INDUSTRIAL ENGINEERING
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ENGINEERING CO-OP
WITH
FEDEX SUPPLY CHAIN

FINAL REPORT

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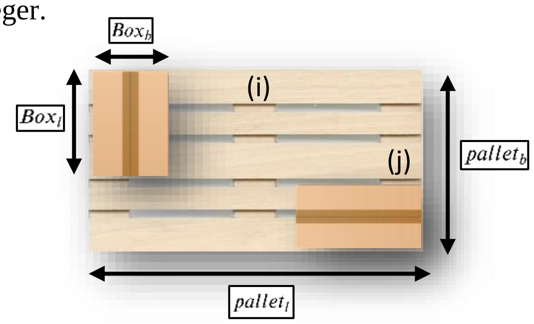
5. Appendix 01: Binary linear program to fit maximum possible boxes on a pallet

A standard pallet is 48 ($pallet_l$) x 40 ($pallet_b$) x 60 when measured in inches and dimension of a box is different for different SKUs. Box edge is not allowed to overhang from pallet edge even by an inch and the top face of the box always comes facing upward which makes this optimization program a 2D model. Both decision variables are binary, and every other variable is a positive integer.



Sets

$$\mathcal{I} = 1, 2, \dots, \lfloor pallet_l / Box_b \rfloor$$

$$\mathcal{J} = 1, 2, \dots, \left\lfloor \frac{pallet_b}{Box_b} \right\rfloor$$

Variables

$yl_{i,j}$: Would be 1 if length of box aligns along length of pallet in a slot (i,j), else 0

$yb_{i,j}$: Would be 1 if breadth of box aligns along length of pallet in a slot (i,j), else 0

Constraints

$$\forall\ j \in J\ \forall\ i \in I \quad yl_{i,j} + yb_{i,j} \leq 1$$

In a slot (i,j) a box can sit either along its L or B but not both

$$\forall\ j \in J \quad Box_l \sum_i yl_{i,j} + Box_b \sum_i yb_{i,j} \leq pallet_l$$

$$\forall\ i \in I \quad Box_l \sum_j yb_{i,j} + Box_b \sum_j yl_{i,j} \leq pallet_b$$

Total edge length occupied by boxes when measured along pallet length/breadth should not exceed pallet length/breadth respectively

Objective function

$$\max_{yl,yb} \quad \sum_{i \in I,\ j \in J} yl_{i,j} + \sum_{i \in I} \sum_{j \in J} yb_{i,j}$$

Maximize sum of boxes where breadth aligns with pallet length and breadth aligns with pallet breadth

The output of the program gives out three different results. ‘Fit’, ‘Levels’ and position matrix (Figure 09). ‘Fit’ describes maximum number of boxes that could fit on the pallet without stacking upon levels. ‘Levels’ indicate number of levels of such arrangements that can be placed one upon the other until total height is not more than 60 inches. The position matrix as shown in (Figure 09) depicts the positional arrangement of the boxes.

Below example with SKU 86698242 (Figure 10) has dimensions as shown in (Table 03) and the program outputs a positional matrix (Figure 09), ‘Fit’ as 5 and ‘Levels’ as 4 which brings the ‘total boxes that could fit’ to 20. ‘units that could fit’ was later calculated by grabbing ‘number of units’ information printed on the box label.

SKU	EM/SD	SKU Description	Length	Width	Height	Weight	Volume	fit	levels	total boxes that could fit	total units that could fit
86698242	SD	STLNT,KIT,SYR,CT,SNGL,60",SPK,MC,WLD	22.7	14.9	14.3	18.5	4836.689	5	4	20	1000

All units are in inches

Table 03 Master dataset that shows cubiscanned dimensions of a SKU 86698242 and box placement attributes

Figure 10 Arrangement of SKU 86698242 on pallet

```
i =  1 j =  1 solution =  1.0
i =  1 j =  2 solution =  -0.0
i =  2 j =  1 solution =  -0.0
i =  2 j =  2 solution =  -0.0
i =  3 j =  1 solution =  1.0
i =  3 j =  2 solution =  -0.0
=================================
i =  1 j =  1 solution =  0.0
i =  1 j =  2 solution =  1.0
i =  2 j =  1 solution =  0.0
i =  2 j =  2 solution =  1.0
i =  3 j =  1 solution =  0.0
i =  3 j =  2 solution =  1.0
=================================
['L', '0', 'L']
['B', 'B', 'B']
5.0
4
```

Figure 09 Positional matrix