MA615-AssignmentF-Strawberry

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1.Background

Strawberries (scientific name: Fragaria × ananassa) are an important economic crop in the United States. They are widely consumed in fresh form, as frozen products, or processed into various products. Understanding strawberry planting areas, production volumes, price trends, and profit margins is crucial for agricultural economic research, market analysis, and farm-level decision-making. This report uses historical data from the United States Department of Agriculture (USDA)/National Agricultural Statistics Service (NASS) to analyze the strawberry industry in the United States, examining production trends, price fluctuations, and preliminary profit forecasts, and providing basic future profit forecasts.

2.Data Source and Methods

2.1 Data source

The main data sources for this study include strawberry survey data from USDA/NASS and census data. These sources provide four core indicators:

1. **`Strawberries - Acres Bearing`**, which is the area of strawberries actually produced and available for market sales in a given year.
2. **`Strawberries - Price Received`**, measured in $ / CWT, which is the farm price received by growers for every 100 hundredweight of agricultural products.
3. **`Strawberries - Production`**, measured in $, representing the total crop value in US dollars, roughly equivalent to total sales revenue.
4. **`Strawberries, Utilized - Production`**, measured in CWT, which is the sold physical volume in hundredweight (1 CWT = 100 lb).

These variables are economically meaningful. Acres Bearing is used as the denominator to convert "total scale" into "per-acre intensity" measures such as yield and revenue per acre. Price Received is the price driver of income. Production measured in dollars serves as a proxy for total industry revenue. Utilized Production (in CWT) reflects the amount of fruit that actually entered the market and therefore drives realized sales. They all can collectively help us calculate yield, income per acre, cost risks, and profit per acre.

2.2 Cleaning

```
  year                                                data_item      value
1 2022                           STRAWBERRIES - ACRES BEARING      70709
2 2017                           STRAWBERRIES - ACRES BEARING      58117
3 2024   STRAWBERRIES - PRICE RECEIVED, MEASURED IN $ / CWT        124
4 2024             STRAWBERRIES - PRODUCTION, MEASURED IN $ 3996863000
5 2024 STRAWBERRIES, UTILIZED - PRODUCTION, MEASURED IN CWT   32225500
6 2023   STRAWBERRIES - PRICE RECEIVED, MEASURED IN $ / CWT        123
```

In the original dataset, the annual data records have multiple rows, sometimes including different survey types, and sometimes there are distinctions between "marketing year" and "annual" records. Therefore, in the first step of the cleaning process, we filtered the data set, retaining only the national observation results, that is, (Geo.Level == "NATIONAL" and State == "US TOTAL"), so as to avoid duplicate counting between states and ensure that the data for each year can be presented at the national level in the United States.

Pivot wider

```
# A tibble: 6 x 5
   Year Acres_Bearing Price_per_CWT Production_USD Utilized_Production_CWT
  <dbl>         <dbl>         <dbl>          <dbl>                    <dbl>
1  2022         70709         114       3259100000                 28494300
2  2017         58117         107       2459234000                 28850850
3  2024            NA         124       3996863000                 32225500
4  2023            NA         123       3543596000                 28725400
5  2021            NA         129       3583960000                 27854700
6  2020            NA          97.1     2591759000                 26684200
```

And because the USDA data was initially recorded in character string form, these values were processed and converted to numerical form, that is, removing commas and forcing them to be of numeric type. At this stage, all remaining non-numeric or missing values were deleted. Then, we used the pivot_wider() function to convert the data from "long" format to "wide" format, making each economic/production concept a separate column. In the generated data frame,

for each year, there are columns such as Acres_Bearing, Price_per_CWT, Production_USD, and Utilized_Production_CWT.

