FACILITY DESIGN OF FRUIT AND VEGETABLE STORAGE AT RETAIL OUTLETS: A GENERIC DESIGN APPROACH

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ABSTRACT

Fast moving consumer goods retail outlets are constructed on high value properties. Occupation of floor space needs to be limited to the essential minimum, especially for non customer interaction spaces. Retail outlets are generally not built to standard designs, but customised to suit their locality and customer potential. The result was the requirement of a supermarket chain for a design tool for fruit and vegetable receiving facilities. The space requirements of storage areas as a function of operational parameters such as store sales volumes are the model outputs. Apart from using the tool for new store designs, it is required to serve as a measurement tool for existing stores.

The study describes the development of the design tool using Pareto principles, regression and finally facility design practices. The tool defines the floor space required relating to the confidence level required for the storage area to be large enough for variations in receipt volumes through the course of a year.

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1   BACKGROUND

Fast moving consumer goods, notably fresh fruit and vegetables, are increasingly becoming within reach of consumer groups with increased disposable income, causing growth in the sector. A major supermarket chain envisaged opening more than 170 new supermarkets in 2013. Fruit and vegetables are delicate merchandise due to the short life cycle, the specific requirement of each product with regards to temperature and humidity as well as the response to ripening hormones such as ethylene and also bruising. From a facility design perspective, the fruit and vegetable receiving, storage and preparations area of a fast moving consumer goods retail outlet needs to be specifically designed. Other factors that influence the design of this functional area are the volumes received at the specific supermarket as well as the space available.

This paper reports an investigation into a fruit and vegetable receiving, storage and preparations area requirements model, that provides space requirements for this functional space of any envisaged or newly established supermarket. For each new store that is in the process of being planned and designed, the goal is to be able to determine the space requirements with inputs such as the store brand, geographical location and the expected annual sales for the store. Pareto principles and regression analysis are used to categorise stores according to fruit and vegetable sales revenue. The distributions of these flow volumes are examined to predict the safety margins of the design guidelines. In the design of fruit storage and handling spaces both production of and sensitivity for ripening hormones, such as ethylene, needs to be key guiding principles. Both the design approach for ripening hormonal considerations as well as the facilities solution is specifically excluded from this paper for focus and length of document reasons.

2   INTRODUCTION

In supermarket supply chains, fruit and vegetables are transported and stored in deep trays of dimensions 600 x 400 x 225 mm at 8°C [1]. In this work, supermarket receipt data for a range of stores are investigated. This information represents relatively large amounts of data that are examined for the presence of statistical distributions, for example the distribution of the number of cases of produce that enters the storage area per day. As fruit and vegetable demand is independent and store orders aim to accurately match sales, variability is considerable. In order to predict volumes, it is therefore necessary to be able to calculate the amount of variation separate from the mean and characterise the data as a distribution. This enables the calculation of confidence intervals to assess both the risk of under design and wastage due to overdesign.

2.1   Normal distribution

A normal probability distribution function can be used to describe the quantity of crates of fruit and vegetable received at a retail store, daily. It describes the probability that a certain variable will have a value that falls in a specific interval of values. Two parameters are considered when dealing with a normal distribution, namely the mean, μ and the standard deviation, σ [2]. The mean is the expected value for a distribution and is the value that is most likely to be observed if an event is repeated [3]. The mean and standard deviation for a sample of n number of observations are calculated as follows:

$$\mu = \frac{\sum_{i=1}^{n} X_i}{n} \qquad (1)$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \mu)^2}{n-1}} \qquad (2)$$

$\mu = mean \qquad \sigma = standard\ deviation \quad X_i = observation\ i \quad n = number\ of\ observations$

The standard deviation is used to calculate how much the fruit and vegetable quantities received vary per day. Considering that the normal distribution depicts certain probabilities that values will fall into certain intervals with a level of confidence, it is necessary for this project to be able to calculate these intervals as the receiving space is designed accordingly. For example, 95% confidence defines an interval beyond the mean of Z= +- 1.96 standard deviations of the sample [2].

