CASE STUDY NO. 4
MANUFACTURING EXTENSION

TEAM "P"

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Enterprise Engineering

Manufacturing Game Extension
ERP Simulation

ERP Muesli Products

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1 STRATEGY

In the Manufacturing simulation extension, there were many more variables to control than there had been in previous simulations. It was impossible to fully assess every combination of variables during the limited planning time prior to the start of the simulation. As such, we decided that it would be best to take a simple approach to the simulation by limiting the variables. We had found that in previous simulations, the best strategy was often the simplest strategy – inventory control and price control. Those two variables generally had the most impact on net profits and all other variables beyond those were best addressed only after inventory and price had been satisfactorily controlled.

Our team's strengths had historically been in maintaining inventory and setting reasonable prices. For this simulation, we decided to eliminate the extra variables of DC 14 and 0.5 kg products. We instead focused on maximizing profits on the 1 kg products in DC 10 and DC 12 and minimizing stockouts.

1.1 PRICING

Throughout the simulation we closely monitored inventory levels and adjusted our prices accordingly. We kept our prices high when we were trying to preserve our inventory and lowered our prices when our stocks had been replenished. We used pricing in conjunction with marketing investment to stimulate sales.

1.2 MARKETING

We decided to invest in marketing in this simulation. We knew that DC 12 was sensitive to marketing, and since we were staying out of the DC 14 market, it was crucial that we maximize our sales in both DC 10 and DC 12. One way for us to maximize sales in DC 12 was to invest in marketing. We closely monitored the effects of our marketing investment and found that it stimulated sales. When our inventory levels were high, we were able to use marketing to increase sales rather than lower prices. Toward the end of the simulation, however, we found that the marketing effect was less pronounced, so we discontinued our investment.

1.3 MANUFACTURING

We invested 500,000€ to reduce setup time between production runs to 5 hours 20 minutes. We found that the return on the lean manufacturing investment diminished with increased investment. We selected our investment amount of 500,000€ because any additional investment beyond that amount would only yield negligible reductions in setup time, as illustrated in Figure 1.

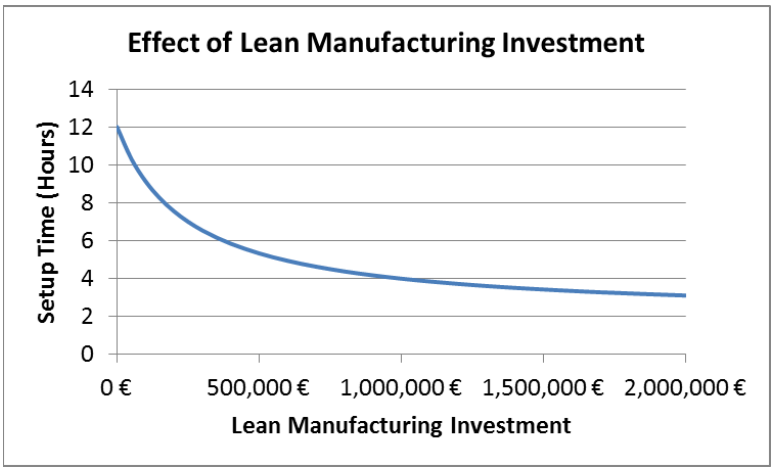


Figure 1. Effect of lean manufacturing investment on setup time

We also invested an additional 500,000€ to increase production capacity to 23,000 boxes per day. Figure 2 shows that the relationship between machinery investment and capacity was linear, so there was no investment amount that would have been mathematically optimal. Thus, we determined the amount of our investment based on previous experience and expected demand.

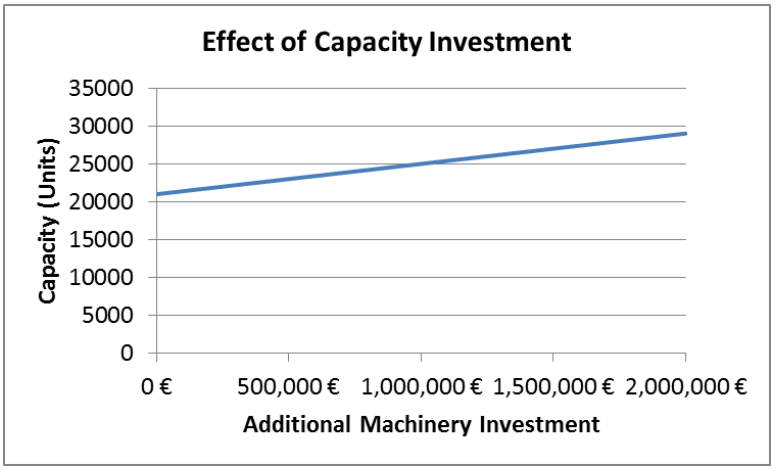


Figure 2. Effect of additional machinery investment on capacity

The combination of the setup time and capacity investments allowed us to respond more quickly and in greater volume to market demand. Because there were so many variables in this simulation, responsiveness and maintaining inventory levels was of the utmost importance.

2 ANALYSIS

We ended the simulation in second place. Team R, the winning team, had a net profit only 5.9% (124,292€) greater than our net profit. Figure 3 shows that we began the simulation with a loss, due to our lean manufacturing investment. However, by the beginning of Quarter 2 we were seeing net profits. We were able to maintain steady profit growth throughout the simulation to finish in second place.

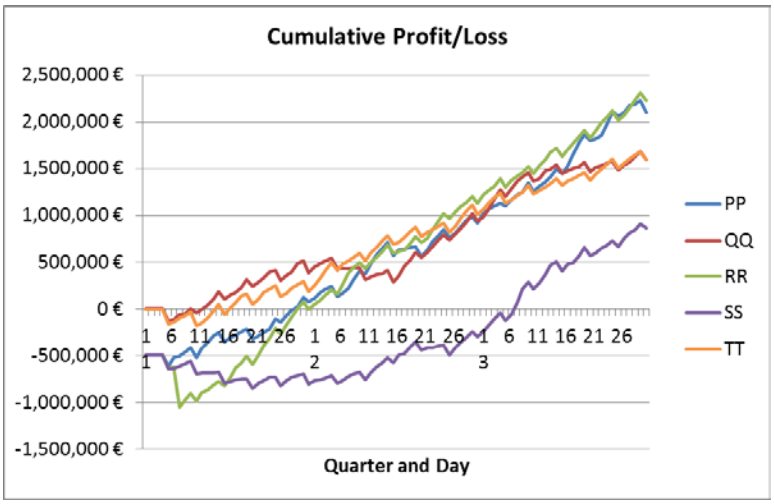


Figure 3. Comparison of cumulative profit/loss for all teams

Our strategy was to focus on DC 10 and DC 12 by exclusively offering 1 kg products. Team R, the winning team, focused on DC 12 and DC 14 and only offered two products in the 1 kg size. As such, we were only direct competitors for two products. Team R invested significantly more than we did in marketing due to the known marketing sensitivity of DC 12 and DC 14 (Figure 4). In order to increase sales in DC 12, we invested in marketing as well, but not to the same extent as Team R.

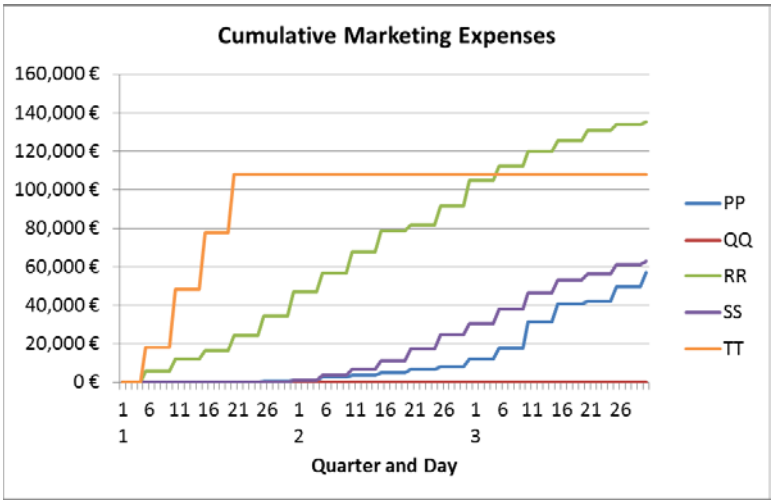


Figure 4. Comparison of cumulative marketing expenses for all teams

At the end of the simulation we had significantly more inventory left over than Team R (Figure 5). This was a mistake, as we should have aimed to deplete as much inventory as possible at the end of Quarter 3 in order to increase our final profit.

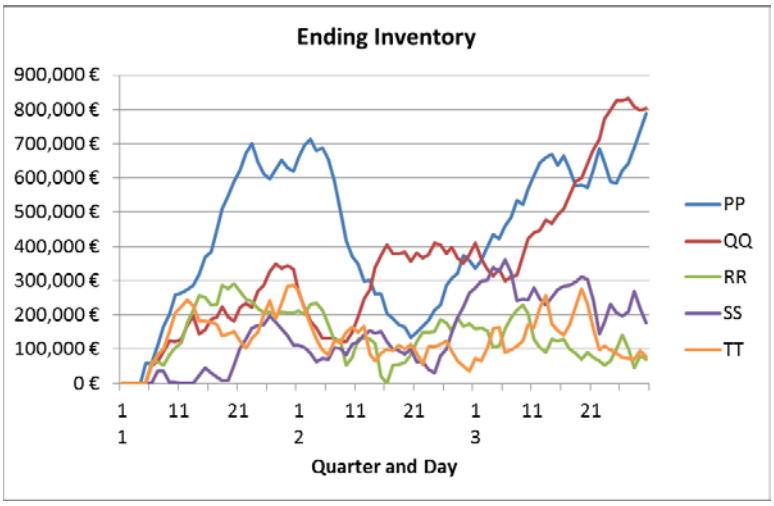


Figure 5. Ending inventory levels for all teams

Appendix A provides additional graphs comparing our income and expenses to the other teams.

2.1 Product Offerings and Inventory

The winning team's strategy was to focus on DC 12 and DC 14 by offering the majority of their products in the 0.5 kg size. Of the six products, Team R only offered Mixed Fruit and Nut in the larger 1 kg size. Team R's strategy was the opposite of ours – we focused on DC 10 and DC 12 and exclusively offered the 1 kg size. We did not make any attempts to sell in DC 14. Figure 6 compares our product offerings with those of Team R, illustrating the differences in product sizes. Figure 7 compares the percentage of each component in each product. The bill of materials for our products compared to Team R was the same by percentage, with the exception of the Strawberry Muesli. For this product, Team R increased the amount of strawberries to 40% and decreased the amounts of oats and wheat by 10% each, whereas our team maintained the original recipe of 20% strawberries and 40% each of oats and wheat.

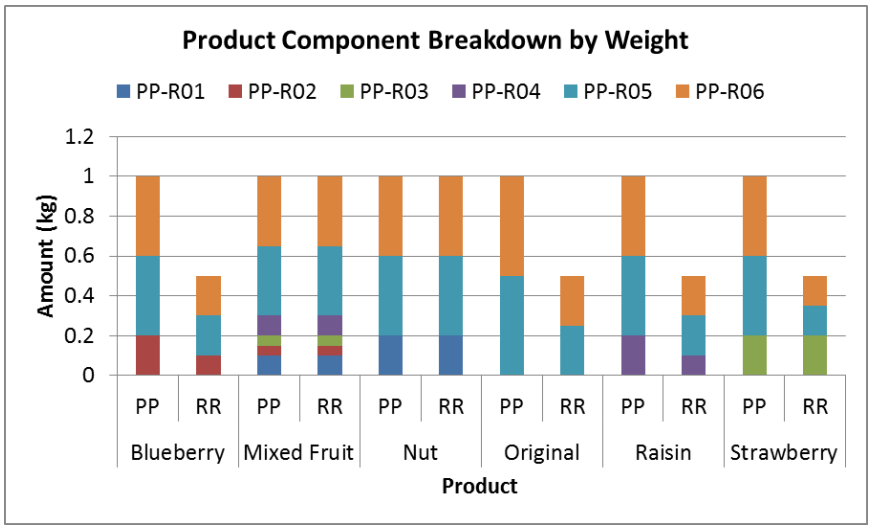


Figure 6. Product component breakdown by weight

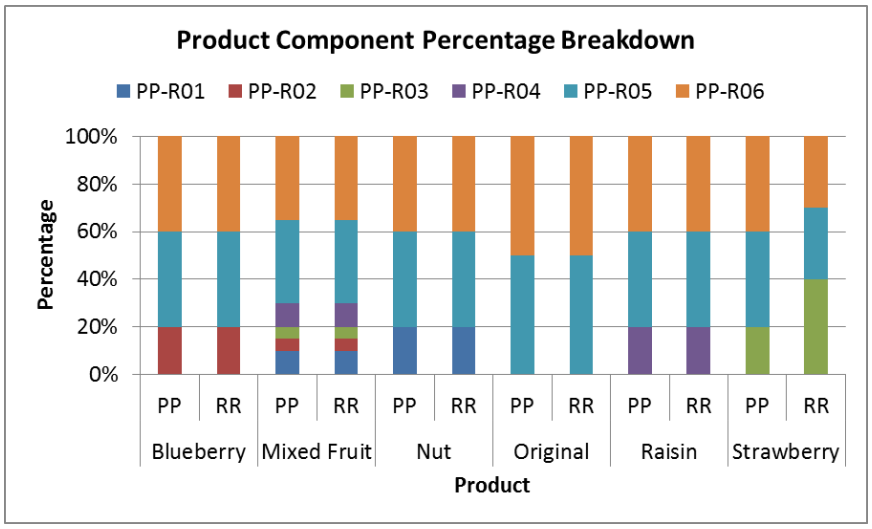


Figure 7. Product component percentage breakdown

Three of the five teams expanded into DC 14 by offering 0.5 kg products. For most of our product offerings we only had competition from one or two other teams. The 1 kg Mixed Fruit Muesli was the only product that all teams offered, and Team T only offered it during Quarter 1 (Figure 8). Inventory levels for all products compared to competitors are shown in Appendix B.