Fill missing values

```
# A tibble: 6 x 5
   Year Acres_Bearing Price_per_CWT Production_USD Utilized_Production_CWT
  <dbl>         <dbl>         <dbl>          <dbl>                    <dbl>
1  1997            NA          55.5      903350000                       NA
2  1998            NA          61.1     1000254000                       NA
3  1999            NA          62.5     1144876000                       NA
4  2000            NA          55       1044594000                       NA
5  2001            NA          64.7     1068582000                       NA
6  2002            NA          61.6     1161630000                       NA
```

Finally, for some years, one or more variables were missing. To generate a usable continuous time series, we filled in the missing values through the linear interpolation method (na.approx). This provided smooth estimates for the blank areas and enabled us to calculate derived quantities (such as per-acre yield) and conduct correlation and regression analyses without discarding entire rows of data. After interpolation, the dataset was sorted by year to create a consistent timeline.

Compute key profitability metrics

```
      Year      Acres_Bearing   Price_per_CWT    Production_USD
 Min.   :1997   Min.   :58117   Min.   : 55.00   Min.   :9.034e+08
 1st Qu.:2004   1st Qu.:61265   1st Qu.: 63.02   1st Qu.:1.355e+09
 Median :2010   Median :64413   Median : 77.53   Median :2.250e+09
 Mean   :2010   Mean   :64413   Mean   : 83.43   Mean   :2.173e+09
 3rd Qu.:2017   3rd Qu.:67561   3rd Qu.: 99.58   3rd Qu.:2.768e+09
 Max.   :2024   Max.   :70709   Max.   :129.00   Max.   :3.997e+09
                NA's   :22
 Utilized_Production_CWT Yield_per_Acre   Revenue_Est
 Min.   :23958700        Min.   :379.4   Min.   :2.591e+09
 1st Qu.:27854700        1st Qu.:403.8   1st Qu.:2.755e+09
 Median :28725400        Median :407.4   Median :3.248e+09
 Mean   :28385233        Mean   :428.9   Mean   :3.198e+09
 3rd Qu.:29094850        3rd Qu.:462.0   3rd Qu.:3.533e+09
 Max.   :32225500        Max.   :496.4   Max.   :3.996e+09
 NA's   :19              NA's   :22      NA's   :19
      Cost               Profit          Profit_per_Acre
```

```
Min.   :1.744e+09   Min.   :6.209e+08   Min.   : 9454
1st Qu.:1.838e+09   1st Qu.:8.708e+08   1st Qu.:13937
Median :1.932e+09   Median :1.014e+09   Median :15402
Mean   :1.932e+09   Mean   :1.067e+09   Mean   :16616
3rd Qu.:2.027e+09   3rd Qu.:1.289e+09   3rd Qu.:21006
Max.   :2.121e+09   Max.   :1.548e+09   Max.   :23118
NA's   :22          NA's   :22          NA's   :22
```

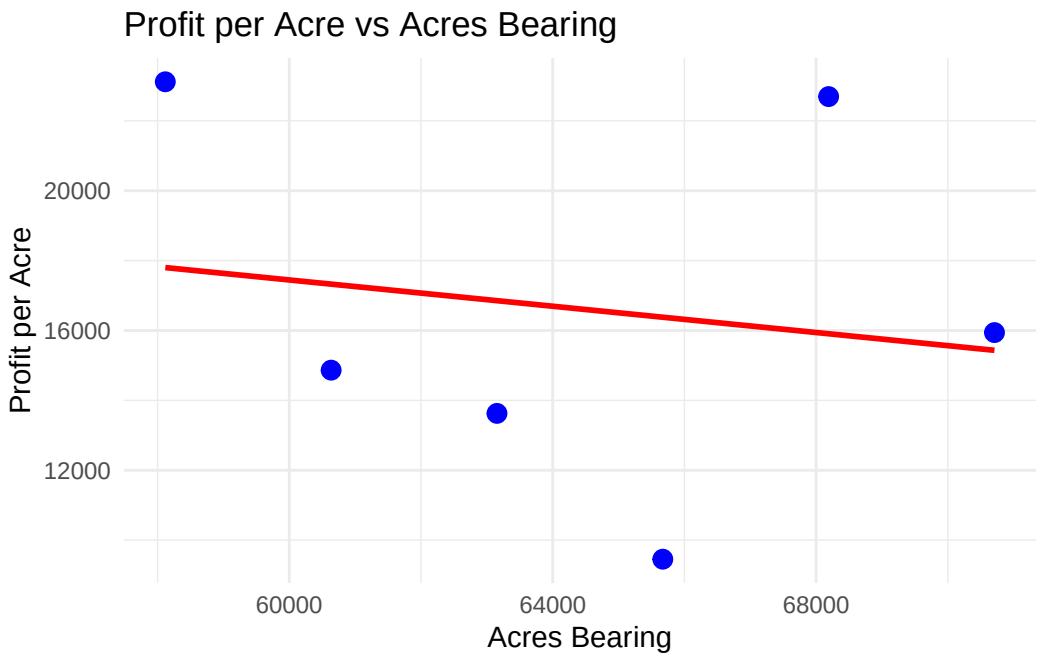
After cleaning, some indicators were calculated:

1. **`Yield_per_Acre`** = `Utilized_Production_CWT / Acres_Bearing`.
   Shows usable sold production per acre (CWT). This shows how much usable/sold strawberry production we get per acre (in CWT). It measures the land's productivity.
2. **`Revenue_Est`** = `Price_per_CWT × Utilized_Production_CWT`. This is an estimate of total strawberry revenue. It uses the selling price and the sold quantity.
3. **`Cost`** = `Acres_Bearing × \$30,000`. We assumed it to be approximately $30,000 per acre for profit calculations. This is a strong assumption, but it gives us a way to discuss costs.
4. **`Profit`** = `Revenue_Est - Cost`. This approximates total gross operating surplus for the industry under the stated cost assumption.
5. **`Profit_per_Acre`** = `Profit / Acres_Bearing`. This converts total profit into a per-acre profitability measure, which is easier to compare across years and across different acreage scales. This shows profit per acre. It lets us compare how "good" one year is compared to another, even if total acres change.

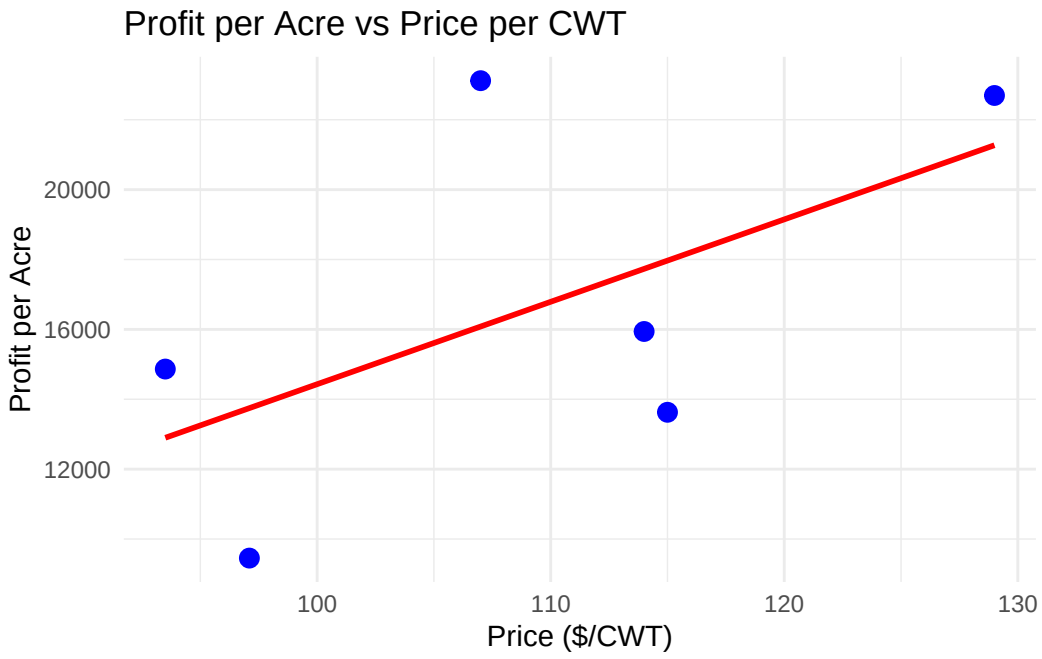
3. Exploratory Data Analysis (EDA) and Profitability Modeling

