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Steelco production schedule optimization

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# Executive Summary

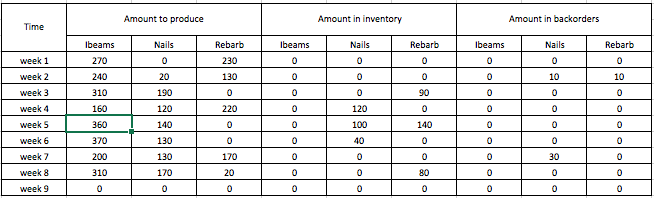
## Overview

Steelco has inquired that BC Consulting examine their company steel production schedule for an eight-week period to minimize waste and cost and maximize revenue. Steelco manufactured I-beams, nails, and rebarb within various capacities and demands last year to produce $2.5 million in profits. With suggested production schedule implementations presented, Steelco could increase their profits 12.2% next year reach profits as high as $2.82 million.

The profit margin mentioned above is the outcome of minimizing costs relating to storing inventory and placing backorders while maximizing revenue from sales (I.e., maximizing profit). With integration of higher production capacities or an e-commerce approach to selling and distributing demands, Steelco could approach even higher profits.

## Recommendation and Future Work

After examining demands mentioned in the *Memorandum of Understanding*, BC Consulting constructed a production schedule illustrated in *Table 1*. The following table will enable Steelco to reach profits as high as $2.82 million next fiscal year. Demands, production standards, suppliers, and economic uncertainty are all subject to variability. In order to account for this, various statistical, stochastic simulation, and predictive modeling techniques can scale this optimization model to forecast demands more accurately, account for uncertainty, and put throttles on inevitable risk that Steelco will see in the future.



*Table 1*: *Steelco recommended production schedule.*

# Technical Report

## Methods Used, Recommendation, and Benefits

Steelco has inquired that BC Consulting examine their company steel production schedule for an eight-week period to minimize waste and cost and maximize revenue. The recommended steel production schedule is represented by week in *Table 1*. *Steelco* manufactures I-beams, nails, and rebarb within various capacities and demands last year to produce $2.5 million in profits. With suggested production schedule implementations presented, Steelco could increase their profits 12.2% next year reach profits as high as $2.82 million. Methods used to approach conclusions involved: *Linear Modeling* and *Linear Programming*. Tools used in junction with the methods were the *LINGO* software for reproducibility.

## Assumptions

Factors involved in the ability to obtain a consistent profit for fiscal year 2018 include: supplier, product, political, and economic variance. Supplier variance may occur when costs by week, cost of shipping, maintenance, labor costs, or the ability to obtain new suppliers fluctuate by any degree. Product variance may be any cost involving the products themselves, these charges may occur in the event products or the processes that induce products change. Examples of product variability could include uncertainty or risk in the ability for a product to actually contain the quality the supplier issued or additional products available for creation and purchase to the general public. Political and economic variance can cause more ripple effects than any, minimum wage standards changes, cost of living, inflation, or any other legal changes that influence the way people can or choose to do commerce with the steel industry. Perhaps the greatest assumption of all is that the products produced are sold with a consistent demand; no excess, spoilage, inability to sell, or distribution representative of a future change. Any and all of these ripple effects will either directly or indirectly influence the costs, revenues, and profits. All of these varying degrees of risk, change, and influence have been scoped out of the analysis to enable a robust and quantifiable solution on the current problem statement.

## Decision Variables, Sets, Parameters, Constraints, and Objective

After decomposing this problem, we were able to acquire more information about the demands and products; pre-requisite information on all data provided in the *Memorandum of Understanding* is listed in *Table 2*. Before beginning, a single tableau was constructed to represent all information to be input into the *LINGO* model, a product from *LINDO Systems*. Initial efforts involved *Excel Solver*, a product of *Microsoft Excel*, however this approach was abandoned due to the succinct mathematical representation that LINGO offers for reproducibility. After acquiring sufficient information for the problem, representing decision variables came next. First, we seek to understand how current demands are being requested over time. Alongside demands for products, understanding what must change across any given combination of products and weeks became essential. Both of these representations are defined in *Table 2*, which will be referred to for the remainder of this report. For additional understanding, parameters are defined in *Table 3* to understand the data elements provided prior to analysis.