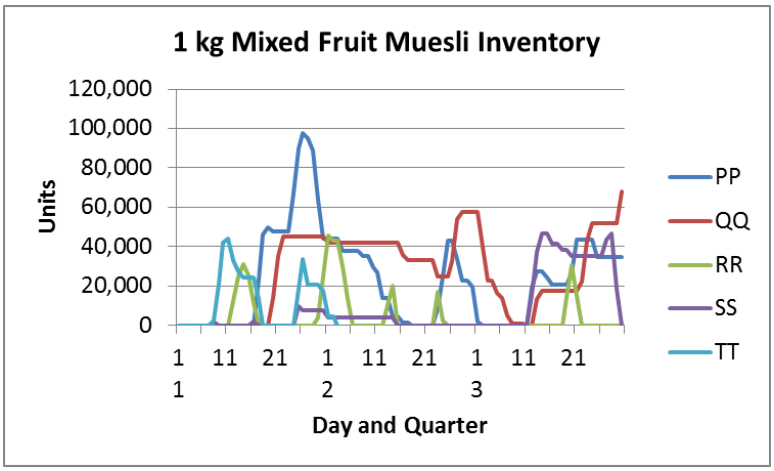


Figure 8. Inventory levels for 1 kg Mixed Fruit Muesli

Figure 9 shows the number of days out of stock for each product offering compared to our competitors. Team T is not shown because they did not offer 1 kg products for the entire duration of the simulation. Teams that did not provide 1 kg versions of a particular product are shown as having zero stockout days. Compared to Team Q, which was our primary competition, as we were both exclusive 1 kg product sellers, we had fewer days out of stock of every product, with the exception of the Mixed Fruit Muesli. We also had fewer days out of stock of the Mixed Fruit and Nut Muesli compared to Team R, the winning team. These were the only two products that we both sold.

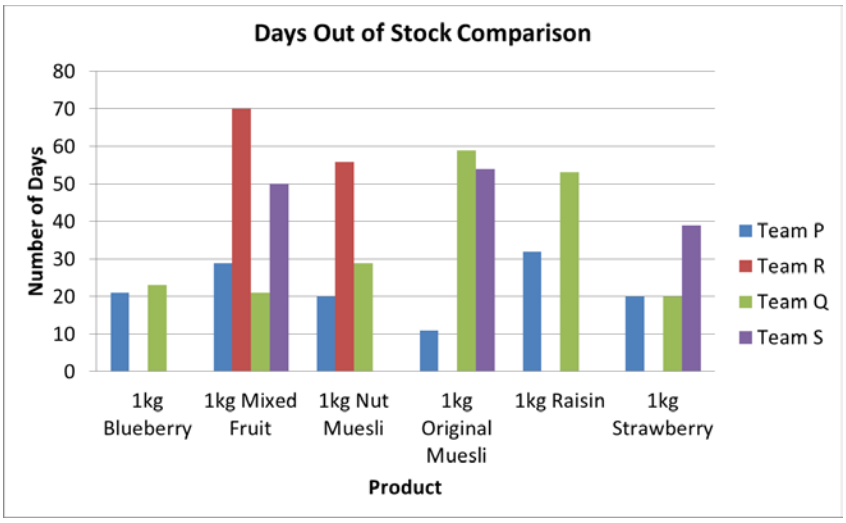


Figure 9. Days out of stock of each product compared to competitors

Past simulations have taught us the importance of minimizing stockout days. We were able to effectively limit the number of stockout days for each of our products through a combination of production planning and price control, as discussed in the following sections.

2.2 PRODUCTION

In order to reduce setup time and increase capacity, we invested 500,000€ each in lean manufacturing and additional machinery. These investments reduced our setup time to 5.3 hours and increased our capacity to 23,000 units per day. Comparisons of our investments, setup time, and production capacity to the other teams are shown in Figure 10, Figure 11, and Figure 12. Team R made double the lean manufacturing investment than we made, but due to diminishing returns (illustrated in Figure 1), Team R's setup time was only 1.3 hours less than ours.

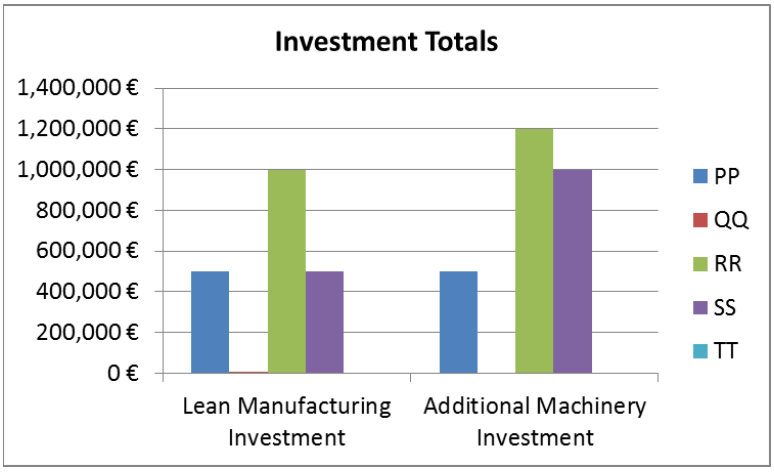


Figure 10. Manufacturing process and equipment investment amounts

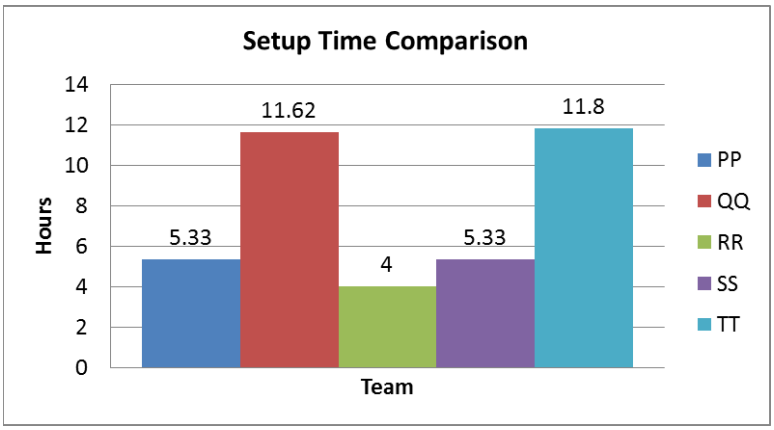


Figure 11. Setup time for each team

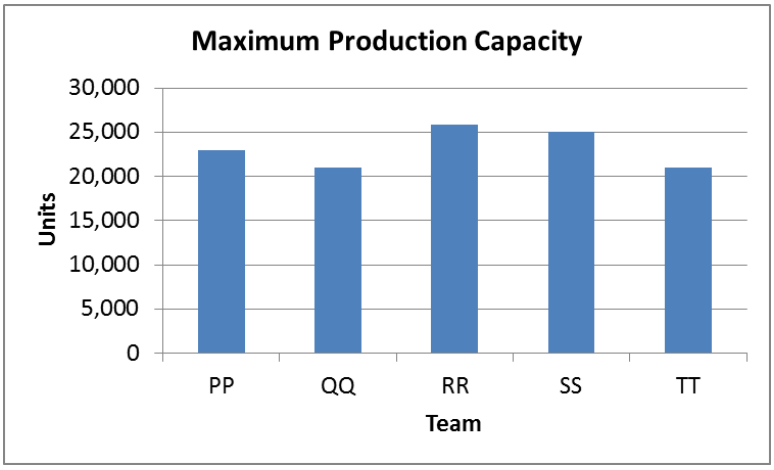


Figure 12. Maximum production capacity for each team

Throughout the simulation, it was crucial that we operate at maximum capacity and reduce idle production days. A few idle days at the beginning of Quarter 1 was expected, as there was no initial inventory and we had to wait for delivery of raw materials. Figure 13 shows that our team failed to maintain inventory levels in Quarter 2, with 11 idle production days. The winning team, Team R, also had idle production days, but at 8 total idle days, had far fewer than our 15 total idle days. Team T did the best job of minimizing idle production days, with idle days only in Quarter 1 and continuous production throughout the simulation.

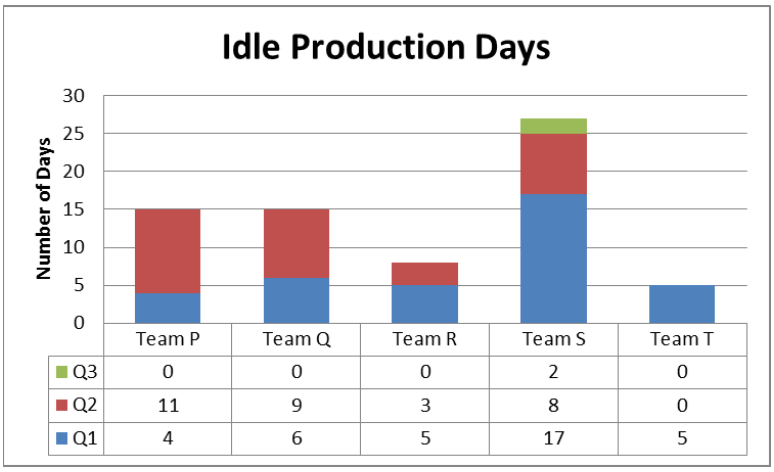


Figure 13. Number of idle production days for each team

Figure 14 shows our production schedule throughout the simulation. Our maximum capacity was 23,000 boxes. The graph clearly shows when we switched products, as we did not produce the full 23,000 units on those days, as we lost 5.3 hours to setup time. Due to miscommunications and difficulties in converting planned orders to production orders, we missed many production opportunities in Quarter 2.

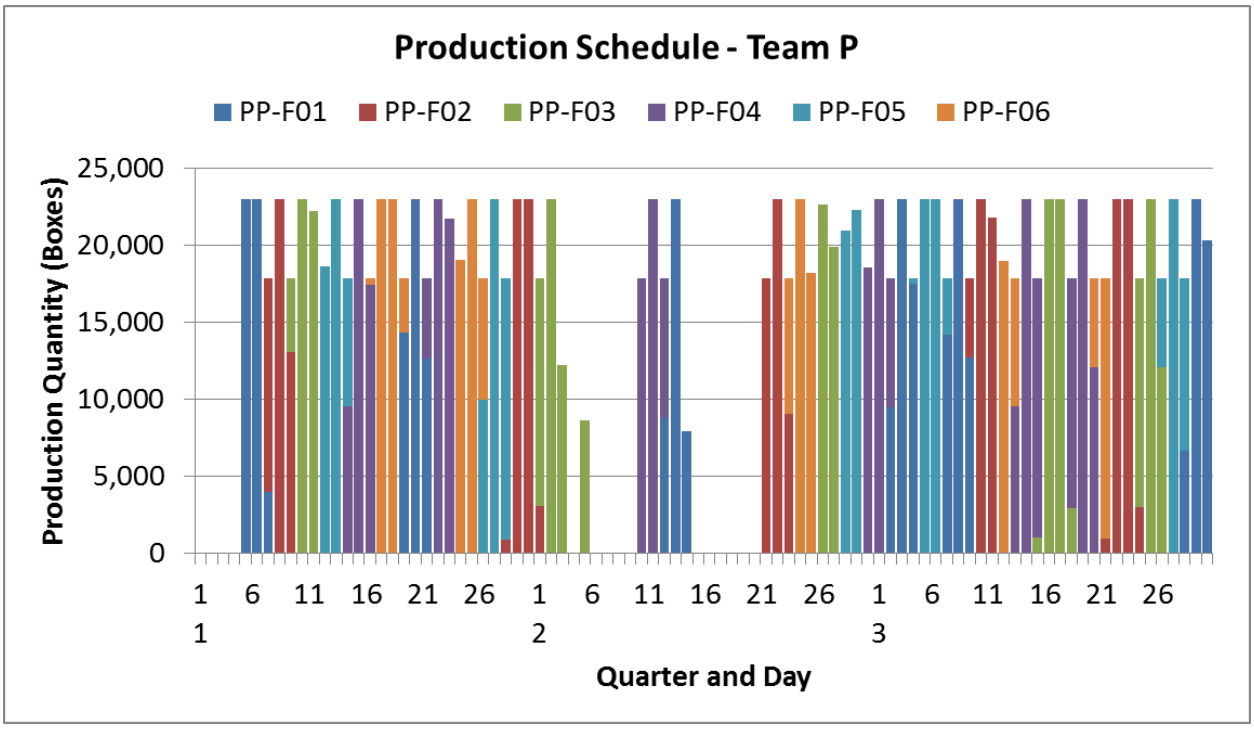


Figure 14. Team P production schedule

Our total production and total sales per quarter compared to that of the winning team is shown in Figure 15. This graph shows that Team R had greater production volume and sales volume in each quarter of the simulation than we had. As we have learned from previous simulations, maximizing production volume and sales volume is crucial in order to finish in first place.