These Z-values are standard for normal distributions and for a certain confidence level, a Z-value exists. When this Z-value, mean and standard deviation are known, it is possible to calculate the upper and lower interval limits for the specific distribution using the following formula:

$$\boldsymbol{Z} = \frac{X - \mu}{\sigma} \tag{3}$$

$\mu = mean$

$\sigma = standard\ deviation$

$X = upper\ interval\ limit$

$Z = number\ of\ standard\ deveations\ from\ X\ to\ \mu$

2.2 Regression analysis

Regression analysis determines the relationship between variables. It is also necessary to investigate the statistical significance of the calculated relationships in order to determine the degree of confidence with which the relationship is accurately determined and with which it can be used for the required objective [4]. For this project it is necessary to find the relationship between certain variables such as size, brand, location, etc. of a retailer and the volume of F&V received during a specific time [5].

The first step in regression analysis is to form a hypothesis that some or other relationship exists between certain variables. As an example, the hypothesis may be formed that the size of a store has an effect on the volume of fruit received per day. Then the volume of fruit becomes the dependent y variable and the size of the store becomes the independent x variable. It is necessary for regression analysis to assign the correct quantitative values to variables [5].

The following definitions and assumptions are made with regards to simple linear regression:

Definition: $x_i = Independent\ Variable$

$y_i = Dependent\ Variable$

$i = Number\ of\ Observations$

$u_i = Error$

Assumption: $E(u_i) = 0$ $u\ has\ a\ mean\ of\ zero\ for\ all\ i$

$E(u_i^2) = \sigma_u^2$ $u\ has\ thesame\ variance\ for\ all\ i$

$E(u_i u_j) = 0, i \neq j$ $no\ correlation\ accross\ observations$

The hypothesized relationship between the dependent and independent variable is formulated as follows [4]:

$$\boldsymbol{y_i = \beta_0 + \beta_1 x_i + u_i} \tag{4}$$

Where: $\beta_0 = constant\ for\ x_i = 0$

$\beta_1 = coefficient\ for\ x_i$

$u_i = Error \tag{5}$

Regression analysis is based upon the principle that a certain line $y_i = \beta_0 + \beta_1 x_i$ is fit to the scatter of observed data. β_0 is the intercept of the line on the vertical axis and β_1 is the slope of the line [5]. In order to decide where to fit this line and determine the coefficients the error term u_i is added to the equation. The error term portrays the estimate error for each observation as the vertical distance between the data point and the estimated line. Regression analysis then chooses among all possible solutions, the line that results in the minimum sum of the squared errors (min SSE) [4].

There is no certainty in only performing a regression analysis that the best fit line is even close to an accurate estimate. Further evaluation is therefore required. By calculating the difference between the actual observed value and the fitted value as per the estimated equation for each observation in the data, and determining the sum of the square of each of these values a conclusion can be made. This value is known as the SSR (sum of squared residuals) [4]. In order to determine the 'wellness of the fit', the coefficient of determination is calculated using the values of SSR [5]. This coefficient is also known as R^2. The closer R^2 is to 1 the closer the fit is and the closer it comes to zero the less accurate the estimation is.

2.3 Multiple linear regression

It is seldom the case in reality that only one variable has an effect on another variable. For multiple regression, the theory changes as follows [4], [6]:

$$y_i = \alpha + \beta x_i + \gamma e_i + u_i \qquad (6)$$

Where:

$$\alpha = constant\ for\ x_i = 0$$

$$\beta = coefficient\ for\ x_i$$

$$\gamma = coefficient\ for\ e_i$$

$$u_i = Error$$

Previously a two dimensional problem, has now become a three dimensional problem and graphical presentation is not so obvious. The concept of fitting a line to the data is not possible anymore and the idea has changed to manipulate the coefficients of the new equations in order to find a plane within the data that will fit best and still result in minimising the SSR [5], [6].

Multiple regression analysis can deal with a large number of variables. Even though people lack the ability to see in multiple dimensions, computers and mathematics can define such a condition. With n variables a 'hyper plane' will be sought in the n-dimensional space to fit the data in such a way that will minimise the SSR. The intercept is the constant term α, where the other coefficients β and γ, etc. form the slope in each dimension [5].

