E.R.S. Industries Bicycle Production Analysis

Production Optimization With Tariffs

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Executive Summary

E.R.S. Industries, a predominant mountain bike manufacturer of the Helena area, currently produces all bikes overseas to reduce costs. The company currently produces two types of suspension mountain bikes and has expressed concern in continuing to manufacture all products overseas due to the recently implemented U.S. tariff. This report discusses the profit maximizing production levels with and without the tariff, the affect of tariffs on production levels and profit, the cost of tariffs, and the possibility of relocating manufacturing to the U.S.

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1 Introduction

E.R.S. Industries, a mountain bike manufacturer, wishes to understand how the choice to locate manufacturing facilities overseas or in the U.S. will affect company profits. The company currently produces two models of bikes: one air-oil and one with variable lockout shocks. The company claims the manufacturing costs are \$200 and \$379, respectively, per bike. However, the wholesale price of each model changes according to the number of sales for each model. Further, E.R.S. Industries estimates the yearly facility operation cost is approximately $\$400,000$ overseas.

Though E.R.S. Industries is currently overseas, the recent implementation of a \$25 import tariff per bike raises concerns regarding the company's profitability overseas. The company's current research and negotiations indicate the overseas facilities could be leased for $\$200,000$ per year, but E.R.S. Industries would remain the owner, meaning they would continue to pay manufacturing costs. However, comparable facilities in the U.S. cost approximately $\$800,000$ per year to own and operate.

This technical report will discuss:

- The optimal production levels for each bike model with and without import tariffs.
- The cost of tariffs if company facilities are located overseas.
- The potential costs and savings to relocate manufacturing to the U.S.
- The possible necessity to relocate facilities according to increased tariff prices.
- The sensitivity of the production levels and profit to the tariff price and manufacturing costs.
- The price elasticity of each bike model.

2 Design

The provided market price data provided by E.R.S. Industries allowed for the creation of functions to model the market price for each bike model. The wholesale price of each bike model is elastic and dependent upon the quantity sold of each model. The data set only contained eighteen data points, so all data points were used to create the market price models.

Figure 1 shows the relationship between the quantity of each bike sold and their respective wholesale prices. As expected by the concept of supply and demand, the wholesale price of each model decreased as more bikes of that model sold. Notice the patterns of the data points in Figure 1 appear very linear. Therefore, this analysis used linear functions of the quantity sold of each bike to model the wholesale price of each bike. Linear regression yields the functions:

$$m_1(x, y) = -0.0089256x - 0.002431y + 355.355$$

$$m_2(x, y) = 0.0023112x - 0.008407y + 624.409$$

where x is the quantity of air-oil bikes sold and y is the quantity of variable lockout bikes sold. $m_1(x, y)$ is the wholesale price of air-oil bikes and $m_2(x, y)$ is the wholesale price of variable lockout bikes, which have Mean Squared Errors of $8.1 \cdot 10^{-28}$ and $7.2 \cdot 10^{-28}$, respectively.

As a result, E.R.S. Industries sales revenue can be modeled by:

$$r(x, y) = m_1(x, y) \cdot x + m_2(x, y) \cdot y.$$

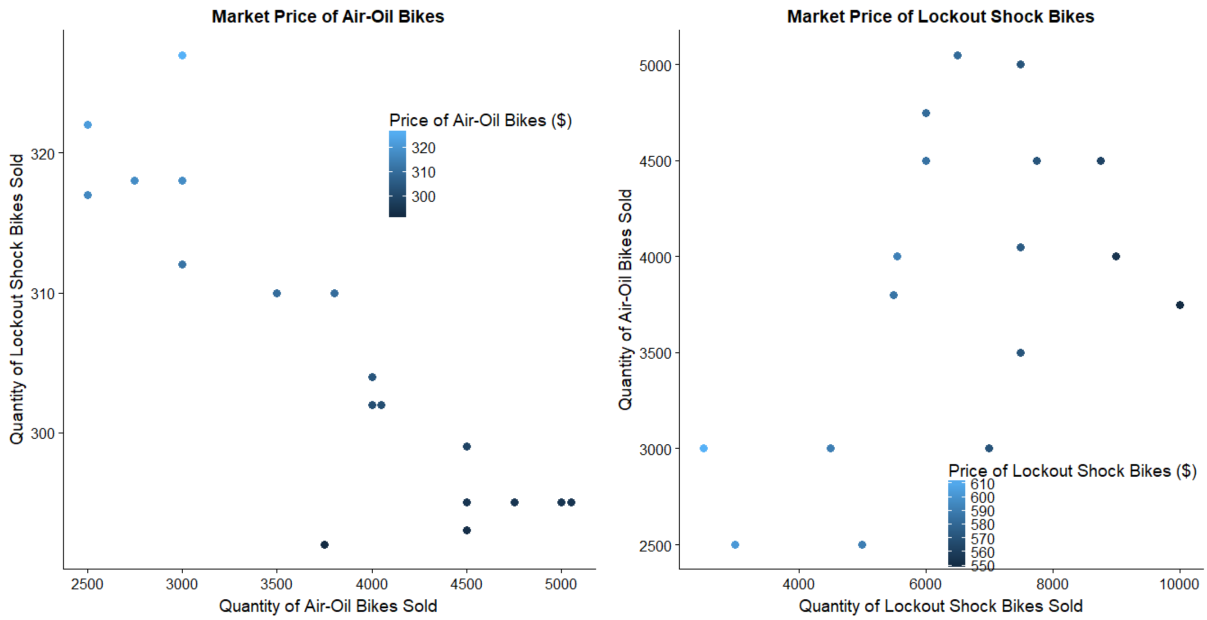

Figure 1: The wholesale price of each model according to the quantity of each model sold.

Given the estimates from E.R.S. Industries, the cost and revenue for operating over seas without a tariff was modeled by:

$$c(x, y) = 400000 + 200x + 379y$$

where x is the quantity of air-oil bikes sold and y is the quantity of variable lockout bikes sold, and $c(x, y)$ is total cost. Therefore, when operating over seas the company's profit was modeled by:

$$P(x, y) = r(x, y) - c(x, y).$$

With the implementation of the tariff, the costs and resulting profit of operating overseas was modeled by:

$$t(x, y) = 400000 + 200x + 379y + 25(x + y)$$

$$P_t(x, y) = r(x, y) - t(x, y)$$

where $t(x, y)$ is the total cost including tariffs and $P_y(x, y)$ is the profit when paying the import tariff per bike.

However, the costs of relocating to the U.S. has additional costs. Thus, the company's costs and profits were modeled with the similar, but slightly different functions:

$$s(x, y) = 1000000 + 200x + 379y$$

$$P_s(x, y) = r(x, y) - s(x, y)$$

where $s(x, y)$ is the cost and $P_s(x, y)$ is the company's profit when manufacturing in the U.S.

2.1 Assumptions

The goal is to optimize the production; however, the manufacturing facilities have production capacities. Using the provided data, the estimated production capacities were estimated to be:

$$x \leq 5050$$

$$y \leq 1000$$

$$x + y \leq 13750$$

where x is the quantity of air-oil bikes and y is the quantity of variable lockout bikes. Since the goal is maximize profit, the lower bounds of bike production were assumed to be 0 bikes. Furthermore, it assumed the manufacturing costs of each model is the same overseas and in the U.S. Lastly, it is assumed all produced bikes are imported to the U.S., and thus the company must pay a tariff for each bike produced.

The optimal production levels were determined by maximizing the profit equations. First, classic multivariate optimization techniques yielded the optimal production capacities for unconstrained production with and without tariffs. Then Lagrange Multiplier optimization methods yielded the optimal production levels when the production capacities were applied.

3 Results and Discussion

3.1 Production Levels

The optimal production levels without the tariff and without the constraints of production capacities are $8,624$ air-oil bikes and $14,546$ lock shock bikes, which resulted in an approximate profit of $\$2,054,797$. The optimal production levels with the tariff and without production capacity constraints are $7,231$ air-oil breaks and $13,067$ lock shock bikes, which resulted in an approximate profit of $\$3,018,906$. Notice how the addition of the tariff resulted in a reduction of production levels and profit. Further, the unconstrained optimal production levels exceed the production capacities, as seen in Figure 2. Therefore, it is expected the production levels will have a drastic impact on optimal production levels and profit.

When the tariff and production constraints are imposed, the optimal production levels exist along the constraint. The addition of the air-oil bike production capacity constraint causes the production levels to drop to 5050 air-oil bikes and $1,3080$ variable lockout bikes, as seen as the green star in Figure 2. These production levels produce an approximate profit of $\$146,900$. The application of the variable lockout bike production capacity constraint results in the optimal production levels of $7,248$ air-oil bikes and $1,000$ variable lockout bikes as seen by the magenta star in Figure 2.