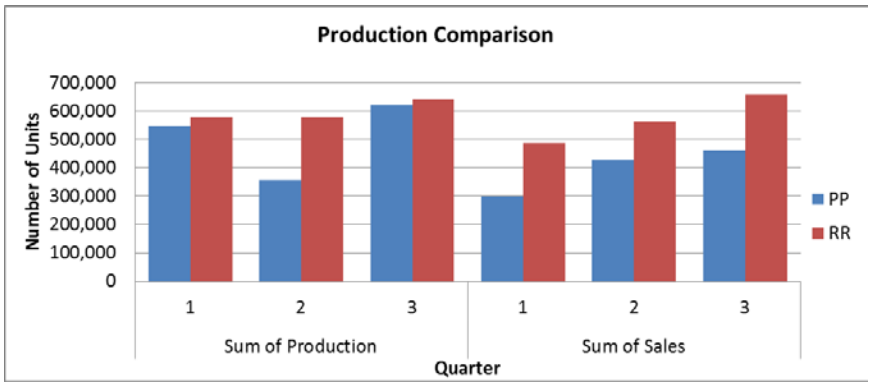


Figure 15. Comparison of total production and total sales between Team P and Team R

2.3 Sales and Pricing

As previously mentioned, our strategy was to focus on DC 10 and DC 12. Figure 16 and Figure 17 show that Team R, the winning team, focused mostly on DC 12 and DC 14. Team R offered two products in the 1 kg size and therefore made some sales in DC 10, but it was clear that this market was not their focus.

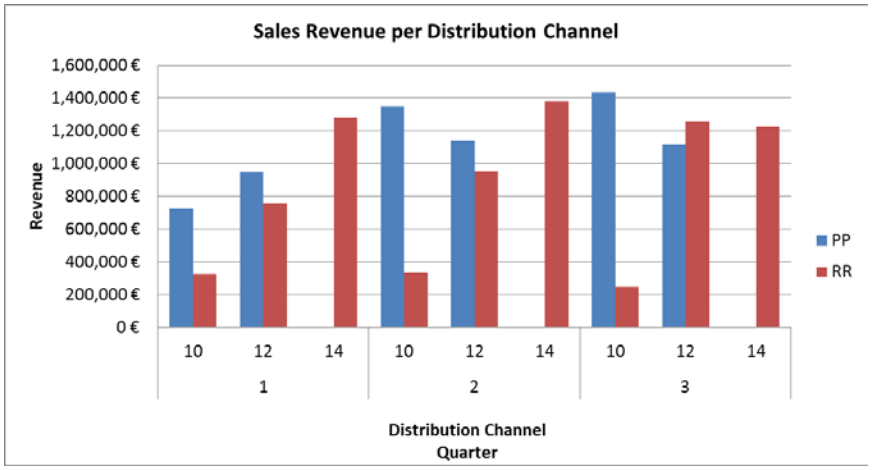


Figure 16. Comparison of sales revenue per distribution channel for Team P and Team R

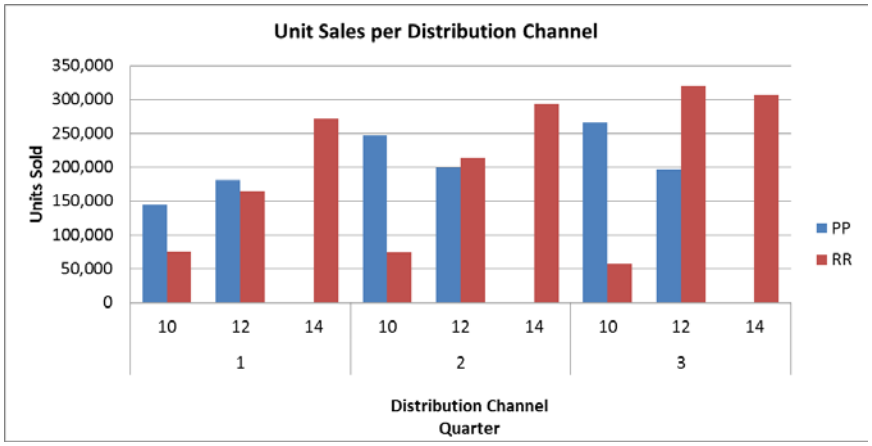


Figure 17. Comparison of unit sales per distribution channel for Team P and Team R

Of the five teams, three teams chose to offer 0.5 kg products and compete in DC 14. Our team was one of two that decided to compete only in DC 10 and DC 12 with 1 kg products. Figure 18 shows that our team's sales revenue was evenly split between DC 10 and DC 12. Team Q was our primary competitor, offering the same products as we did, but they had greater sales in DC 10 than in DC 12. The discrepancy between the distribution of sales between our team and Team Q is probably due to the fact that Team Q did not make any marketing investment. Because we invested in marketing, we were able to improve our DC 12 sales. The three teams that offered 0.5 kg products only had minimal sales in DC 10. Only 10% of the winning team's sales revenue came from DC 10.

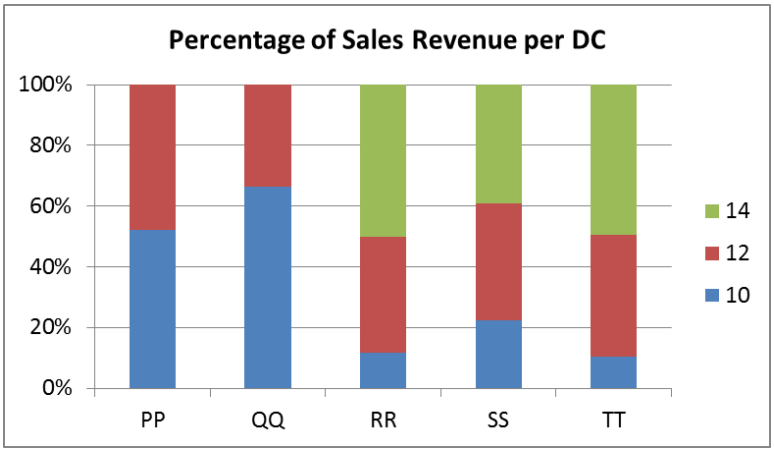


Figure 18. Percentage of sales revenue per distribution channel for each team

Team R, the winning team, was very competitive in the common products between their team and our team (Figure 19). Team R outsold us in the common products for most quarters, especially for the Nut Muesli in DC 12. A full comparison of our unit sales and sales revenue compared to our competitors for each product is provided in Appendix C and Appendix D.

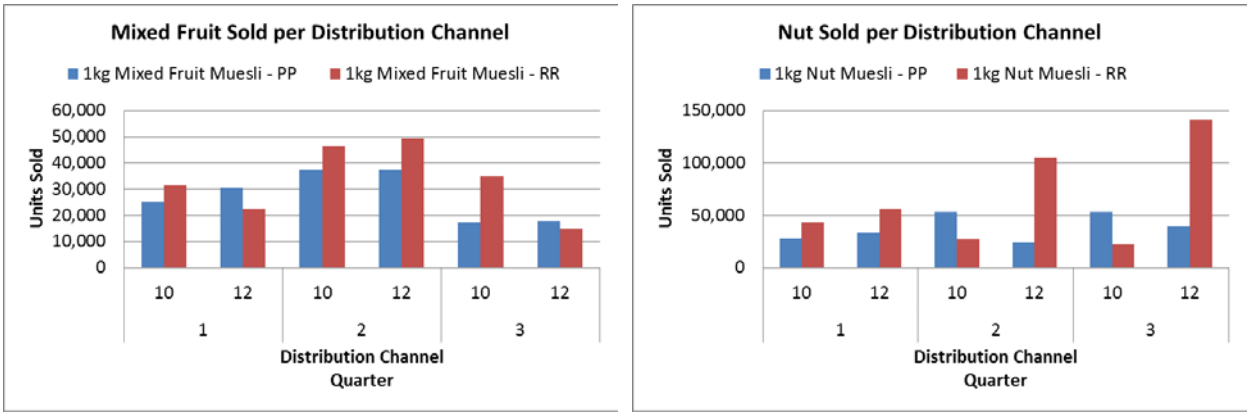


Figure 19. Comparison of unit sales per distribution channel for common products between Team P and Team R

Figure 20 shows that Raisin Muesli was our best seller, followed closely by Nut Muesli and Blueberry Muesli. However, Blueberry Muesli brought in the most sales revenue, due to its higher pricing.

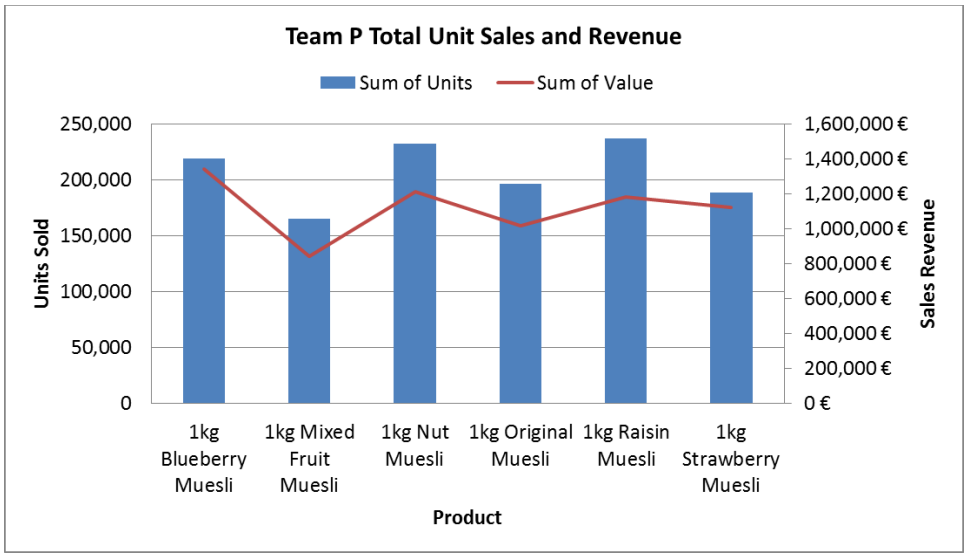


Figure 20. Team P total unit sales and revenue per product offering

Our pricing remained fairly steady throughout the simulation. We did change our pricing in response to changing inventory levels, but tried to maintain a relatively constant price. One of the Best Practices we took away from the previous Manufacturing simulation was that it is important to avoid overreacting to the market. As such, we were careful in our pricing to avoid changing our prices too drastically.

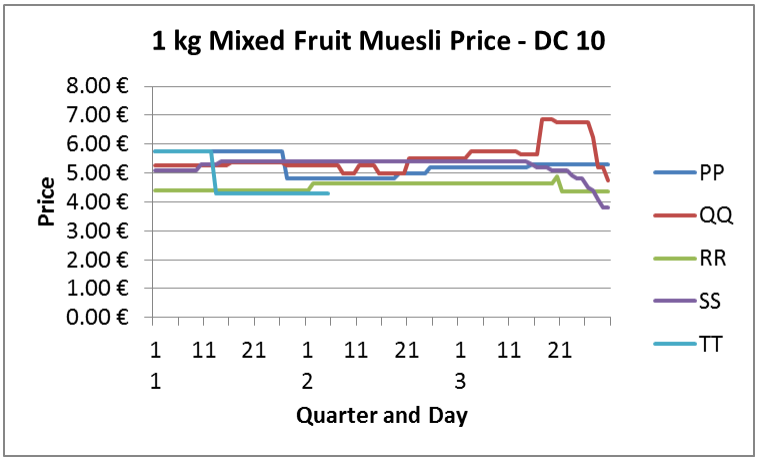


Figure 21. Pricing comparison for 1 kg Mixed Fruit Muesli in DC 10

Figure 21 shows that our prices were generally consistent with our competition. We were able to find a balance between profit margin and sales volume. We tried to avoid setting prices that were significantly higher or lower than our competition. Appendix E provides price comparisons for each of our product offerings.

2.4 Correlations

We investigated several different correlations, as shown in Appendix F. The strongest correlations that we found were between price and profit for the Original Muesli in both distribution channels (Figure

22). We found a positive correlation between price and profit per sales order, which was stronger in DC 10 than in DC 12.

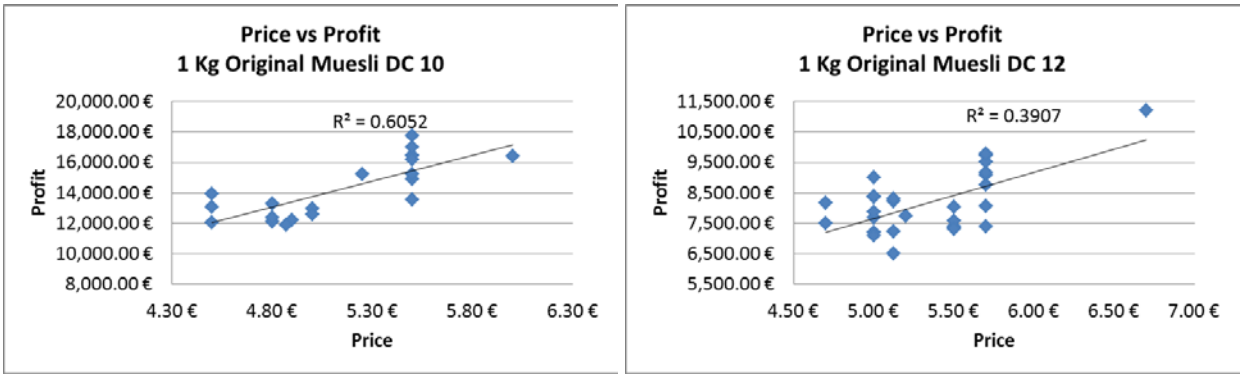


Figure 22. Correlation between price and profit for Original Muesli in DC 10 and DC 12

3 CONCLUSION

Our primary strategy was to keep the simulation simple by offering only one product size and focusing on only two distribution channels. Our strategy was very different from that of Team R. Team R focused on entirely different distribution channels and placed a heavy emphasis on marketing, since both DC 12 and DC 14 are known to be sensitive to marketing.