2.4 Storage considerations

In the supermarket storage area, unit loads are defined as deep trays measuring 600 x 400 x 225 mm. These unit loads are received and assigned to a certain storage location. In fixed storage location allocation, each individual Stock Keeping Unit (SKU) is assigned to a specific location. This method holds the advantage of making items easy and quick to find, at the cost of space utilisation, especially where item volumes are seasonally fluctuating such as with fruit and vegetables. In the case of random location storage, a unit load may be assigned to any available storage location. Although this method requires other methods of locating the items once they have been placed, it usually requires less space than fixed storage location as there are no open spaces waiting on specific items [7], [8].

Popularity based storage is linked to Pareto's law. Typically, 85% of the volume will be occupied by 15% of the materials stored. In order to store such products in an efficient manner, the 15% of products with the highest volume need to be stored together and in

close proximity to the entrance/exit so that the travel distance is minimised [7]. A combination of fixed and random location storage is practical. A SKU is assigned to a certain zone in which it will be stored according to its volume. This zone is fixed, however where each item is placed in the zone is random and assigned according to the quantities received on the day. An ABC analysis can be done in order to identify these zones. Zone A is located closest to the receiving and shipping areas and zone C is located furthest away from these areas. It is clear from data analysis that Pareto's law is applicable as items such as apples and bananas, etc. are more popular and consume more volume in the storage area. They are therefore located close to receiving and shipping entrances.

Material accessibility is the degree of effort it takes to reach a certain item in a storage facility [7]. The storage area needs to work according to First-In-First-Out principles and the naturally occurring Last-in-First-Out practice is to be avoided deliberately. Honeycombing is also to be constantly considered and avoided. This is wasted space when a row or stack cannot be utilised, because adding other materials would result in blocked storage [7].

2.5 Data analysis

For primary handling of data, a database program such as Microsoft Access is more suitable for larger datasets than spreadsheet types of software, such as MS Excel. Investigating Statistical Analysis Software, there are different levels of programs categorised by cost and the amount of experience necessary to use the program, starting with the most basic programs such as Microsoft Excel and R. Both these programs require only basic programming skills and are easy to use, however are not suitable for this project as they cannot process the amount of data required [9].

For more advanced needs, programs such as STATA, Statistica 11.0 and SPSS statistics exist. STATA can handle moderately sized data sets and is affordable. It lacks some features as it is only able to open one data source per operation. It is however easy to use and easily programmable. SPSS Statistics is also an easy to use program with the necessary features to handle the data of this project. It lacks some control in statistical output, however for this project this might not be a concern [9]. Statistica 11.0 is easy to use and can handle vast amounts of data. It can do various types of regression analysis necessary for this project as well as execute the desired statistical analysis functions on the data. The highest level of statistical analysis tools includes SAS Analytics Pro. This is an efficient statistical tool with many features and allows comprehensive data manipulation. Relatively comprehensive and advanced programming is required for the use of SAS [9]. For the regression analysis Statistica 11.0 is used.

3 METHODOLOGY

The bulk of the design project included the analysis of store receipt data and facilities design. It is performed as follows: (1) Data is transformed into MS-Access format and appropriate queries are coded. (2) Statistica 11.0 is used to analyse the data statistically and the desired distributions of fruit and vegetable crates received per day are determined. (3) A Pareto analysis is done and the stores are divided in eight categories. (4) Storage space layout design is performed employing storage appropriate locality practices, such as popularity based, random and fixed as well as combinations of these methods. (5) Layout design receives particular attention to implement FIFO storage. (6) The user tool is developed in Microsoft Excel using Visual Basic for Applications coding.