However, the application of these two constraints still produce production levels outside of the feasible region. The total production capacity constraint is the binding constraint, as the profit maximizing production levels lies on the total production capacity line as seen in Figure 2. Therefore, the profit maximizing production levels with the constraint that also adhere to the production capacities is $4,055$ air-oil bikes and $9,694$ lock shock bikes. At these production capacities without the tariff, the company will earn an approximate profit of $\$1,668,445$. When paying the tariff, the company will earn a profit of approximately $\$1,324,720$ dollars per year and will pay approximately $\$343,725$ in tariffs each year.

If the E.R.S. Industries had the same production capacities when manufacturing in the U.S., the optimal production levels would remain at $4,055$ air-oil bikes and $9,694$ variable lockout bikes. However, due to the increased operational costs, E.R.S. Industries would only earn a profit of approximately $\$1,068,470$ per year.

3.2 Tariff Price

With production and wholesale prices remaining comparable regardless of location, only the costs result in a difference in profit. While the company will pay $\$343,725$ in tariffs if overseas,

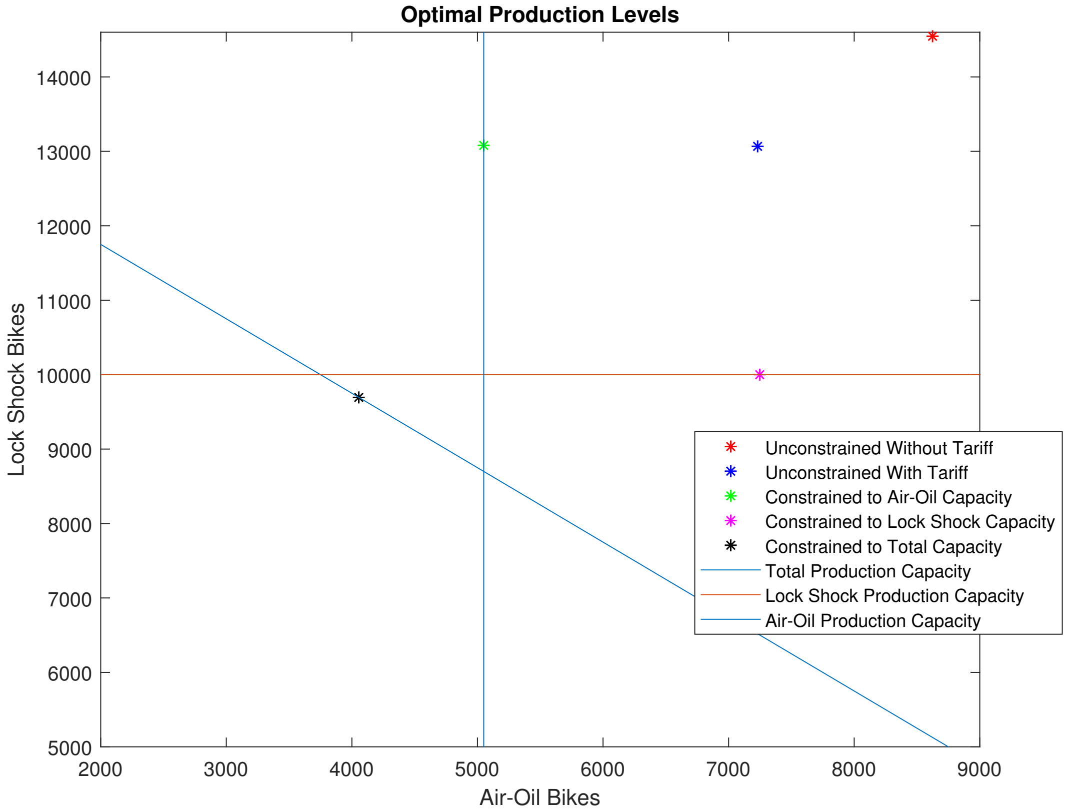

Figure 2: Graph of the production capacity constraints and profit maximizing production levels.

the company pays an additional $\$600,000$ in operational costs per year if manufacturing in the U.S.. This results in additional cost of $\$256,250$ per year. Notice this difference is approximately the same as the difference is profits between manufacturing overseas and in the U.S.. As a result, it is monetarily beneficial for E.R.S. Industries to remain overseas despite the \$25 tariff per bike. Figure 3 shows a linear relationship between profit and the tariff price. In fact, E.R.S. will continue to earn a greater profit overseas until the tariff exceeds approximately \$43.60 per bike, as seen in Figure 3.