Unlike previous simulations, we did not lower our prices toward the end of the simulation. This was a mistake, however, as we were left with a lot of ending inventory. While inventory is counted as an asset at the end of the simulation, it is worth more as sales than as inventory. If we had dropped our prices in order to clear out inventory toward the end of Quarter 3, it is possible that we would have been able to overtake Team R in net profit.

3.1 LESSONS LEARNED

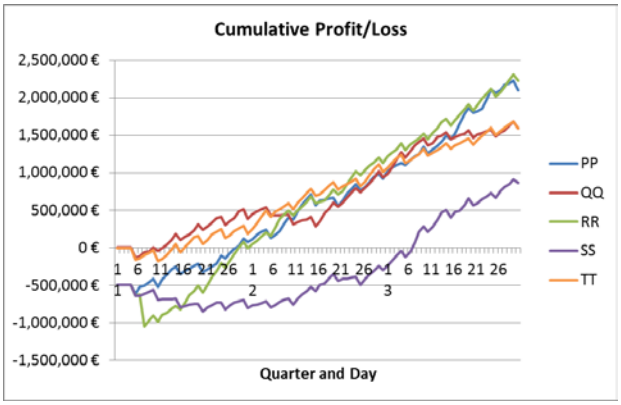
We learned that there are many ways to affect sales, including pricing and marketing. In the previous Manufacturing simulation we did not make any marketing investment. In this simulation we did invest in marketing, which increased our sales in DC 12. Our final ratio of sales between DC 10 and DC 12 was close to 1:1. In the previous Manufacturing simulation, we had many more sales in DC 10 than in DC 12. The even distribution of sales between DC 10 and DC 12 that we observed in this simulation can be attributed to marketing. Thus, while price and inventory levels have historically proven to be the most influential variables, marketing does have an effect and can be a valuable tool if used judiciously.

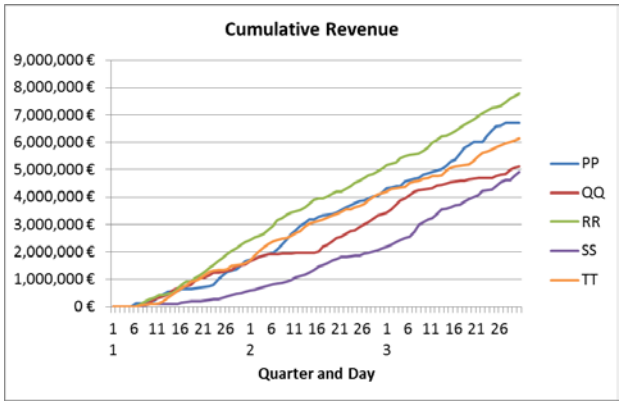
We also learned that finished goods are more valuable as sales than as inventory. We ended the simulation with significantly more inventory than our competitors, which represents unrealized profits that could have put us ahead of the winning team. Had we taken steps to move our inventory at end of the simulation, such as by lowering our prices, we may have been able to overtake the winning team in net profit.

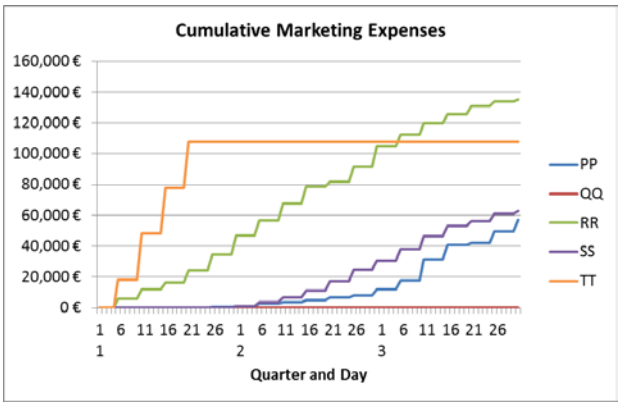
3.2 BEST PRACTICES

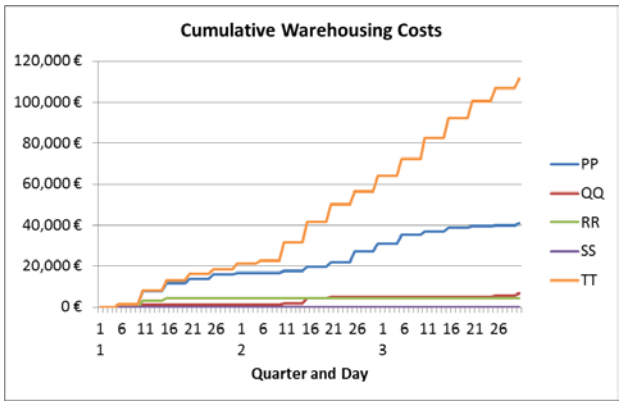
There are several Best Practices that we tried to implement in this simulation, due to our previous experiences. We tried to maintain constant communication between all team members. We closely monitored our inventory levels and sales in order to determine pricing and production schedules. We were flexible and open to changing our strategy if the market was not responding as expected. We also stayed calm and focused on the long-term results. We started the simulation with a huge loss due to our lean manufacturing investment, but we remained calm and maintained steady growth in order to finish in second place.

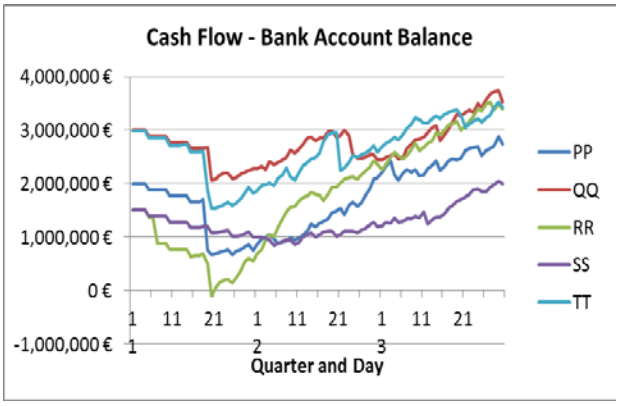
4 APPENDIX A: FINANCIAL ANALYSIS

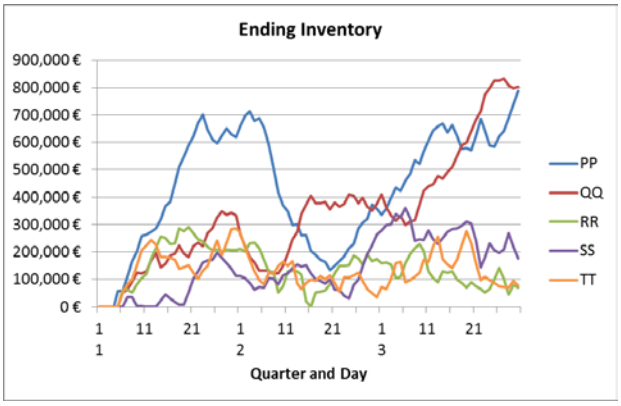


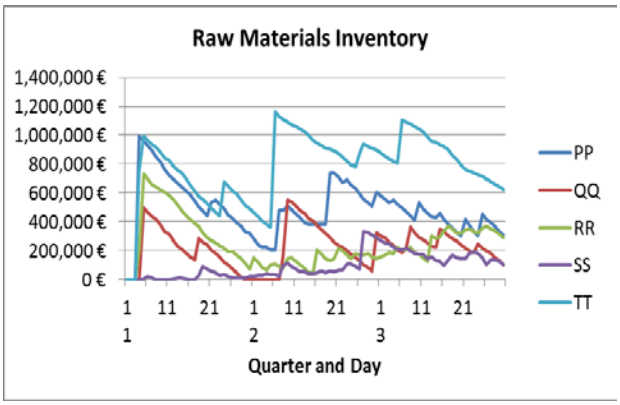








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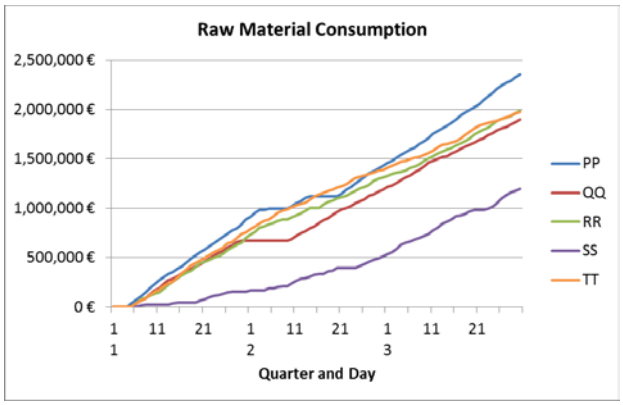
QQ
RR
SS
TT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Quarter and Day
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QQ
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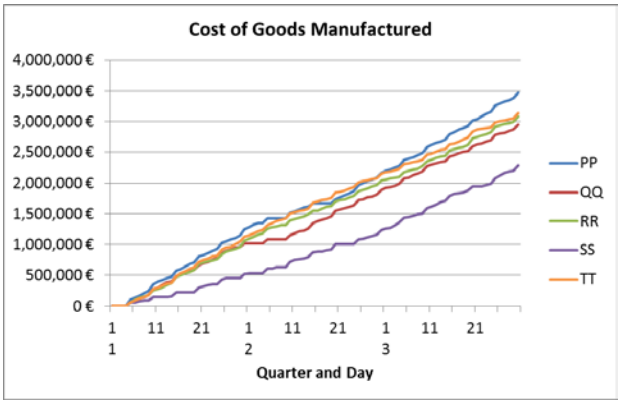
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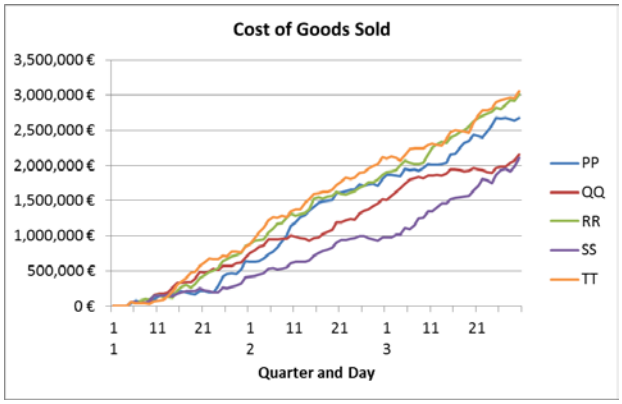
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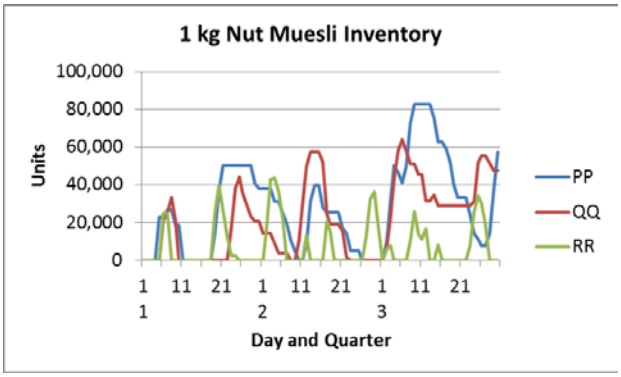
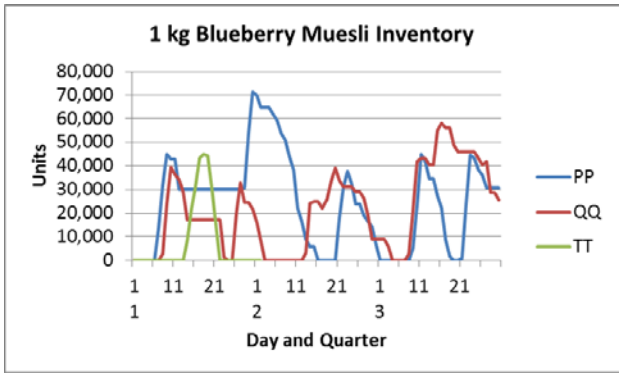
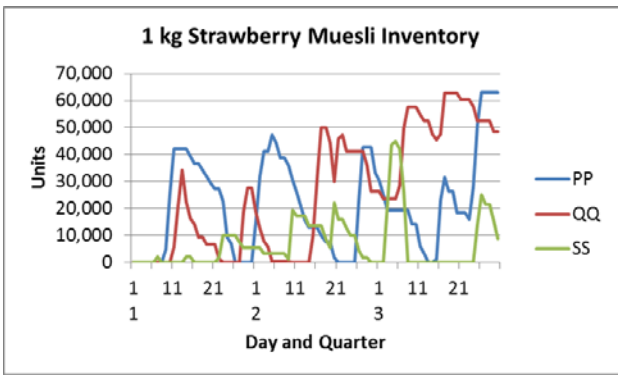
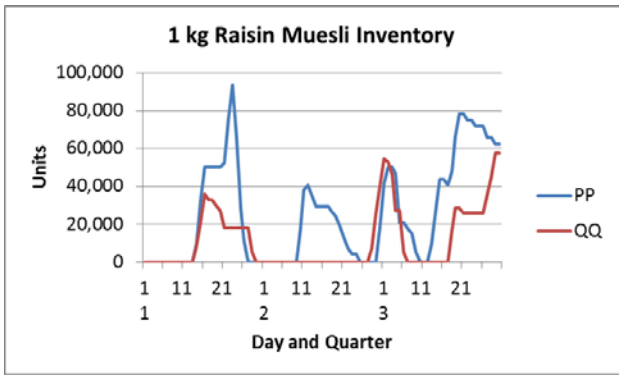
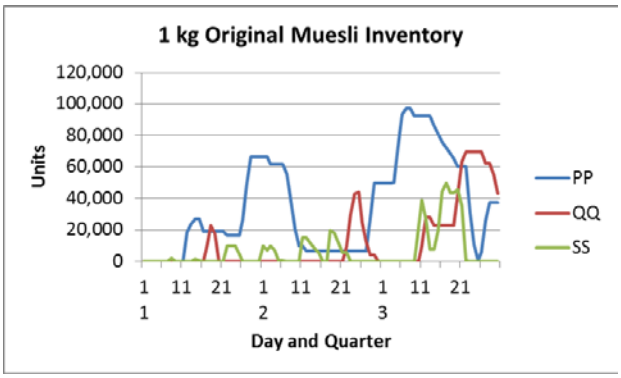
5 APPENDIX B: INVENTORY LEVELS