4 ANALYSIS RESULTS

Branch data was categorised according to Fruit and Vegetable annual sales revenue. This resulted in eight store categories that have a certain range of fruit and vegetable volume delivered daily. A distinction was made between produce stored at 5 and 15 degrees C. Figures 4 and 5 show the relationship between the number of cases received and the

category of annual sales revenue. The large difference between average and maximum volumes emphasise the need for a statistical approach, considering the variance as well.
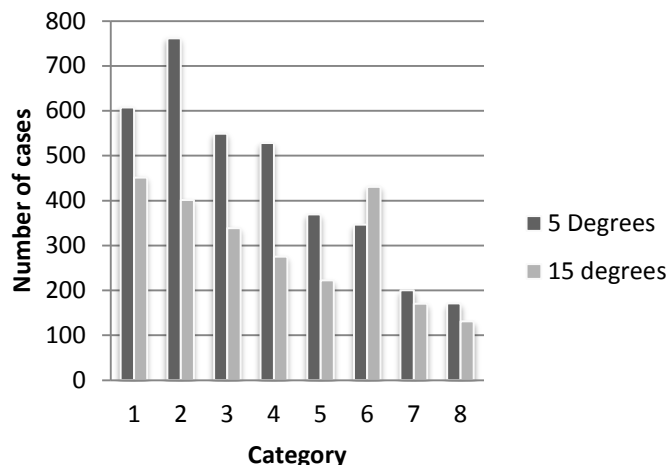

Figure 1: Average number of cases fruit and vegetables delivered per day per category for both temperature compartments
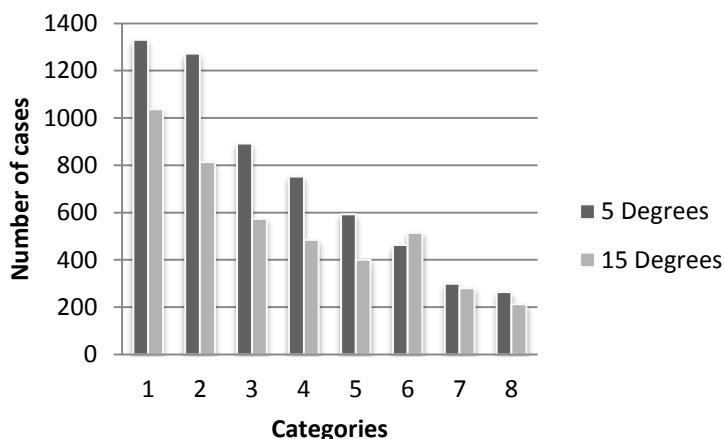

Figure 2: Maximum number of cases of fruit and vegetables delivered per day per category for both temperature compartments

Other information shows the number of crates received per year for each fruit and vegetable item. This is used to compile the ABC analysis determining which items use the most space during the year. This data differs for each category. Therefore a design for each category is done using basic design principles in order to acquire the volume for each new store.

4.1   Regression analysis on store data

A regression analysis is done in order to find a relationship between the various parameters of a store and the annual fruit and vegetable revenue. This was done in case of the situation where the company does not have the annual fruit and vegetable revenue estimates to enter into the tool, and then it can be calculated using a formula.

The result of this regression was that annual sales, brand and division are strongly correlated with the annual fruit and vegetable sales of a store. A R squared of 0.599 was obtained. Therefore this regression results can be used in order to obtain the estimated annual fruit

and vegetable sales for new stores using the available variables and a store can then be categorised accordingly in order to find the appropriate design for the storage area.

4.2   Statistical analysis of quantity crates received per day

By running queries in MS Access and obtaining records for each temperature compartment per category store, the quantity of crates received per day for a year, it was possible to run this data with Statistica 11.0 for each category and for both temperature compartments.