3.3 Sensitivity Analysis

Sensitivity analysis of the unconstrained overseas model shows the production level of the air-oil and variable lockout shock bikes are not sensitive to the tariff price, as the sensitivity values are -0.192 and -0.113 respectively. However, the production level of each bike model is sensitive to its respective manufacturing cost. For every 1% increase in the manufacturing cost of the air-oil bike, the production level of the air-oil bike decreases by 1.55% while the production level of the variable lockout bikes increases by 0.005%. Similarly, for every 1% increase in the manufacturing cost of the variable lockout bikes, the production level of the lock shock bike decreased by 1.725% while the production level of the air-oil bike increases by 0.0168%.

Like the sensitivity analysis of the unconstrained overseas model, sensitivity analysis of the the unconstrained U.S. model showed the the production level of each bike model is sensitive to its respective manufacturing costs. For every 1% increase in the manufacturing cost of the air-oil bike, the production level of the air-oil bike decreases by 1.30% while the production level of the variable lockout bikes increases by 0.004%. Similarly, for every 1% increase in the

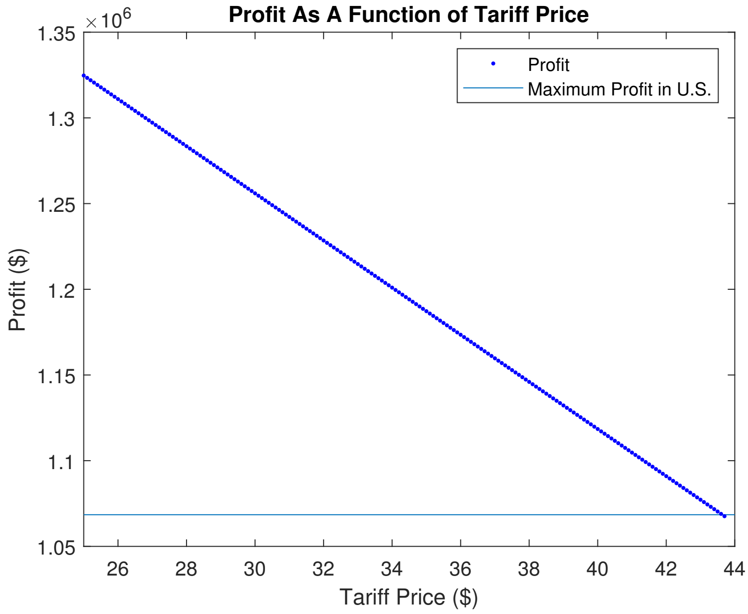

Figure 3: The relationship between E.R.S. Industries profit when producing at profit maximizing optimal production levels and the U.S. import tariff price.

manufacturing cost of the variable lockout bikes, the production level of the variable lockout bike decreased by 1.550% while the production level of the air-oil bike increases by 0.014%.

Further, when operating overseas, if the binding constraint or total production capacity increased by one bike, E.R.S. Industries would experience a profit increase of approximately \$57. When operating in the U.S., if the total production capacity increases by one bike, profit will increase by approximately \$82.

3.4 Discussion

The sensitivity analysis shows the production levels, and ultimately profit, is sensitive to the manufacturing cost of each bike model. Thus, if the manufacturing costs increased, the profit would decrease. If the manufacturing costs are higher in the U.S., it would be beneficial for E.R.S. Industries to remain overseas beyond a \$43.60 tariff per bike. Furthermore, the minor increases in profit that would result from a one bike increase in the total production capacity indicate that is in E.R.S. Industries' best interest to maintain current production capacities if the manufacturing prices remain constant and the whole sale prices continue to follow the same trend.

4 Conclusion

The findings of this analysis support the decision for E.R.S. Industries to manufacture bikes overseas rather than in the U.S., despite the recent tariff. E.R.S. Industries should seek to remain overseas until the total cost of tariffs per year is equivalent to the $600,000$ operating cost savings of having facilities overseas. The total cost will exceed the cost savings when the tariff exceeds \$43.60 per bike. With or without the tariff, production levels should remain at $4,055$ air-oil and $9,694$ variable lockout shock bikes, as these production levels maximize profit given the total production capacity constraint. However, it is in the company's best interest to maintain the current production capacity. Despite the recent tariff, E.R.S. Industries should continue to own and operate production facilities overseas.