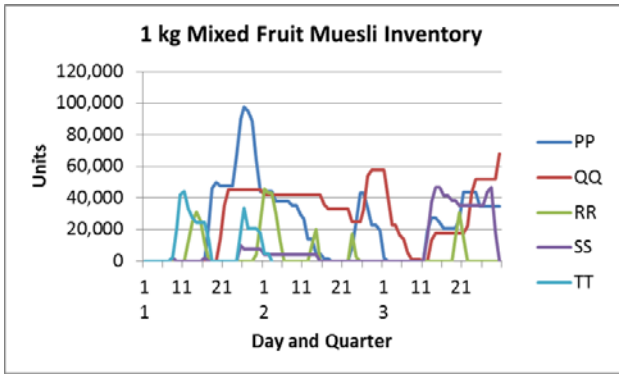




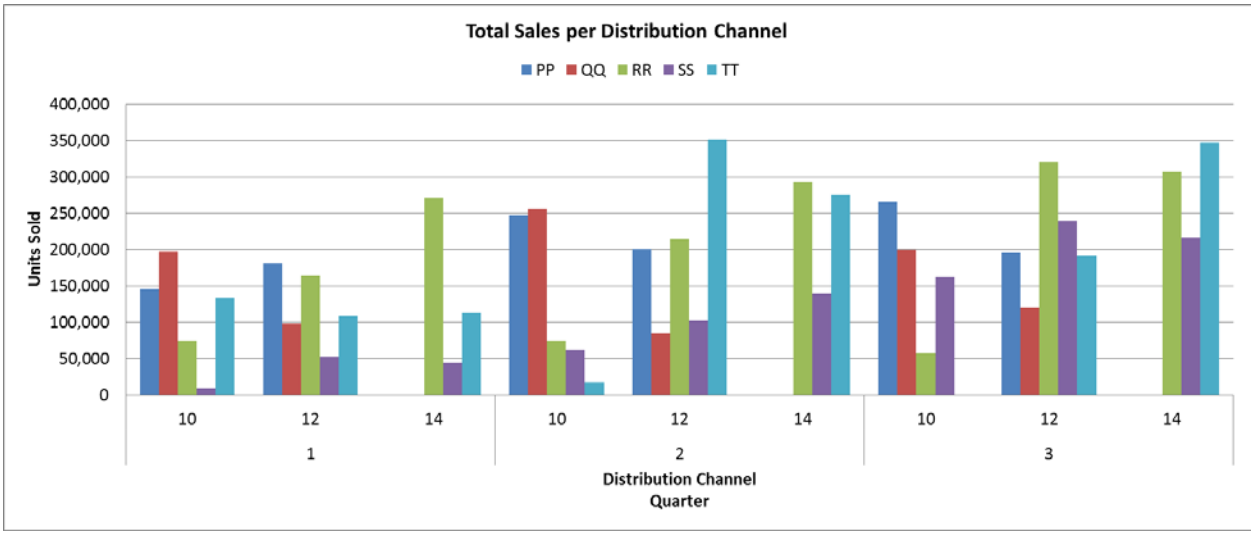


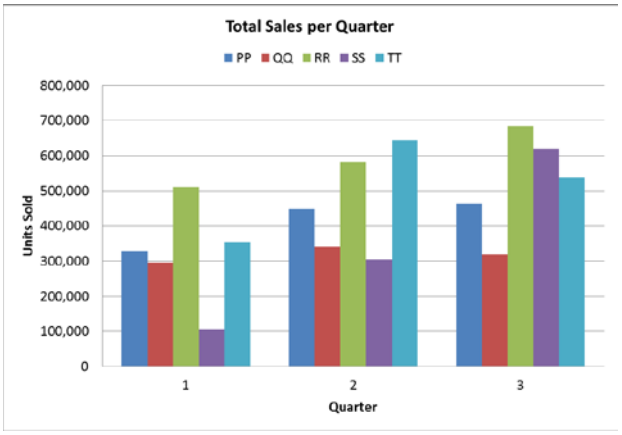


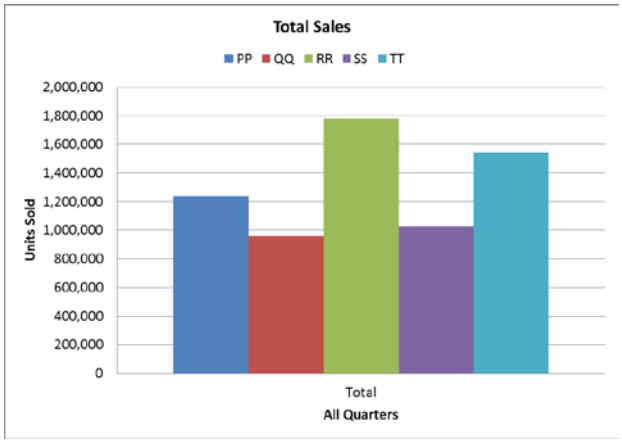


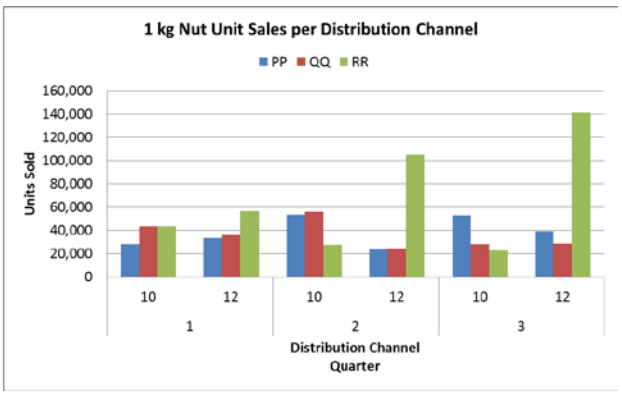


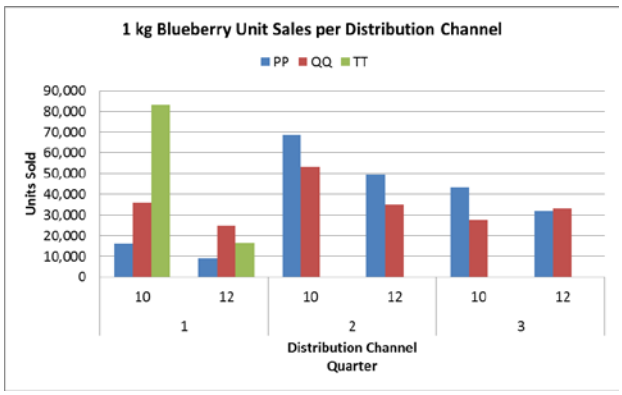
6 APPENDIX C: UNIT SALES

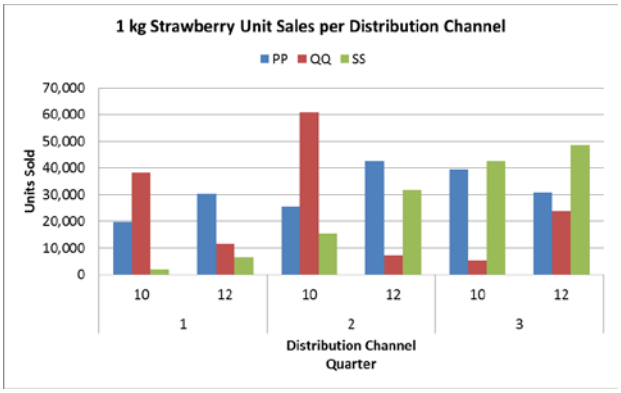


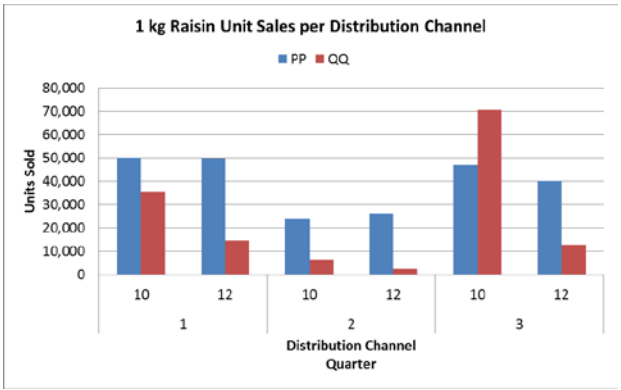


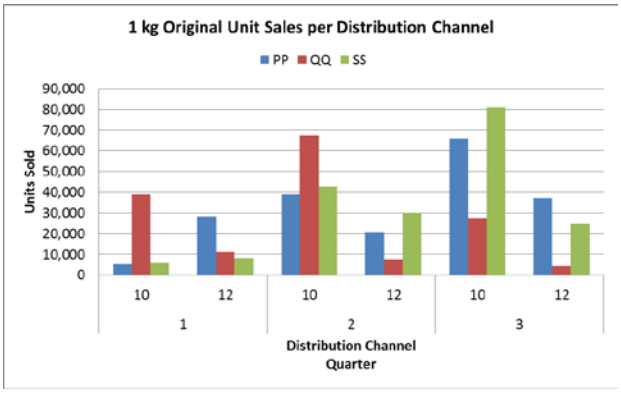


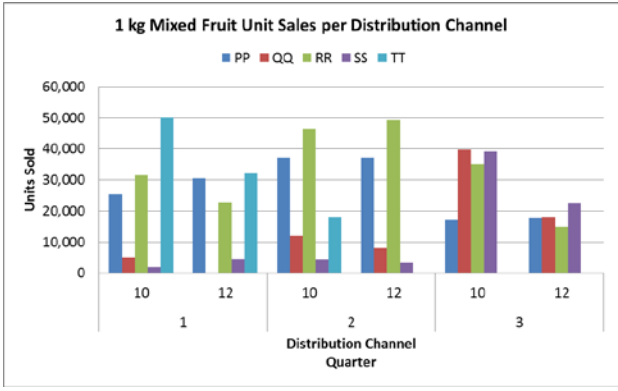




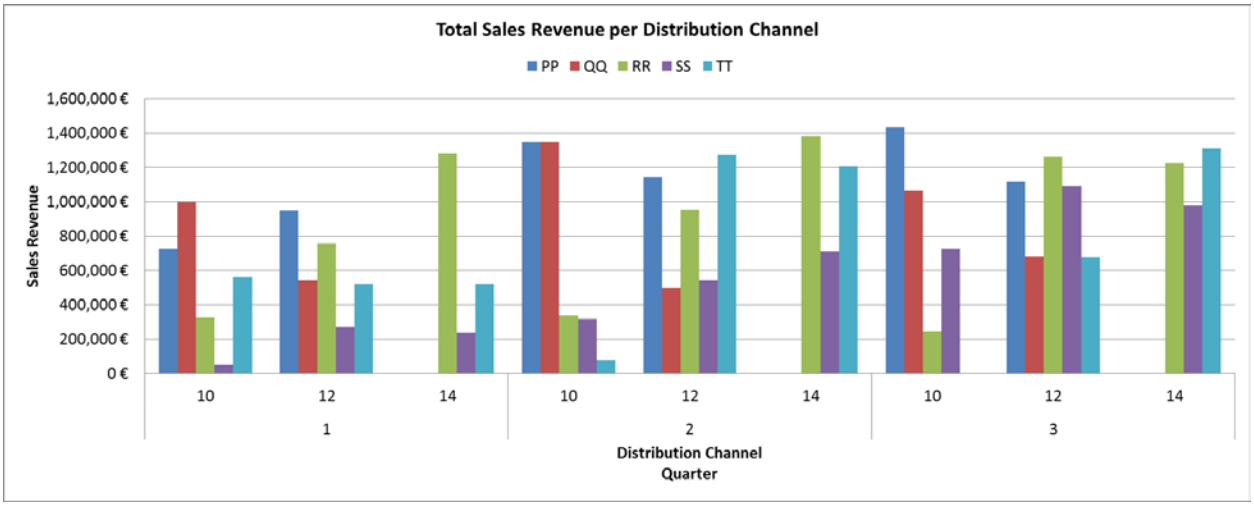

1 kg Strawberry Unit Sales per Distribution Channel
PP QQ SS
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Units Sold
10 12 10 12 10 12
1 2 3
Distribution Channel
Quarter

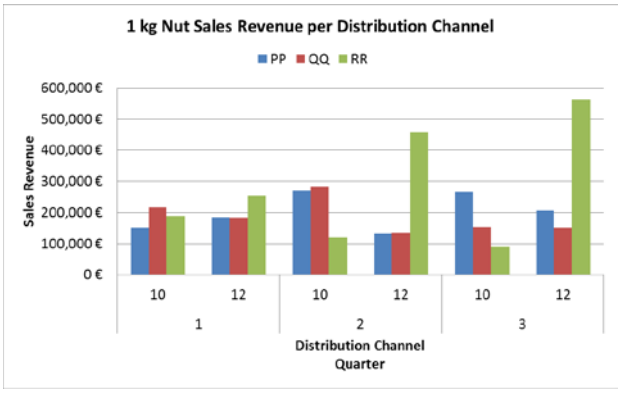

1 kg Raisin Unit Sales per Distribution Channel
PP QQ
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Units Sold
10 12 10 12 10 12
1 2 3
Distribution Channel
Quarter