Histograms are drawn up to portray the frequencies of the different quantities of crates received at stores per day and the results tended towards normal distributions. Normal distributions were fit to the data and by using Statistica 11.0 it was possible to calculate the mean and standard deviation for data from each temperature compartment for all categories. The results of all categories were plotted and the histograms for both temperature compartments of category 1 is shown in Figures 3 and 4.
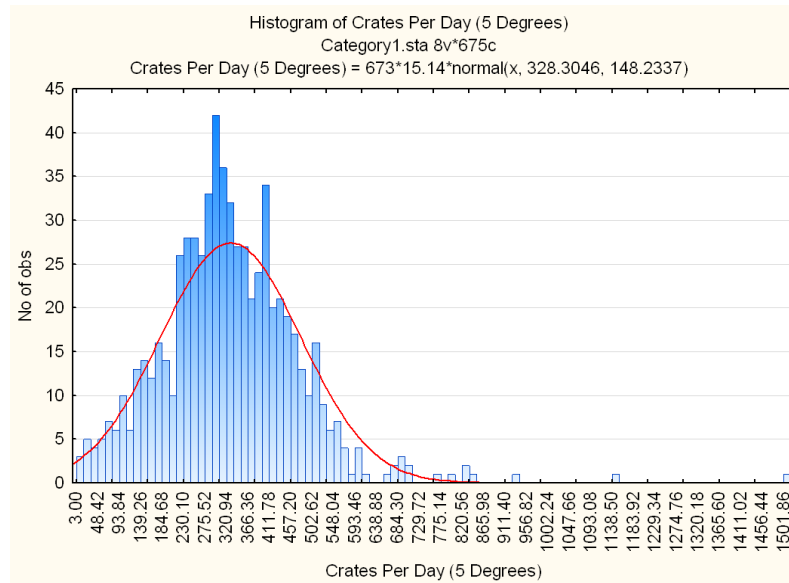

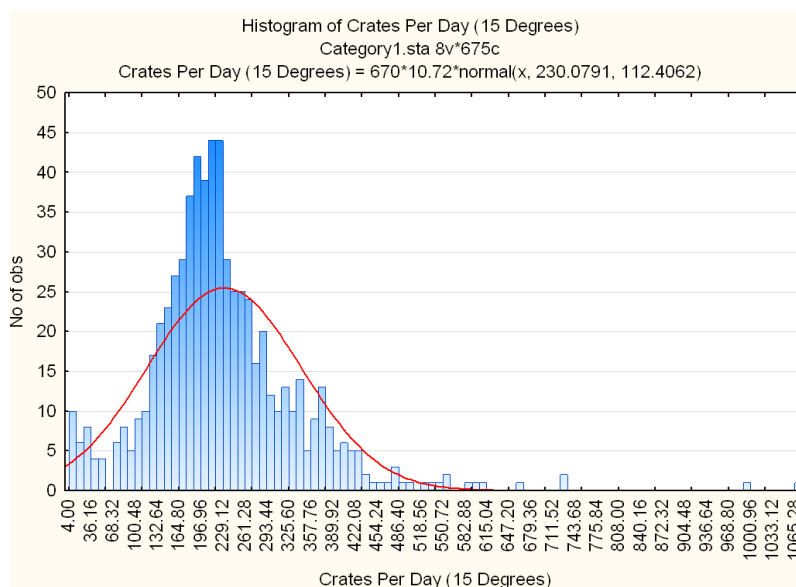**Figure 3: Frequency of quantity crates received per day for a category 1 store (5˚C area)**

Figure 4: Frequency of quantity crates received per day for a category 1 Store (15˚C area)

The calculated means and standard deviations are shown in *Table 1* below. These values were used to calculate confidence intervals for two different confidence levels, namely 70% and 90% confidence. These values are also depicted in the table below.

Table 1: Category means, standard deviations and confidence limits

Category	Mean	Minimum	Maximum	Standard Deviation	70% LL	70% UL	90% LL	90% UL
Category 1 (5 Degrees)	328.3046	3.000000	1517.000	148.2337	251	406	139	519
Category 1 (15 Degrees)	230.0791	4.000000	1076.000	112.4062	172	289	86	375
Category 2 (5 Degrees)	370.3022	1.000000	1412.000	182.3206	275	466	137	605
Category 2 (15 Degrees)	185.8348	1.000000	958.0000	106.0386	131	242	50	322
Category 3 (5 Degrees)	260.2631	1.000000	1566.000	133.8748	191	331	89	432
Category 3 (15 Degrees)	142.7319	1.000000	940.0000	85.30550	99	188	34	253
Category 4 (5 Degrees)	260.2631	1.000000	1566.000	133.8748	191	331	89	432
Category 4 (15 Degrees)	142.7319	1.000000	940.0000	85.30550	99	188	34	253
Category 5 (5 Degrees)	165.4381	1.000000	1682.000	89.42009	119	213	51	281
Category 5 (15 Degrees)	93.34987	1.000000	880.0000	58.79087	63	125	18	169
Category 6 (5 Degrees)	126.5316	1.000000	1210.000	70.82611	90	164	36	218
Category 6 (15 Degrees)	136.9428	1.000000	2012.000	84.65687	93	182	29	246
Category 7 (5 Degrees)	84.80151	1.000000	1449.000	54.63793	57	114	15	155
Category 7 (15 Degrees)	52.78603	1.000000	960.0000	39.86671	32	74	2	104
Category 8 (5 Degrees)	65.27929	1.000000	857.0000	46.94592	41	90	6	126
Category 8 (15 Degrees)	41.78666	1.000000	806.0000	32.30156	25	59	1	84