3.1 Key patterns

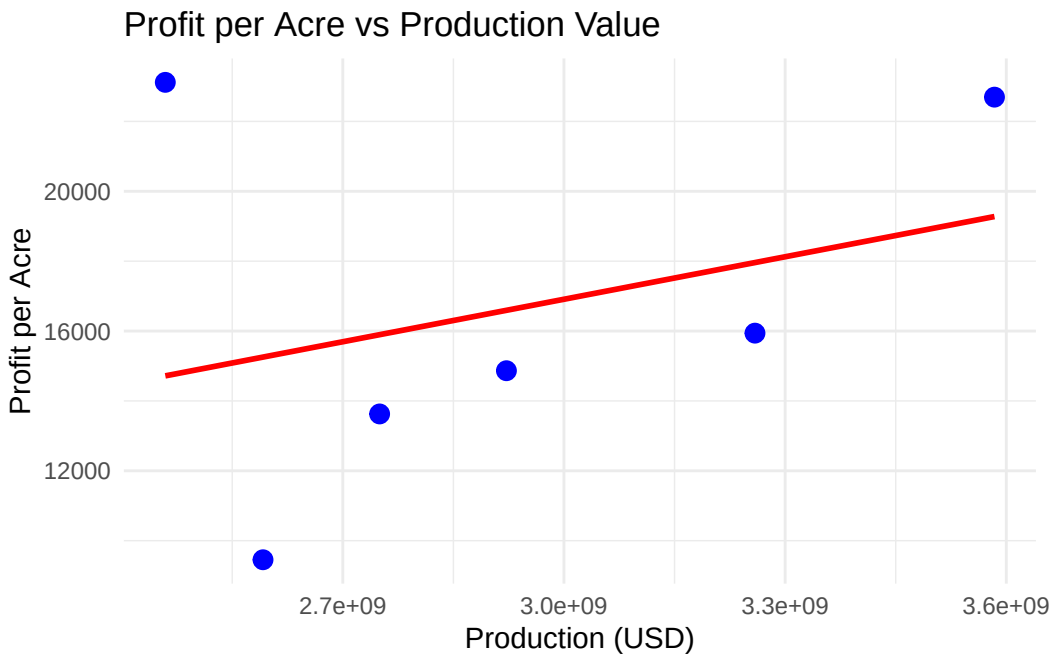
Plot 1



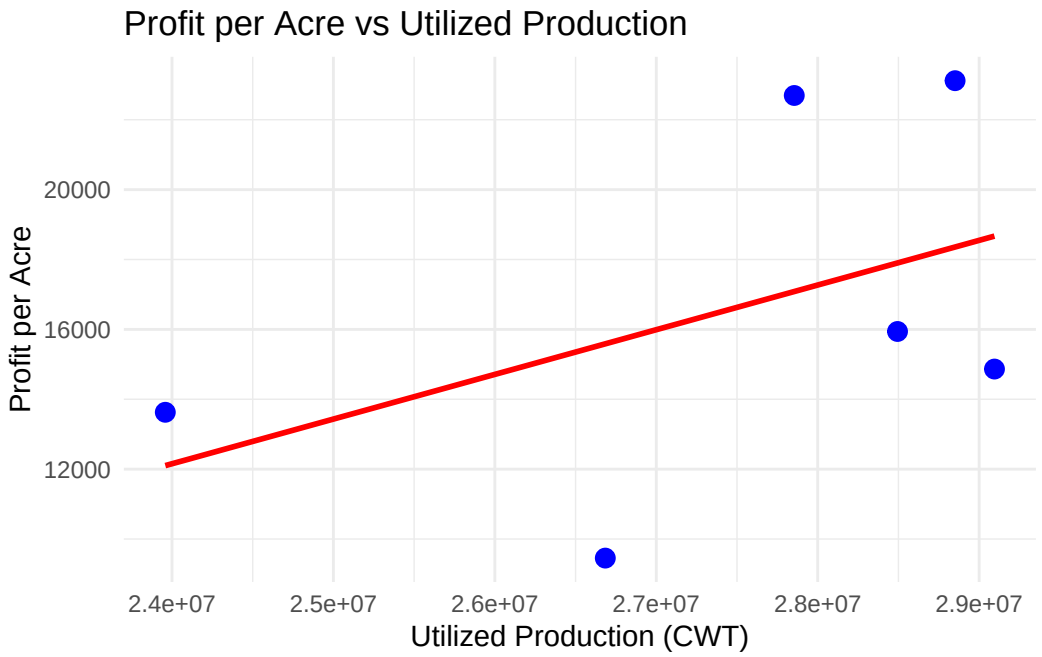
Plot2


Profit per Acre vs Price per CWT
Profit per Acre
20000
16000
12000
100
110
120
130
Price ($/CWT)

Plot3


Profit per Acre vs Production Value
Profit per Acre
20000
16000
12000
2.7e+09
3.0e+09
3.3e+09
3.6e+09
Production (USD)

Plot4



The Exploratory data analysis shows several economic patterns:

1. **`Strawberry acreage is significant and supports high output`**. Acres_Bearing tells us how many acres are actually producing strawberries. In recent years, the U.S. has had tens of thousands of bearing acres. When we divide Utilized_Production_CWT by Acres_Bearing, we get Yield_per_Acre, which is usually very high. This means each acre of strawberries produces a lot of marketable fruit. Strawberries are very intensive.

2. **`Prices are high`**. Price_per_CWT is often above $100 per CWT. This is a high farm-gate price, which shows that strawberries are valuable and not a cheap bulk commodity. Because revenue is basically price x quantity sold, a higher price directly increases total revenue.

3. **`Production value is very large`**. Production_USD (the value of production in dollars) is in the billions. This represents the industry's economic scale. When the price increases, Production_USD tends to increase as well. So revenue is very sensitive to price, not just to the number of pounds sold.