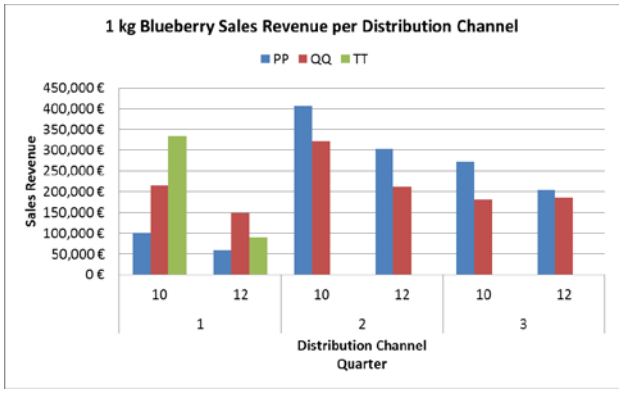

1 kg Original Unit Sales per Distribution Channel
PP QQ SS
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Units Sold
10 12 10 12 10 12
1 2 3
Distribution Channel
Quarter

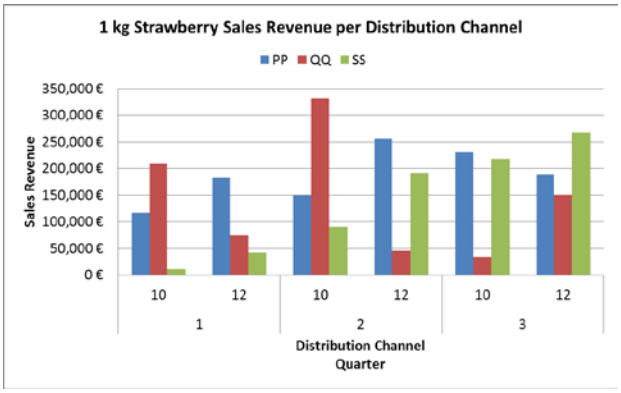

1 kg Mixed Fruit Unit Sales per Distribution Channel
PP QQ RR SS TT
60,000
50,000
40,000
30,000
20,000
10,000
0
Units Sold
10 12 10 12 10 12
1 2 3
Distribution Channel
Quarter

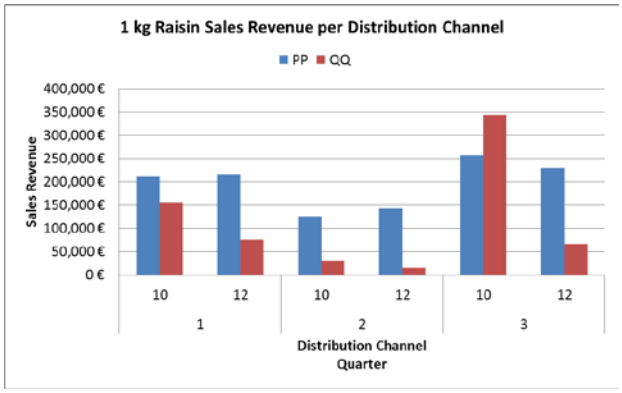
7 APPENDIX D: SALES REVENUE

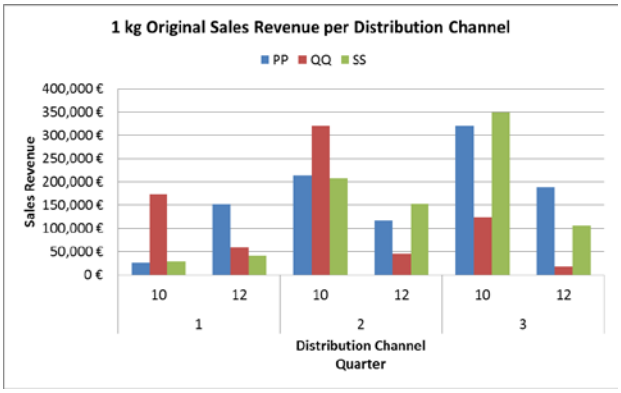


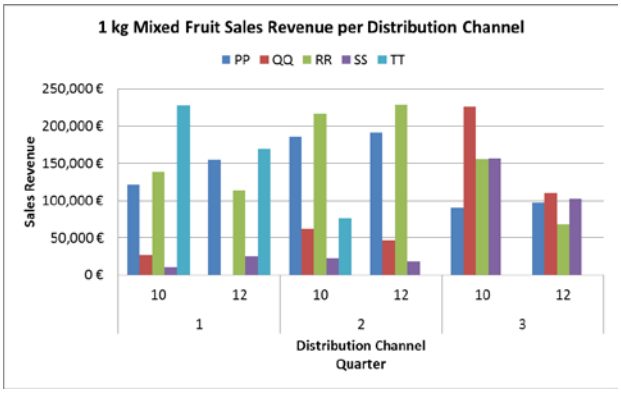




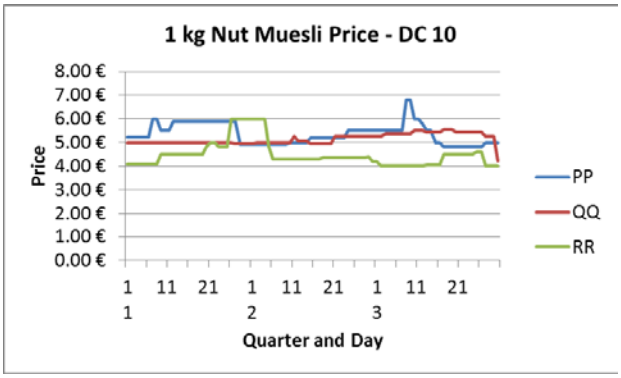


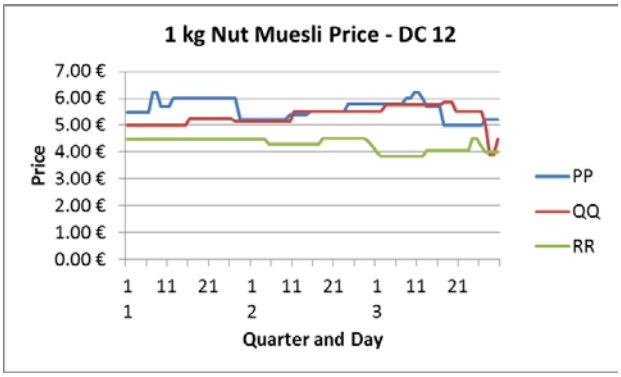


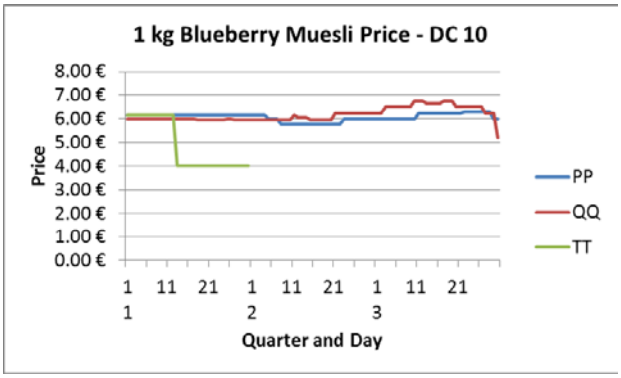

1 kg Original Sales Revenue per Distribution Channel
PP
QQ
SS
400,000 €
350,000 €
300,000 €
250,000 €
200,000 €
150,000 €
100,000 €
50,000 €
0 €
Sales Revenue
10
12
10
12
10
12
1
2
3
Distribution Channel
Quarter

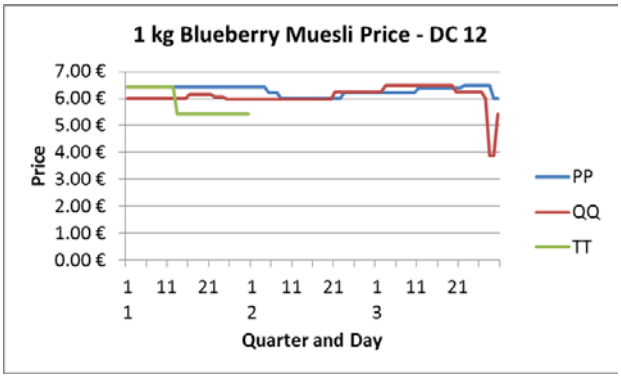

1 kg Mixed Fruit Sales Revenue per Distribution Channel
PP
QQ
RR
SS
TT
250,000 €
200,000 €
150,000 €
100,000 €
50,000 €
0 €
Sales Revenue
10
12
10
12
10
12
1
2
3
Distribution Channel
Quarter