5 DESIGN RESULTS

5.1 ABC analysis on item volumes

For this project the ABC analysis items were categorised as follows: A-items are the few items that make for 70% of the volume received, B-items are the items that take up the next 20% of the volume and C-items are the smaller items that account for the final 10% of the volume. According to Pareto's principle there are only a few items that make up the A group, where the C group will consist of most of the items. It was possible to obtain the amount of cases received per year for each item type. This information was necessary to do an ABC analysis. By using this information, it was possible to calculate the average percentage of volume that each item takes up per year for each category. These calculated percentages for the 5 degree area for category 1 is shown in *Table 2*.

Using the percentage of the received volume per item type it is possible to convert this information into quantity of crates received per item type with regards to both 70% and 90% confidence levels. The quantity of crates received is also shown in *Table 2*. The ABC analysis for both temperature compartments for the remaining categories are part of the study but not shown in the paper.

Table 2: ABC classification of item types throughout the year as well as the quantity of crates received per item according to the fraction of volume.

5 Degrees Area			Confidence:	0.7	Confidence:	0.9		
Sub Category Description	Crates per year	Percentage	Cumulative %	Max	Min	Max	Min	Zone
GREENS	35004	0.158	0.158	65	40	96	22	A
LETTUCE	22359	0.101	0.260	42	26	62	14	A
MUSHROOMS WHITE	16419	0.074	0.334	31	19	45	11	A
VEG FRESH CUT	12218	0.055	0.389	23	14	34	8	A

