WAREHOUSING STRATEGY:

LIMITS OF THE THEORY OF INVENTORY CENTRALIZATION

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1. General background

According to Slack & *alii* (2004), the most common approach to deciding how much of any particular item to order, when stock needs replenishing, is called the economic order quantity (**EOQ**) approach. This approach, also called **Wilson Model** (1934), attempts to find the best balance between the advantages and disadvantages of holding stock and to minimize the total cost: with low values of order quantity, holding costs are low but the costs of placing orders are high because orders have to be placed very frequently… The sum of holding and order costs is minimized when order quantity is equal to:

$$\sqrt{2 D C_O / C_h}$$

This value, the EOQ (also called Wilson formula), constitutes the optimal quantity. In this formula, **D** represents the **demand** per period of time, C_o is the **cost of placing an order** and C_h the **cost of holding one unit in stock** for a period of time.

By close links with this approach, the **theory of inventory centralization** is based on the Square Root Law (Starr & Miller, 1962 ; Maister, 1976 ; Mc Kinnon, 1989 ; Fernie & Sparks, 2004), which is establishing the global cost from the cost of holding inventories in warehouses. In this case, the **move from ten depots towards a completely centralized system** using only one warehouse **reduces the inventory requirement by 68 per cent** (McKinnon 1989), that is to say exactly:

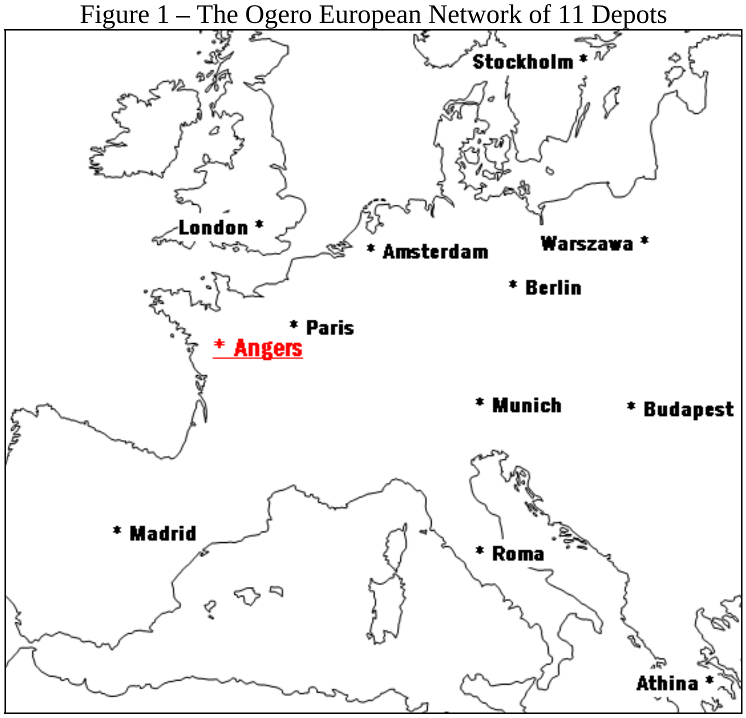
$$[1 / \sqrt{10}] - 1$$

It is the reason why we call it the Square Root Law.

Ogero Company case

For example, we can take the Ogero Company. This is the case of the European distribution of a French **liqueurs manufacturer** located in Angers (France). Initially (before 1995), this producer achieved its deliveries *via* a **network of 11 depots** located close to its customers: Paris, London, Madrid, Amsterdam, Rome, Stockholm, Munich, Berlin, Athens, Budapest and Warsaw. Figure 1 below gives a good idea of these locations which are well distributed throughout Europe.

Figure 1 – The Ogero European Network of 11 Depots



In 1994, the demand of each of the 11 depots was about 800 pallets a year. The cost of holding one pallet in stock for a year (C_h) was about $500 and the cost of placing an order (C_o) about $125.

So, for each depot, the costs to the Ogero Company were as follows:

$$EOQ = \sqrt{2 \text{ x } 800 \text{ x } 125 / 500}$$

EOQ = 20 pallets / order

Total cost = EOQ x C_h

(according to the Wilson Model theory)

Total cost = 20 x 500

Total cost = $10,000 a year per depot

As shown by the Wilson formula, the EOQ gave 20 pallets per order and per depot, that is to say 40 orders a year, a cover of 9 days stock and a **global cost** of about **$110,000 a year for the 11 depots**.