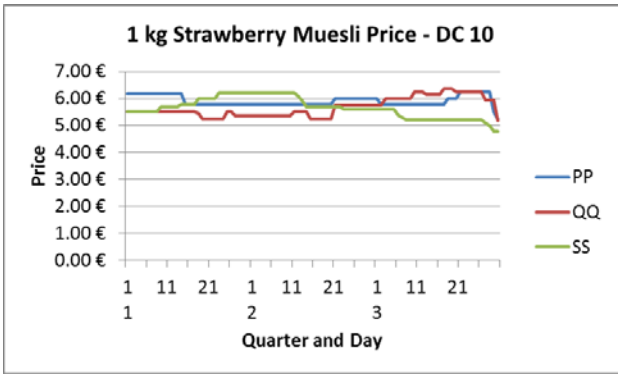
8 APPENDIX E: PRICING

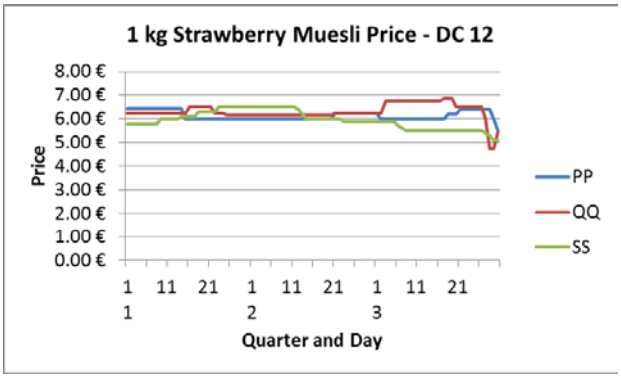


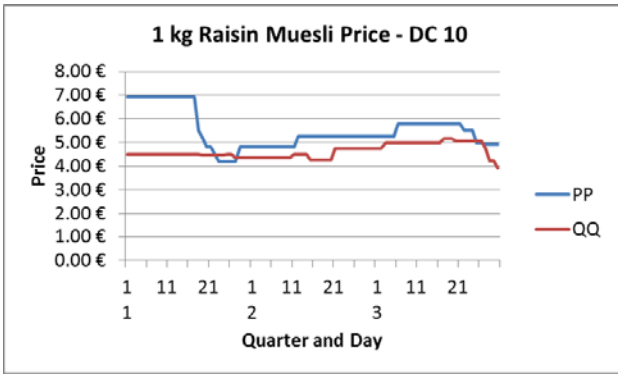


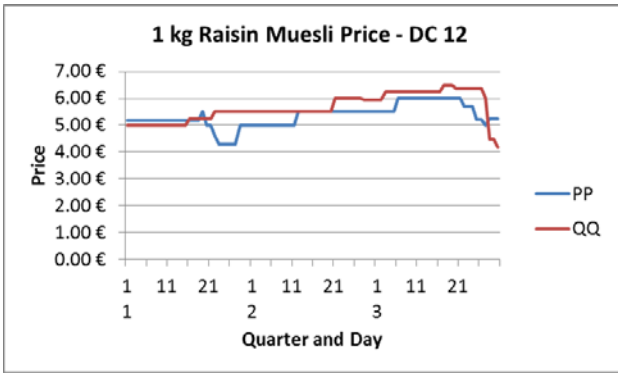


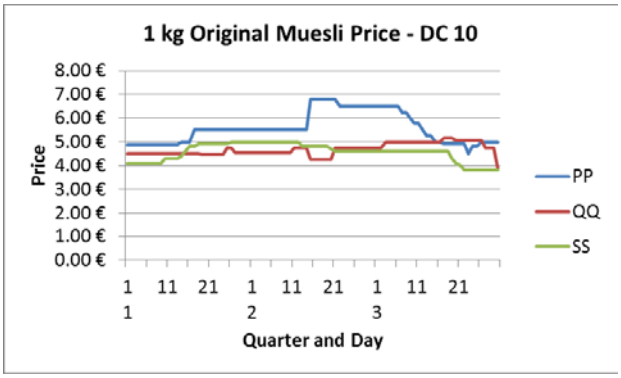


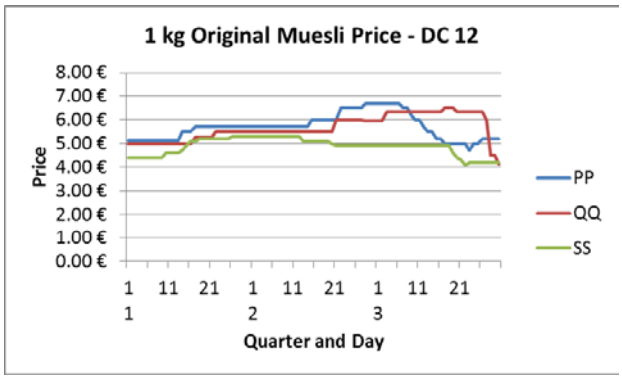


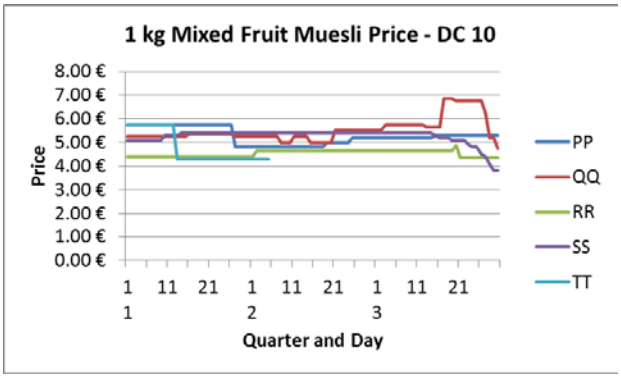


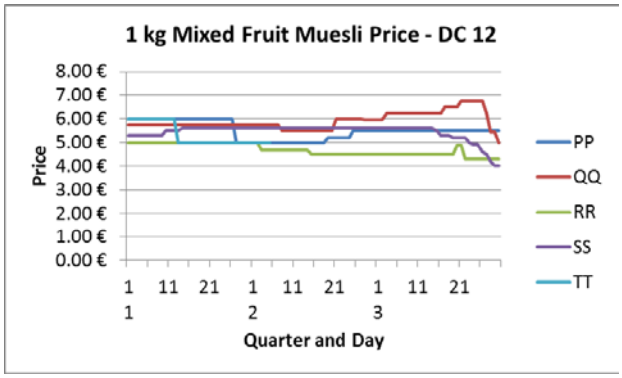





1 kg Original Muesli Price - DC 10
8.00 €
7.00 €
6.00 €
5.00 €
4.00 €
3.00 €
2.00 €
1.00 €
0.00 €
Price
1 11 21 1 11 21 1 11 21
11 12 13
Quarter and Day
PP
QQ
SS

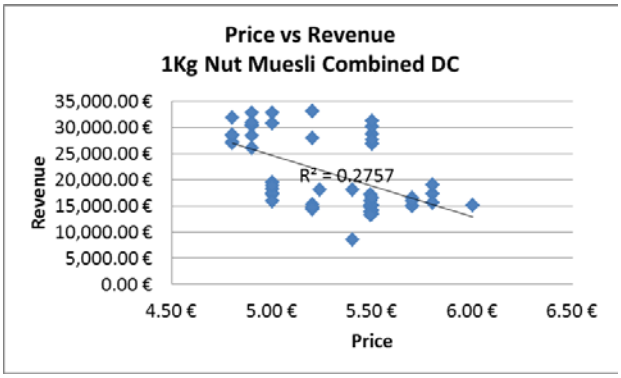

1 kg Original Muesli Price - DC 12
8.00 €
7.00 €
6.00 €
5.00 €
4.00 €
3.00 €
2.00 €
1.00 €
0.00 €
Price
1 11 21 1 11 21 1 11 21
11 12 13
Quarter and Day
PP
QQ
SS

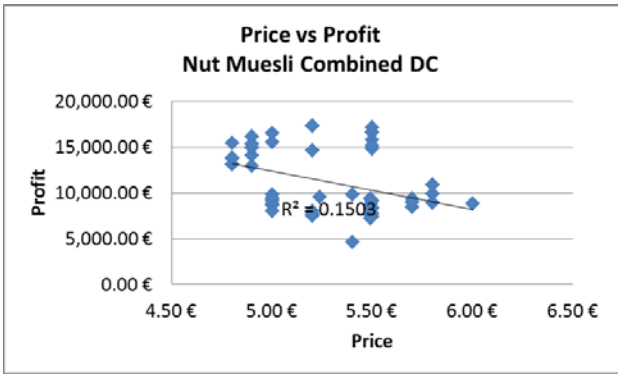

1 kg Mixed Fruit Muesli Price - DC 10
8.00 €
7.00 €
6.00 €
5.00 €
4.00 €
3.00 €
2.00 €
1.00 €
0.00 €
Price
1 11 21 1 11 21 1 11 21
11 12 13
Quarter and Day
PP
QQ
RR
SS
TT

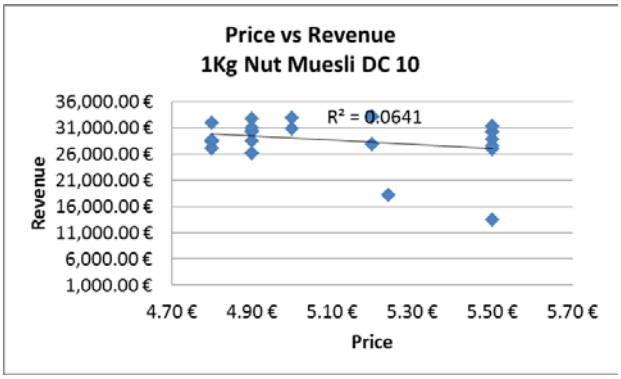

1 kg Mixed Fruit Muesli Price - DC 12
8.00 €
7.00 €
6.00 €
5.00 €
4.00 €
3.00 €
2.00 €
1.00 €
0.00 €
Price
1 11 21 1 11 21 1 11 21
11 12 13
Quarter and Day
PP
QQ
RR
SS
TT