CARROTS	10716	0.048	0.438	20	13	30	7	A
HERBS	10132	0.046	0.484	19	12	28	7	A
CABBAGE	9156	0.041	0.525	17	11	26	6	A
RED APPLES	8937	0.040	0.565	17	11	25	6	A
CAULIFLOWER	8696	0.039	0.605	16	10	24	6	A
SPINACH	6546	0.030	0.634	13	8	18	5	A
GOLDEN APPLES	6063	0.027	0.662	12	7	17	4	A
PLUMS	5870	0.027	0.688	11	7	17	4	A
BI-COLOUR APPLES	5458	0.025	0.713	11	7	15	4	B
BEANS & PEAS	5457	0.025	0.738	11	7	15	4	B
POT PLANTS ASSTD	4395	0.020	0.758	9	5	13	3	B
GRAPE SEEDLESS	4231	0.019	0.777	8	5	12	3	B
PADKOS PREPACKS	4126	0.019	0.796	8	5	12	3	B
GREEN APPLES	3966	0.018	0.814	8	5	11	3	B
CLING PEACHES	3673	0.017	0.830	7	5	11	3	B
SWEET CORN	3609	0.016	0.846	7	5	10	3	B
STRAWBERRIES	3501	0.016	0.862	7	4	10	3	B
PEARS BAG PREPACK	3455	0.016	0.878	7	4	10	3	B
GRAPE SEEDED	3115	0.014	0.892	6	4	9	2	B
NECTARINES	2945	0.013	0.905	6	4	9	2	B
PEACHES	2892	0.013	0.918	6	4	8	2	C
BEETROOT	2758	0.012	0.931	6	4	8	2	C
SALAD PRE-PREPARED	1959	0.0089	0.940	4	3	6	2	C
PEARS LOOSE SELL	1663	0.0075	0.947	4	2	5	2	C
COCONUT	1603	0.0073	0.955	3	2	5	1	C
LITCHI	1183	0.0054	0.960	3	2	4	1	C
KIWIFRUIT	1106	0.0050	0.965	3	2	4	1	C
SOFT FRUIT MIX PACKS	1058	0.0048	0.970	2	2	3	1	C
SPRING ONION	1028	0.0047	0.974	2	2	3	1	C
BROCCOLI	1004	0.0045	0.979	2	2	3	1	C
CELERY	911	0.0041	0.983	2	2	3	1	C
PERSIMMON	703	0.00318	0.986	2	1	2	1	C
RADISH	649	0.00294	0.989	2	1	2	1	C
MUSHROOMS BROWN	630	0.00285	0.992	2	1	2	1	C
PRUNES	559	0.00253	0.995	2	1	2	1	C
FOREST BERRIES	233	0.00105	0.996	1	1	1	1	C
SPROUTS	166	0.00075	0.996	1	1	1	1	C
CHERRIES	164	0.00074	0.997	1	1	1	1	C
FRUIT CUPS	134	0.00061	0.998	1	1	1	1	C
CHICORY	133	0.00060	0.998	1	1	1	1	C
F&V GENERIC ITEMS	123	0.00056	0.999	1	1	1	1	C
RHUBARB	62	0.00028	0.999	1	1	1	1	C
FIGS	42	0.00019	0.999	1	1	1	1	C
VEGETABLE MIXED PREPACKS	42	0.00019	1.000	1	1	1	1	C
ASPARAGUS	40	0.00018	1.000	1	1	1	1	C
LEEKS	25	0.00011	1.000	1	1	1	1	C
PARSNIPS	15	0.000068	1.000	1	1	1	1	C
QUINCE	12	0.000054	1.000	1	1	1	1	C
TURNIPS	3	0.000014	1.000	1	1	1	1	C
APRICOTS	1	0.0000045	1.000	1	1	1	1	C
HORSERADISH	1	0.0000045	1.000	1	1	1	1	C

5.2   Structured layout design per category store

When designing the layout for each category, the following factors are taken into account, namely the storage location allocation method, material accessibility and travel distances. For the fruit and vegetable receiving, storage and preparations area a hybrid of popularity based, fixed and random location allocation is used, where fixed zones are allocated to A-, B-and C-items, but in the zones random allocation occurs between items. It is also necessary to design using the FIFO principle and minimise travel to the most popular items.

ABC analysis data (percentage of received volume per item) and 70% and 90% interval data is used to determine the average number of crates of a specific item received per day. From this the total average number of crates received at the RSPA for A-items, as well as B-items and C-items, are determined. This data determines the size of zones A, B and C.

Four methods for stacking deep trays in the RSPA were chosen as set methods for this design. These methods and the dimensions for each are detailed in the project report. The

stacking options have set base dimensions and can hold a certain number of cases, making the design process determined and adjustable. The quantity of cases calculated was converted into floor space through using these set options.

Taking company preferences as well as the set options described in the previous paragraph and basic design principles, such as aisle space, into consideration, it was possible to design layouts for all 8 categories. Only the layout design at 90% confidence level for category 1 can be seen in Figure 9 below.

Figure 5: Layout design at 90% confidence level for category 1

The set stacking options are shown in the image. For this category it is observed that option 1, is used for all the A-items (depicted in red). This option holds 36 cases and has dimensions 1.2m x 1.2m. This layout also uses option 2 stacking for B-items shown in blue which holds 24 cases and option 5 racking that holds 30 C-items. An aisle width of 0.7 m is used throughout designs and aisle direction is longitudinal and parallel to the direction of product flow through the storage space. A-items are located closest to doorways with good accessibility in order to keep travel distances to a minimum for these popular items. All designs follow the same basic principles. Results regarding the sizes calculated for the various sections can be seen in the following table, Table 3.