*Table 2*: Decisions variables and parameters

|  |  |  |
| --- | --- | --- |
| **Decision**  **Variables** |  | Represents the number of product (in tons) j produced in week I; for and |
|  |  | Represents the number of product (in tons) j sold in week I; for and |
|  |  | Represents the number of backorders (in tons) of product j at the start of week I; for and |
|  |  | Represents the amount of product j (in tons) available at the start of week I; for and |
|  |  |  |
| **Parameters** |  | Represents the demands for product j in week I; for and |
|  |  | Represents the amount of revenue produced from selling one ton of product j; |
|  |  | Represents the demand penalty for accruing one ton of backorder, i.e., ; |

*Table 3*: Demands given for product j in week I;

|  |  |  |  |
| --- | --- | --- | --- |
| **Weeks** | **IBeams (tons)** | **Rebarb (tons)** | **Nail (tons)** |
| 1 | 270 | 240 | 10 |
| 2 | 240 | 30 | 10 |
| 3 | 310 | 90 | 70 |
| 4 | 160 | 80 | 140 |
| 5 | 360 | 140 | 200 |
| 6 | 370 | 90 | 200 |
| 7 | 200 | 90 | 100 |
| 8 | 310 | 100 | 170 |
| **Parameters** |  |  |  |
|  | 1500 | 750 | 1000 |
|  | 1000 | 300 | 100 |
| **Additional**  **Costs** |  |
| Steel cost | 500/ton |
| Inventory cost | 40/week |

With a clear understanding of the data elements and decision variables, the constraints were clearly defined in the *Memorandum of Understanding*. Steelco knows their production capacities, so the total tons of steel in any given week cannot exceed 500 tons *(*See *Constraint 1*). Additionally, the supply must meet demand, regardless of whether the tons of steel are on hand or not. To enforce this, Steelco allows backordering, but this is not favorable to most customers. To account for this, a penalty is enforced in the *Objective Function*, which will be mentioned shortly, but the constraint which allows backordering is illustrated by flow system defined in *Figure 1* (Also see *Constraint 2*). Steelco also understands that the amount of product sold must meet demand (See *Constraint 3*). We know that we are considering no inventory or backorders at the start of our first week, and we must allow no excess inventory or backorders to remain after our final month being studied (See *Constraint 4* and *Constraint 5*). With the clear understanding that we will never produce negative products, weeks, inventory, or backordering, we assume them all as positive, real numbers. Each of the above constraints can be found in a more robust formulation in *Table 5*. We also represent the objective function in *Table 5* to clearly show constraints with the overarching objective.

*Figure 1*:

Visual representation of *Constraint (2)* in *Table 5* to show our supply and demand relationship.

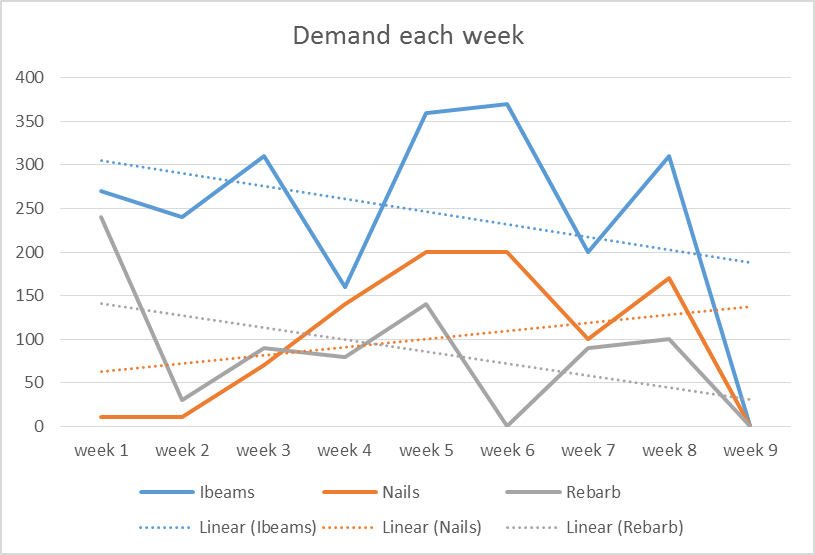
*Table 5:* Constraints against all decision variables and parameters