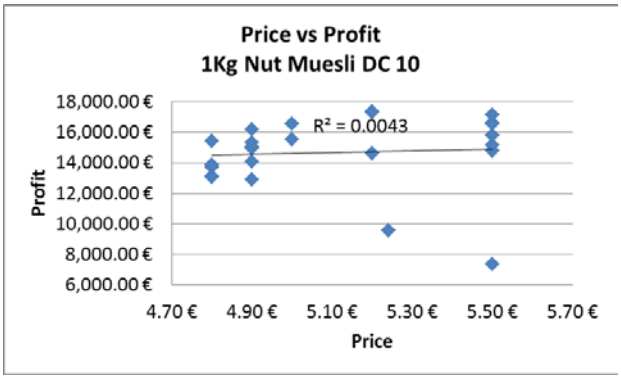
9 APPENDIX F: CORRELATIONS

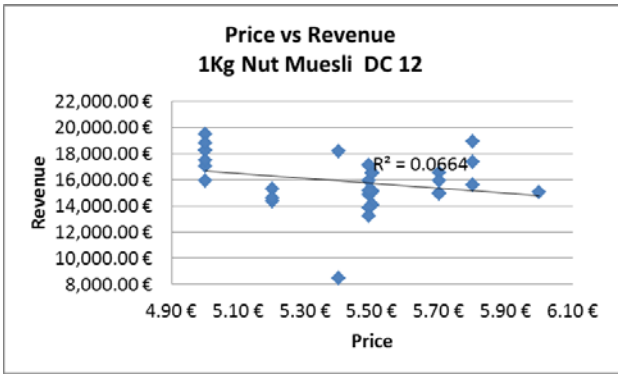
9.1 NUT MUESLI

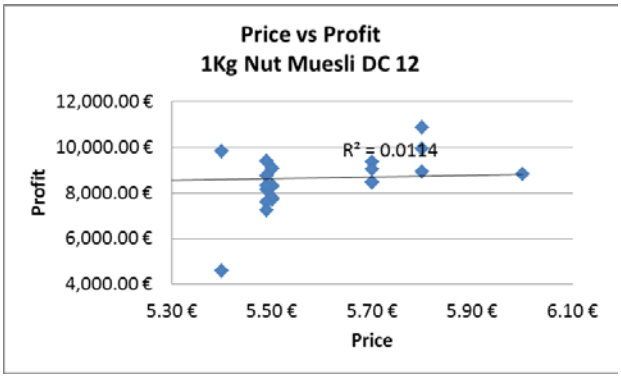




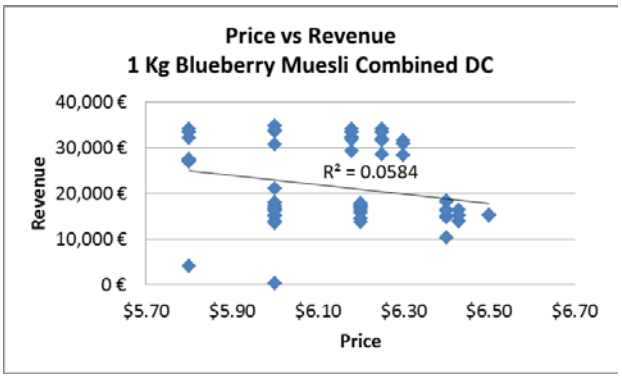


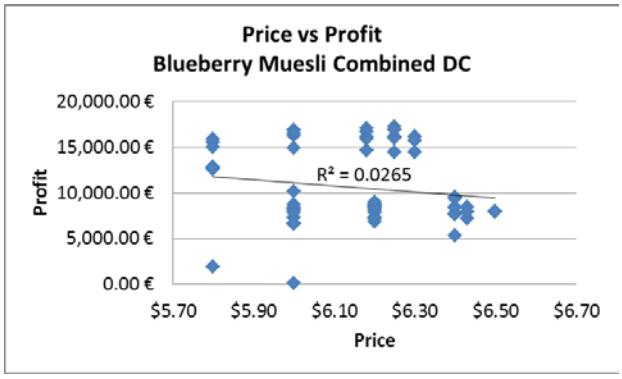


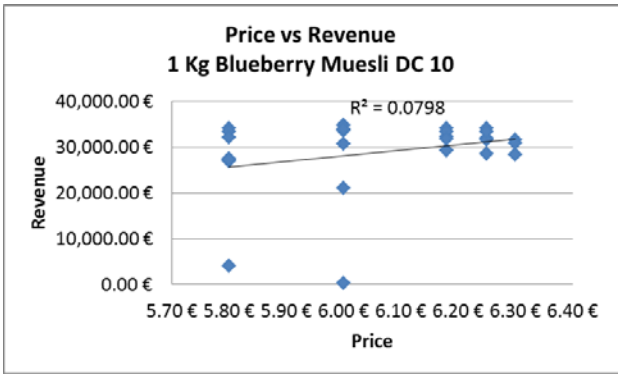


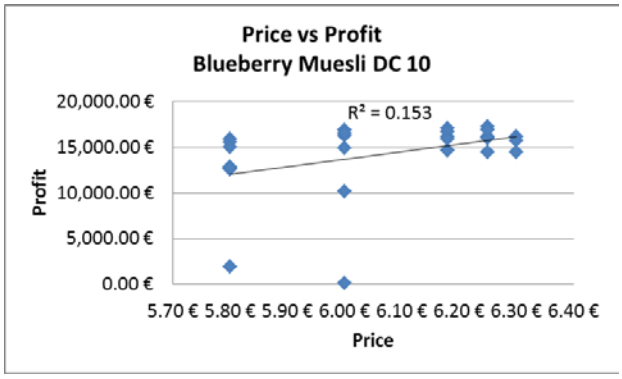


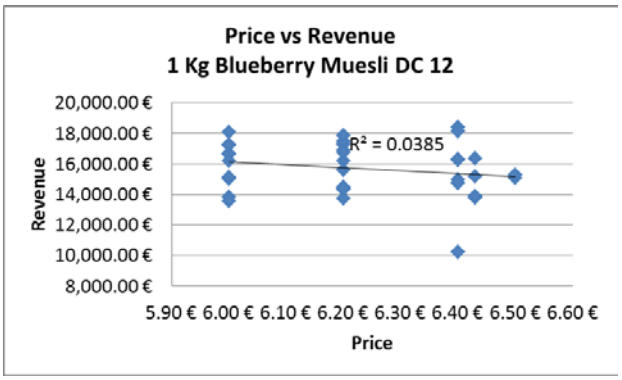
9.2 BLUEBERRY MUESLI

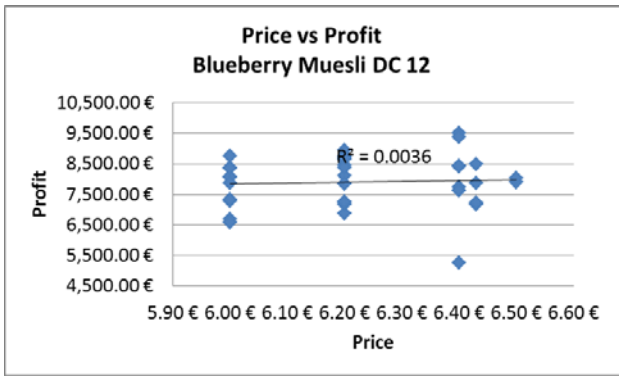




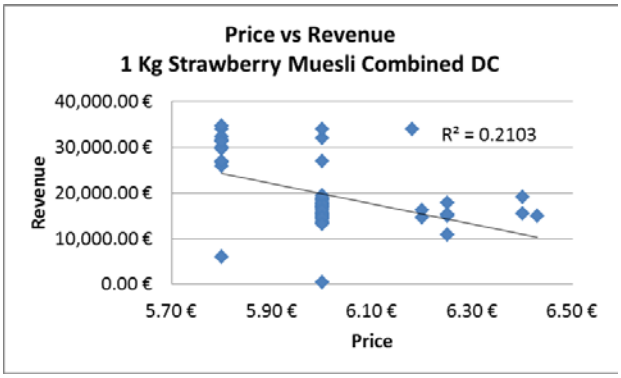


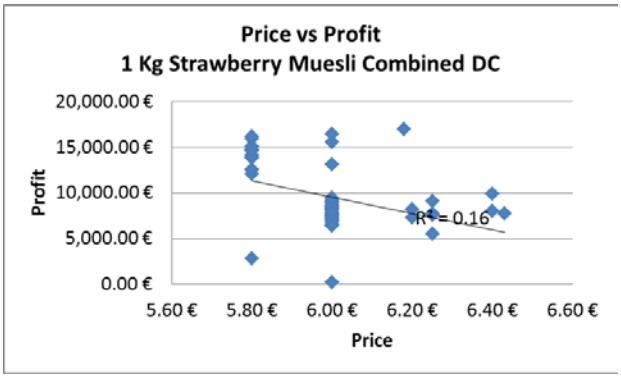


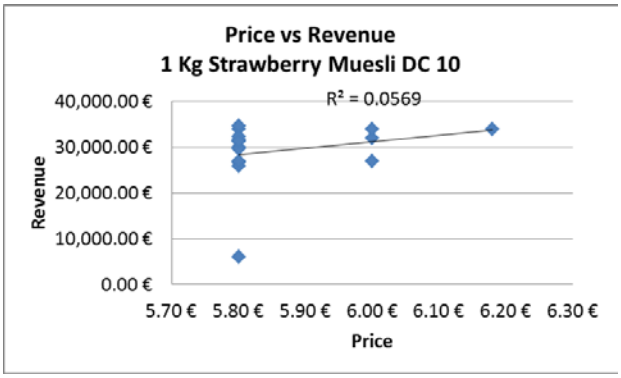


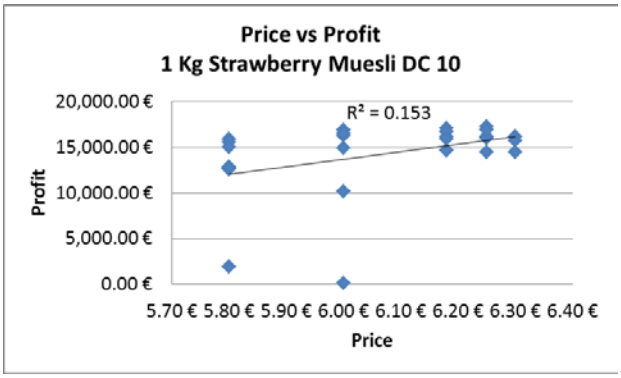


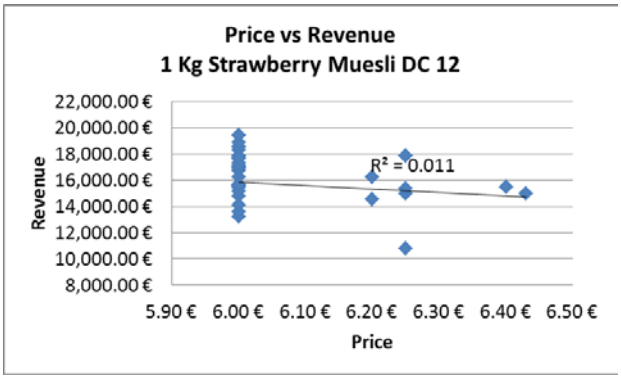
9.3 STRAWBERRY MUESLI

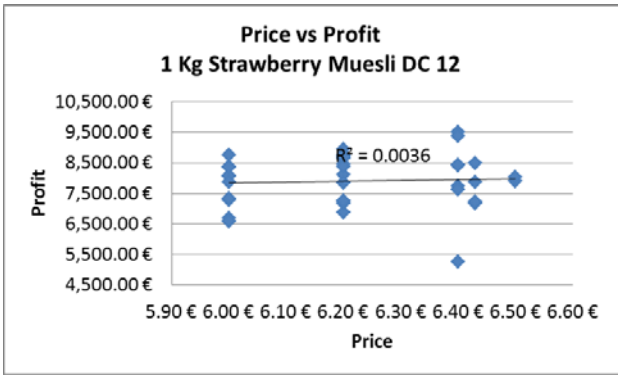




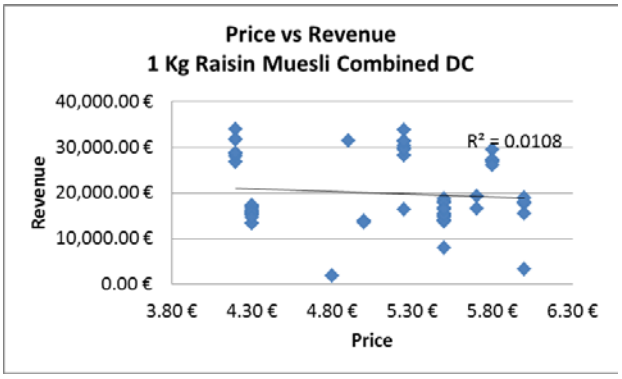


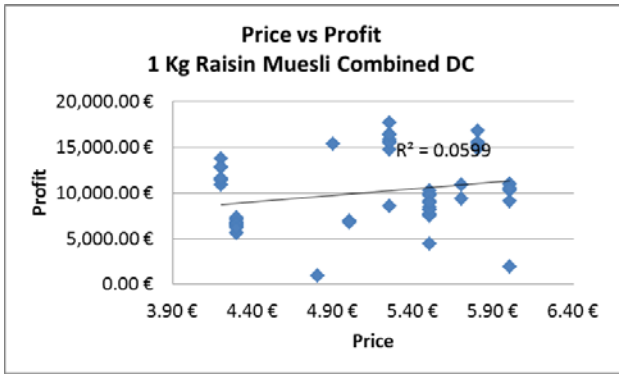


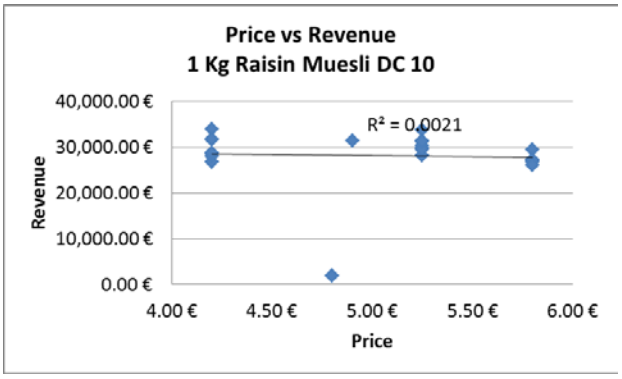


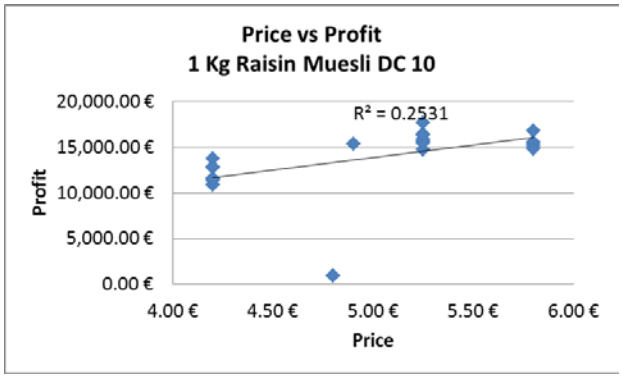


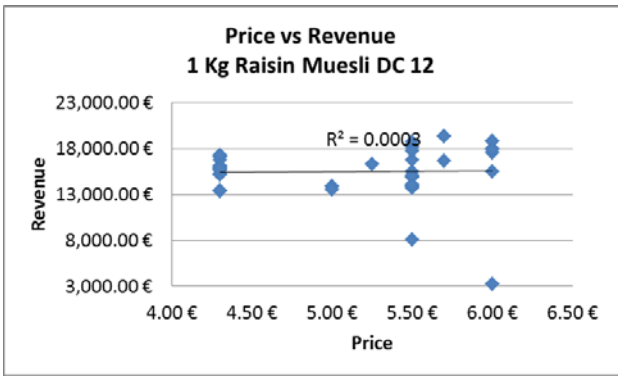
9.4 RAISIN MUESLI

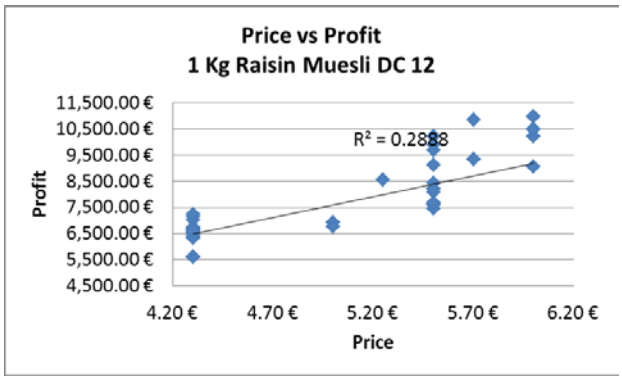




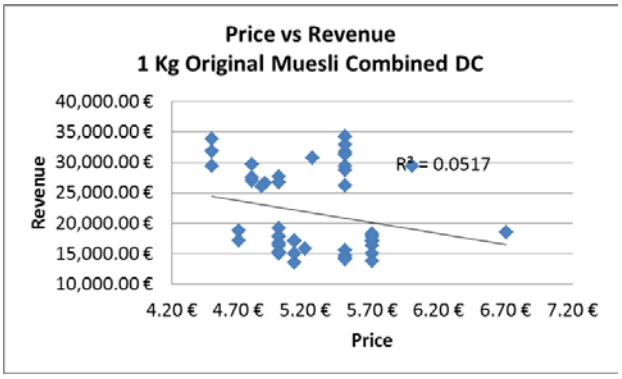


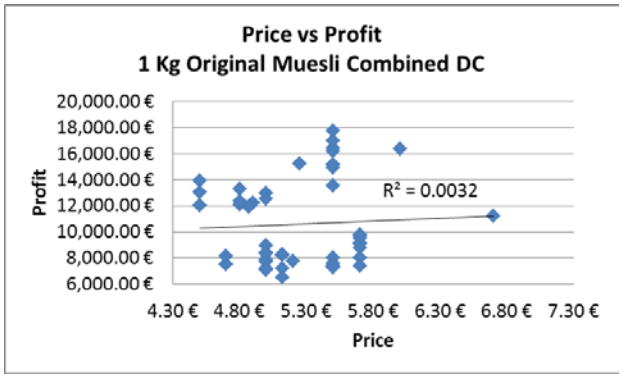


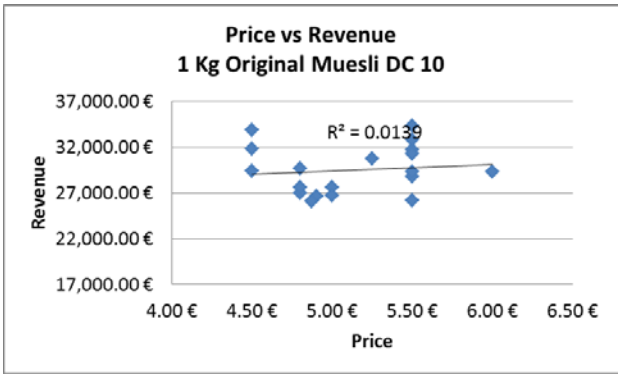


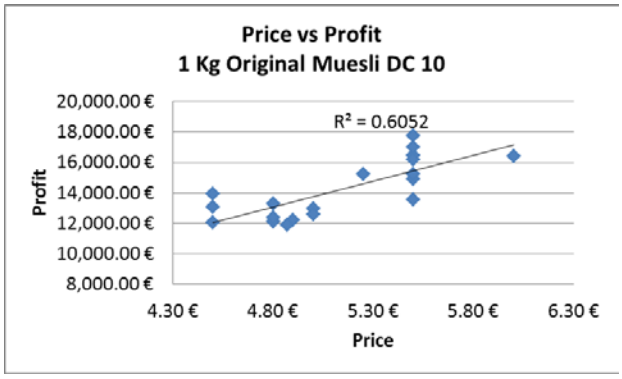


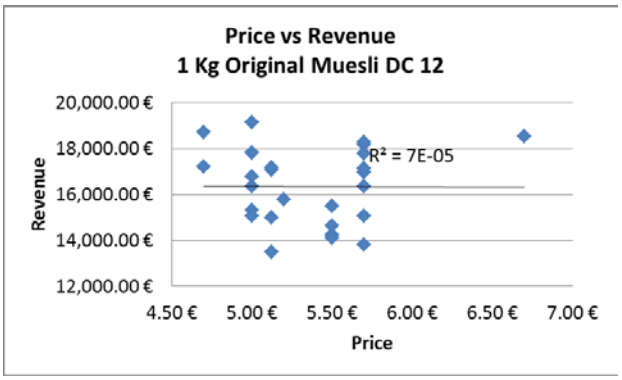
9.5 ORIGINAL MUESLI

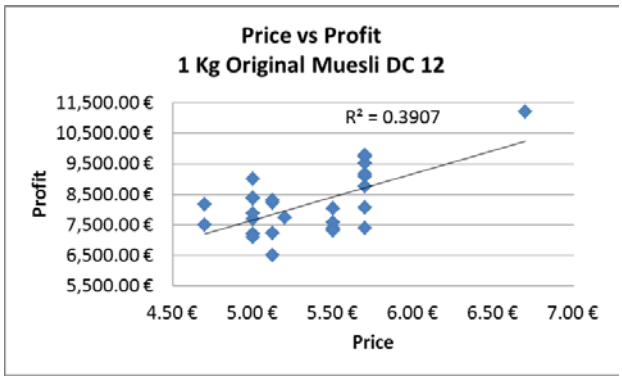












9.6 MIXED FRUIT MUESLI