Table 3: Layout dimensions and calculated area

	Confidence (%)				2)	Total (m2)
		5 Degree Area	15 Degree area	5 Degree Area	15 Degree area	
1	90	5.4m x 6.7m	5.4 x 5.2	36.18	28.08	64.26
	70	5.4m x 5.5m	5.4m x 4.3m	29.7	23.22	52.92
2	90	5.6m x 6.7m	5.6m x 4.3m	37.52	24.08	61.6
	70	5.0m x 6.1m	5.0m x 4.3m	30.5	21.5	52
3	90	5.2m x 5.5m	5.2m x 3.6m	28.6	18.72	47.32
	70	5.2m x 4.3m	5.2m x 3.1m	22.36	16.12	38.48
4	90	5.6m x 4.8m	5.6m x 4.8m	26.88	26.88	53.76
	70	5m x 3.7m	5m x 2.5m	18.5	12.5	31
5	90	5m x 4.3m	5m x 3.6m	21.5	18	39.5
	70	4.4m x 3.7m	4.4m x 3.0m	16.28	13.2	29.48
6	90	5.2m x 3.0m	5.2m x 3.0m	15.6	15.6	31.2
	70	4.0m x 3.7m	4.0m x 3.6m	14.8	14.4	29.2
7	90	3.6m x 3.6m	3.6m x 3.7m	12.96	13.32	26.28
	70	2.7m x 3.0m	2.7m x 3.7m	8.1	9.99	18.09
8	90	3.6m x 3.2m	3.6m x 3.5m	11.52	12.6	24.12
	70	2.1m x 3.6m	2.1m x 3.2m	7.56	6.72	14.28

From this table it is evident that the 5 degree area usually stores larger quantities and larger space should be assigned to this compartment. A trend can be observed in the sizes and lower categories have significantly smaller floor areas, as was expected.

6   CONCLUSIONS

The main objective for this project was to develop a generic facility design tool, namely a fruit and vegetable receiving, storage and preparations area requirements model that largely automates and structures the fundamentals of the facility design for any newly planned store with a fruit and vegetable division. The task consisted of the following elements: (1) a background study of the theory and literature, (2) analysis of data to identify distributions and relationships, (3) categorisation of stores based on fruit and vegetable sales, (4) application of relevant facility design principles for operational efficiency and (5) implementation of the results in a MS Excel tool for the user.

The end product of this project is a user friendly management tool that takes certain inputs from the company and provides all the desired outputs of a new store, such as expected fruit and vegetable daily receipt distribution, and a detailed layout suggestion for the store. Practical company preferences were implemented in the design phase and the end product is in accordance with the requirements of the customer.

As the customer is a major supermarket chain in Africa, South of the Sahara, the implementation scope of the tool may be significant.

7   ACKNOWLEDGEMENT

8   REFERENCES

[1]   **Zietsman I**. 2013. Interviewee, *Industrial engineer at Project Industrial Partner*.

[2]   **Render, B., Stair, R. and Hanna, M.** 2009. *Quantitative analysis for management*, Pearson Education Ltd, London.

[3]   **Kurtz, A.M. S.** 1979. *Statistical methods in education and psychology*, Springer-Verlag, New York.

[4]   **Cottrell, A.** Date read (2013-07-11). *Regression Analysis,*

http://users.wfu.edu/cottrell/ecn215/regress.pdf

[5]   **Sykes, A.** Date read (2013-05-18). *An Introduction to Regression Analysis*, http://www.law.uchicago.edu/node/1309

[6]   **Schroeder, L., Sjoquist, D. and Stephan, P.** 1986. *Understanding regression analysis: An introductory guide*, Sage, Beverly Hills.

[7]   **Thompkins, J.A., White, J., Bozer Y. and Tanchoco, J.** 2010. *Facilities Planning*, 4th Edition, John Wiley & Sons Inc., Hoboken.

[8]   **Shipping Data**. Date read (2013-07-11). *Random location storage*, http://shipping-data.com/glossary/random-location-storage

[9]   **Pope, E.** Date read (2013-05-24). *A Few Good Statistical Analysis Tools* http://www.idealware.org/blog/few-good-statistical-analysis-tools?page=6