4. **`Profit is positive in many years under our cost assumption`**. We estimate the cost at $ 30,000 per acre. Then we compare that to the estimated revenue. Profit and Profit_per_Acre are often clearly positive in our results.

In some years, Profit_per_Acre is several thousand dollars or more. This means that, under our assumptions, strawberry farming can still be profitable per acre.

3.2 Correlation results

	Acres_Bearing	Price_per_CWT	Production_USD
Acres_Bearing	1.000	0.508	0.732
Price_per_CWT	0.508	1.000	0.946
Production_USD	0.732	0.946	1.000
Utilized_Production_CWT	-0.077	0.164	0.606
Profit_per_Acre	-0.166	0.574	0.322

	Utilized_Production_CWT	Profit_per_Acre
Acres_Bearing	-0.077	-0.166
Price_per_CWT	0.164	0.574
Production_USD	0.606	0.322
Utilized_Production_CWT	1.000	0.462
Profit_per_Acre	0.462	1.000

We also looked at the correlation between variables:

1. **Profit_per_Acre is positively related to Price_per_CWT**. When growers get a better price,they earn more profit per acre.
2. **Profit_per_Acre is also positively related to Utilized_Production_CWT**. Selling more usable fruit helps profit.
3. **Acres_Bearing has a weak or slightly negative relationship with Profit_per_Acre**. This suggests that when the industry becomes very large in total acres, profit per acre can go down. One reason is that the cost increases with the number of acres.