|  |
| --- |
| **Constraint** |
| (1) |  |
| (2) |  |
| (3) |  |
| (4) |  |
| (5) |  |
| **Objective** |
| (1) | Max profit =  revenue – cost = |

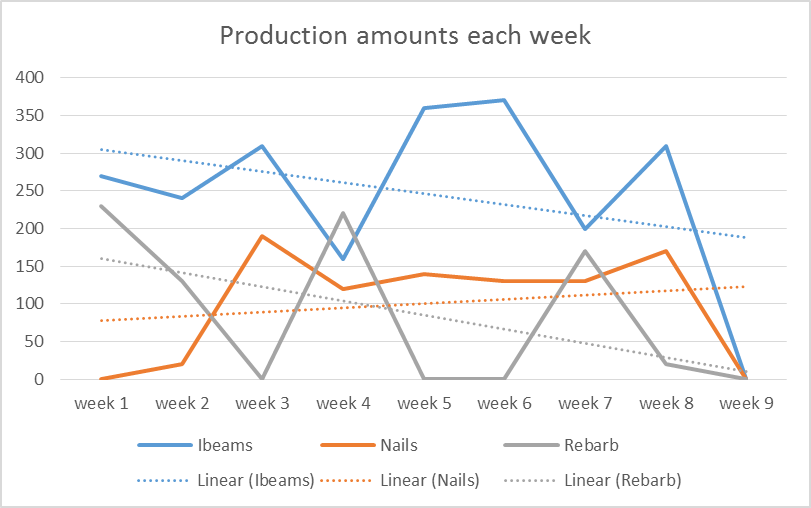
## Model Output, Interpretation, and Sensitivity

After a full run through the *LINGO* software, the output results are reflected in *Table 1*. The table represents an optimal production schedule for Steelco. The first observation lies is the major column on the left-most side of the larger table representing the production of each steel product (in tons). This column shows production exactly equal to the demands , displaying that the recommended production schedule will meet the customer demands. The next interesting observation lies in the middle major column showing weeks 3, 4, 5 and 8 being the only exception to carry over inventory into the next month. The primary suspect as to why this is necessary is the backorders that will be placed due to demand exceeding supply in weeks 2 and 7; weeks just prior to inventory being held over to account for the extra unmet demand. As mentioned before, weeks 2 and 7 only for products nails and rebarb have no occurrence of Ibeams getting backordered due to such a high penalty when they are absent from supply. This directly corresponds why we never backorder or hold extra Ibeams in inventory; they are too costly to keep around or not meet demand for, so it is essential to sell them immediately and always make just enough. The other products have flexibility to be absent, because it becomes more optimal to introduce a backorder cost or extra inventory cost to meet later demands. We do not introduce the cognitive effects of what a backordered customer is going through when they are pushed off for a week or more, but this surely does not look good on the company if this does occur. Therefore, we must assume the cost accounts for all of these effects, which in reality is unlikely. We can take a deeper look into the demands each week in *Figure 1*. This shows that we will most likely see customer demand at about 175 tons of Ibeams, 140 tons of nails, and 35 tons of rebarb. We can look into what production might look like if we stepped another week into the future in *Figure 3* as well as future inventory placement in *Figure 4*. Pertaining to inventory, we would like to keep between 20 and 40 tons of rebarb and nails with no I-beams to satisfy projected demands. We also see the backorder patterns in *Figure 5* illustrating the increasing trend for backordering of nails.

