the data (i=1,2,3,…)

n=Number of periods in the moving average

Ai = Actual value with age i

MA= forecast

MA =  19

**3. exponential forcasting :**

|  |  |  |  |
| --- | --- | --- | --- |
| Period | Sales  Unit (1000) | α = 0.2 | |
| Forecasted | Error |
| ---- | ---- | --- | --- |
| Feb. (2) | 19 | --- | --- |
| Mar. (3) | 18 | 19 | -1 |
| Apr. (4) | 15 | 18.8 | - 4.2 |
| May (5) | 20 | 18.36 | - 0.04 |
| Jun. (6) | 18 | 20.032 | - 2.048 |
| Jul (7) | 22 | 19.6384 | 1.5424 |
| Aug (8) | 20 | 20.76608 | 0.14912 |
| **Sep (9)** |  | **20.119296** |  |

**4. Naïve approach :**

|  |  |  |  |
| --- | --- | --- | --- |
| Period | Sales  Unit (1000) | Forecasted  ( Naïve) | Error |
| Feb. (2) | 19 | --- | --- |
| Mar. (3) | 18 | 19 | -1 |
| Apr. (4) | 15 | 17 | -2 |
| May (5) | 20 | 13 | 7 |
| Jun. (6) | 18 | 27 | -9 |
| Jul (7) | 22 | 9 | 11 |
| Aug (8) | 20 | 33 | -13 |
| **Sep (9)** |  | **7** |  |

**5- A weighted average :**

***F* =0.60(20) + 0.30(22) + 0.10(18) =20.4.**

1. **Which method seems least appropariate? Why?**

The least appropiate method is the naive one

1. Mark Cotteleer owns a company that manufactures sailboats. Actual demand for Mark’s sailboats during each season in 2006 through 2009 was as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Season | Year | | | |
| 2006 | 2007 | 2008 | 2009 |
| Winter | 1400 | 1200 | 1000 | 900 |
| Spring | 1500 | 1400 | 1600 | 1500 |
| Summer | 1000 | 2100 | 2000 | 1900 |
| Fall | 600 | 750 | 650 | 500 |

Mark has forecasted that the annual demand for his sailboats in 2011 will equal 5600 sailboats. Based on this data determine the forecasted value for the spring 2011.

**Soltuion:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Season** | **year** | | | | **Average**  **2006-2009**  **Demand** | **Average seasonal demand** | **Seasonal index** |
| **2006** | **2007** | **2008** | **2009** |
| Winter | 1400 | 1200 | 1000 | 900 | 1125 | 1250 | 0.9 |
| Spring | 1500 | 1400 | 1600 | 1500 | 1500 | 1250 | 1.2 |
| Summer | 1000 | 2100 | 2000 | 1900 | 1750 | 1250 | 1.4 |
| Fall | 600 | 750 | 650 | 500 | 625 | 1250 | 0.5 |
| Total | **Average Seasonally demand = 5000/4 = 1250** | | | | 5000 |  |  |
|  | Seasonal index = (**Average 2006-2009 demand) / (Average seasonal demand )** | | | | | |  |

Forecasted value for the spring 2011 is

* 

1. The manager of a large manufacturer of industerial pumps must choose between two alternative forecasting techniques. Both techniques have been used to prepare forecasts for a six-months period. Compute the MAD and MSE. Relying on MAD which technique has the beter performance.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Month | | 1 | 2 | 3 | 4 | 5 | 6 |
| Demand | | 492 | 470 | 485 | 493 | 498 | 492 |
| Forecast | Tech-1 | 488 | 484 | 480 | 490 | 497 | 493 |
| Tech-2 | 495 | 482 | 478 | 488 | 492 | 493 |

**Soltuion:**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Month** | **Demand** | **Tech-1** | ***e*** | ***|e|*** | ***e2*** | **Tech-2** | ***e*** | ***|e|*** | ***e2*** |
| **1**  **2**  **3**  **4**  **5**  **6** | **492**  **470**  **485**  **493**  **498**  **492** | **488**  **484**  **480**  **490**  **497**  **493** | **4**  **-14**  **5**  **3**  **1**  **-1**  **ـــــــــــــ**  **-2** | **4**  **14**  **5**  **3**  **1**  **1**  **ــــــــــــــ**  **28** | **16**  **196**  **25**  **9**  **1**  **1**  **ــــــــــــــ**  **248** | **495**  **482**  **478**  **488**  **492**  **493** | **-3**  **-12**  **7**  **5**  **6**  **-1**  **ــــــــــ**  **+2** | **3**  **12**  **7**  **5**  **6**  **1**  **ـــــــــ**  **34** | **9**  **144**  **49**  **25**  **36**  **1**  **ـــــــــ**  **264** |

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**Technique 1 is better than technique 2 in this comparison where both MAD and MSE of technique 1 are less than that of technique 2.**