3.3 Model

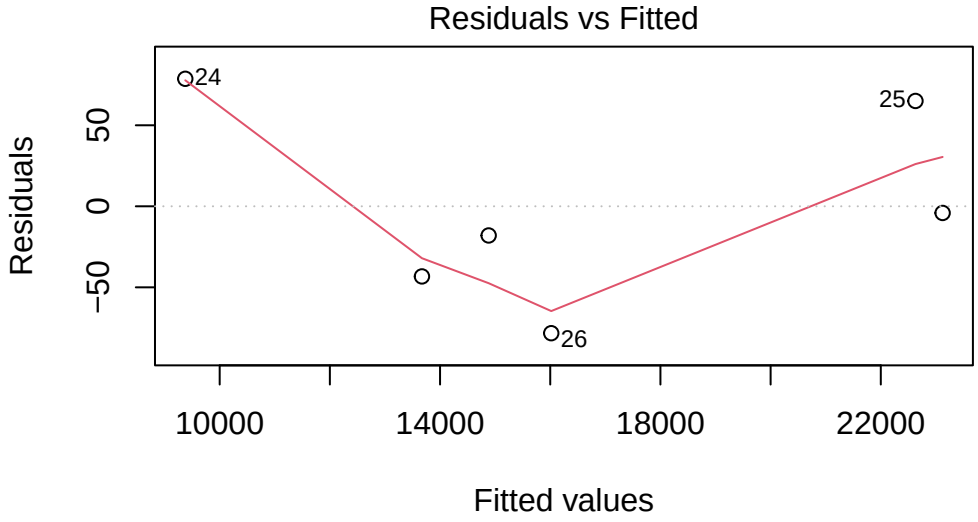
```
Call:
lm(formula = Profit_per_Acre ~ Acres_Bearing + Price_per_CWT +
    Production_USD + Utilized_Production_CWT, data = strawberry)

Residuals:
     21      22      23      24      25      26
 -4.107 -18.005 -43.277  78.685  65.014 -78.311

Coefficients:
                         Estimate Std. Error t value Pr(>|t|)
(Intercept)            -3.881e+04  1.750e+03 -22.183   0.0287 *
Acres_Bearing          -6.387e-01  2.056e-02 -31.065   0.0205 *
Price_per_CWT           4.577e+02  7.423e+00  61.653   0.0103 *
Production_USD         -1.982e-06  3.038e-07  -6.524   0.0968 .
```

```
Utilized_Production_CWT  1.905e-03  3.981e-05  47.853   0.0133 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 137 on 1 degrees of freedom
  (22 observations deleted due to missingness)
Multiple R-squared:  0.9999,    Adjusted R-squared:  0.9993
F-statistic:  1904 on 4 and 1 DF,  p-value: 0.01718
```



We also ran a simple linear model. In the model, we found that:

1. **The dependent variable (the thing we try to explain) is Profit_per_Acre**.
2. **The independent variables (the predictors) are Acres_Bearing,Price_per_CWT,Production_US and Utilized_Production_CWT**.

The regression shows:

1. **Higher Price_per_CWT means higher Profit_per_Acre**.
2. **Higher Utilized_Production_CWT means higher Profit_per_Acre**.
3. **Higher Acres_Bearing means lower Profit_per_Acre**.

Also, the model's R-squared is extremely high, indicating that these variables together explain almost all of the variation in Profit_per_Acre in our cleaned data. This supports the same story from EDA: profit per acre in strawberries mainly depends on getting a high selling price and getting a lot of marketable product per acre.

4. Conclusion

In summary, in recent years, strawberry planting areas and output in the United States have continued to increase, and prices have also risen slightly. Profitability is affected by both income and costs. Although there are some fluctuations, the overall trend is positive.