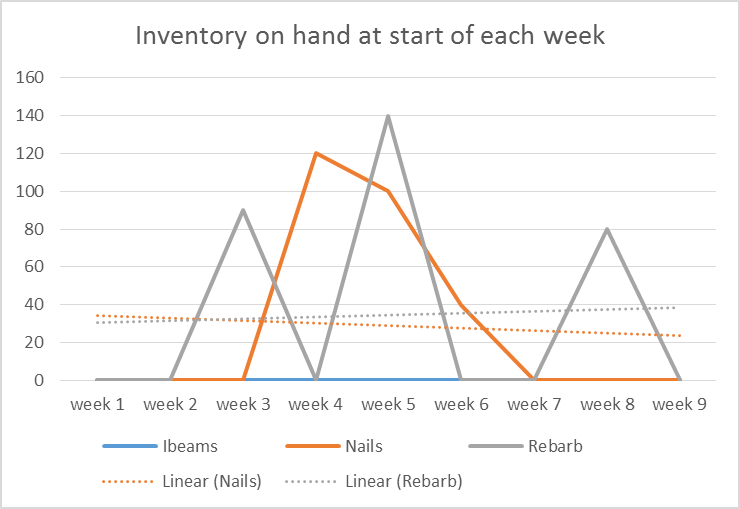
*Figure 2:* Forecasted demand into week 9



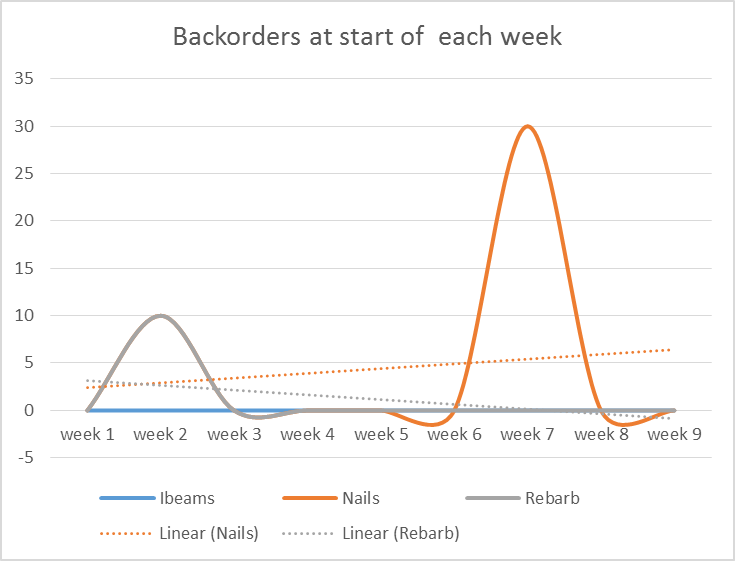
*Figure 3:* Forecasted production into week 9



*Figure 4:* Forecasted inventory placement into week 9



*Figure 5:* Forecasted backorders per week into week 9



## Conclusion and Recommendation

Last year Steelco manufactures I-beams, nails, and rebarb within various capacities and demands to produce $2.5 million in profits. With suggested production schedule implementations presented, Steelco could increase their profits 12.2% next year reach profits as high as $2.82 million. The profit margin mentioned is the outcome of minimizing costs relating to storing inventory and placing backorders. With integration of higher production capacities or an e-commerce approach to selling and distributing demands, Steelco could approach even higher profits. Demands, production standards, suppliers, and economic uncertainty are all subject to variability. In order to account for this, various statistical, stochastic simulation, and predictive modeling techniques can scale this optimization model to forecast demands more accurately, account for uncertainty, and put throttles on inevitable risk that Steelco will see in the future.