By 1995, Ogero wished to reduce its logistic costs. The company therefore became interested in the **theory of inventory centralization** and has decided to abandon its network of 11 depots in favor of a completely centralized system using **only one warehouse**: a **European Logistics Center** (**ELC**) located in Stuttgart (Germany).

Stuttgart has been chosen as this city was the **center of gravity** of the previous network. At the beginning of the study, Ogero considered locating the ELC in Angers close to its production unit. But, as we can see in Figure 2, the Angers location is too remote to offer optimal distribution over the whole of Europe. This is why Stuttgart was selected.

In 1996, the Stuttgart ELC processed 8,800 pallets, that is to say the same quantity as 1994, where each of the 11 depots processed 800 pallets. This time, the costs to the Ogero Company for the ELC were as follows:

$$EOQ = \sqrt{2 \text{ x } 8{,}800 \text{ x } 125 / 500}$$

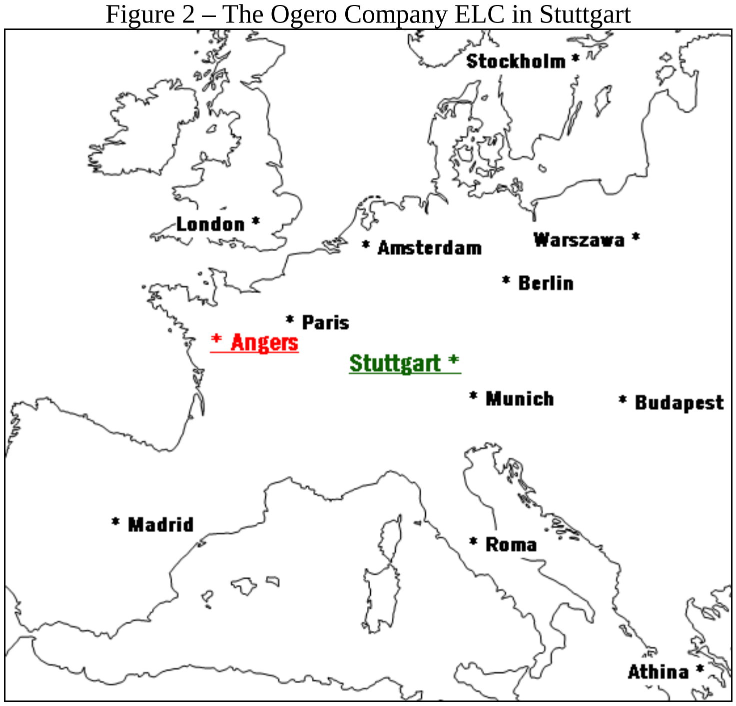
EOQ = 66.33 pallets / order

Total cost = EOQ x C_h

Total cost = 66.33 x 500

Total cost = $33,116 a year

Figure 2 – The Ogero Company ELC in Stuttgart



So, with an EOQ of approximately 66 pallets per order, that is to say a total truckload (TL), the number of orders per year increased to 133 and the cover decreased to less than 3 days stock. Eventually, the implementation of the theory of inventory centralization was generating **savings** of about:

$$\mathbf{[\,1 / \sqrt{11}\;] - 1}$$

that is to say a **70% decrease** ($76,834 a year exactly).

2. Generalisation of the Square Root Law

Keeping the hypothesis of the Square Root Law (C_o and C_h are constant), it is possible to make a generalization of this law: the move from **d depots** towards a more centralized system using **w warehouses** reduces the inventory requirement by:

$$\mathbf{[1 / \sqrt{d / w}\ ] - 1}$$

So, if d is equal to 100 and w is equal to 10, again we get a reduction of 68% (McKinnon 1989). Now, when d is equal 50 and w to 10 the inventory requirement is reduced by:

$$[1 / \sqrt{50 / 10}\ ] - 1$$

that is to say a lower reduction, about 55%.

Finally, when d is equal to 100 and w to 5 the inventory requirement is reduced by:

$$[1 / \sqrt{100 / 5}\ ] - 1$$

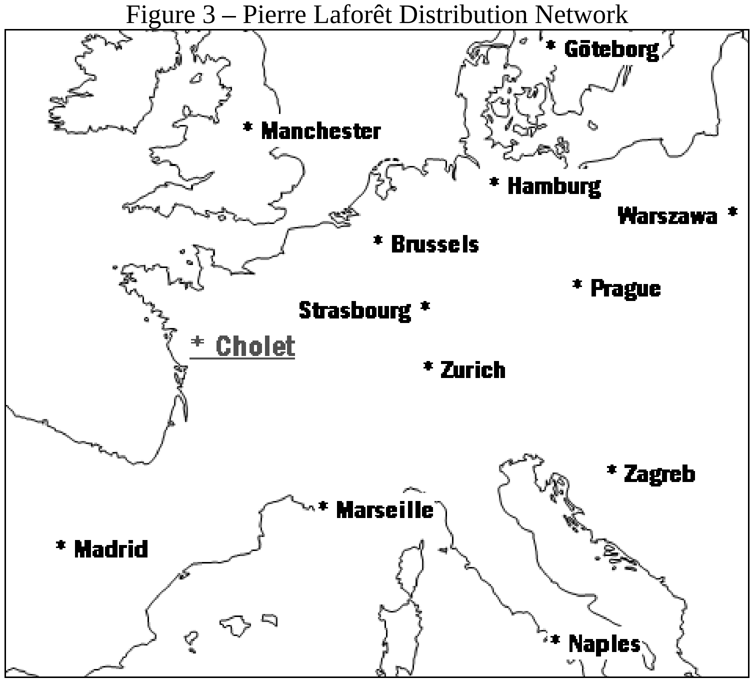
that is to say a higher reduction of about 78%.

Therefore, the savings depend on **the ratio of d : w - the higher this ratio is, the higher the reduction is.**

Pierre Belleforêt Society case

By way of example, we can take the Pierre Belleforêt Society. This is the case of the European distribution of a French **furniture retailer**, whose main suppliers are located near Cholet (France). Initially (before 1997), this retailer achieved its deliveries from the different production units of the Cholet region *via* a **network of 12 depots** located close to its customers: Strasbourg, Marseille, Madrid, Brussels, Manchester, Naples, Göteborg, Zurich, Hamburg, Prague, Zagreb and Warsaw. Figure 3 gives a good idea of these different European locations. Despite the fact that the suppliers organized the transportation from the factories to the depots with the help of a specialized carrier (in order to massify the volumes), the 12 depots belonged on the other hand to Pierre Belleforêt.

Figure 3 – Pierre Laforêt Distribution Network



In 1996, the demand of each of 12 depots was about 48 containers a year. The cost of holding one container in stock for a year (C_h) was about $33,000 and the cost of placing an order (C_o) about $1,375.

So, for each depot, the costs to the Pierre Belleforêt Society were as follows:

$$\text{EOQ} = \sqrt{2 \times 48 \times 1{,}375 / 33{,}000}$$

EOQ = 2 containers / order

Total cost = EOQ x C_h

Total cost = 2 x 33,000

Total cost = $66,000 a year per depot

Then, the EOQ gave 2 containers per order and per depot, that is to say 24 orders a year, a cover of 2 weeks stock, and a **global cost** about **$792,000 a year for the 12 depots**.

Wishing to reduce its logistic costs in 1997, the Pierre Belleforêt Society was also interested in the theory of inventory centralization and decided to go from a network of 12 depots to a more **centralized system using 4 warehouses**, called "**Regional Distribution Centers**" (**RDC**), located in Aix-en-Provence (France), Munich (Germany), Amsterdam (The Netherlands) and Gdansk (Poland). As we can see in Figure 4, these different towns were selected because they were local centers of gravity of the customer's network:

- Aix-en-Provence RDC for Madrid, Marseille and Naples;
- Munich RDC for Prague, Zurich and Zagreb;
- Amsterdam RDC for Brussels, Manchester and Strasbourg;
- Gdansk RDC for Göteborg, Hamburg and Warsaw.

Also, the 12 depots are now completely closed: they have been replaced by only 4 RDC, which still belong to the Pierre BelleForêt Society today.

Since 1998, the furniture manufacturers do not directly deliver any more the 12 depots, but only to 4 RDC's. So, the **inbound transportation cost from factories to the RDC** is always **payable by the suppliers** but is, of course, **less expensive** than the total transportation cost in the previous model applied ten years ago, where each depot was directly delivered to by the manufacturers. This is one of the main reasons why furniture selling prices have decreased. On the other hand, the **outbound transportation cost from the RDC to the consumer** has constituted a **new cost** and is, this time, **payable by the retailer** - the Pierre Belleforêt Society…

In 1998, the four RDC's processed 576 containers altogether (on average 144 containers per RDC), that is to say the same quantity as in 1996 where each of the 12 depots processed 48 containers. This time, the costs to the Pierre Belleforêt Society for each RDC were as follows:

$$EOQ = \sqrt{2 \text{ x } 144 \text{ x } 1{,}375 / 33{,}000}$$

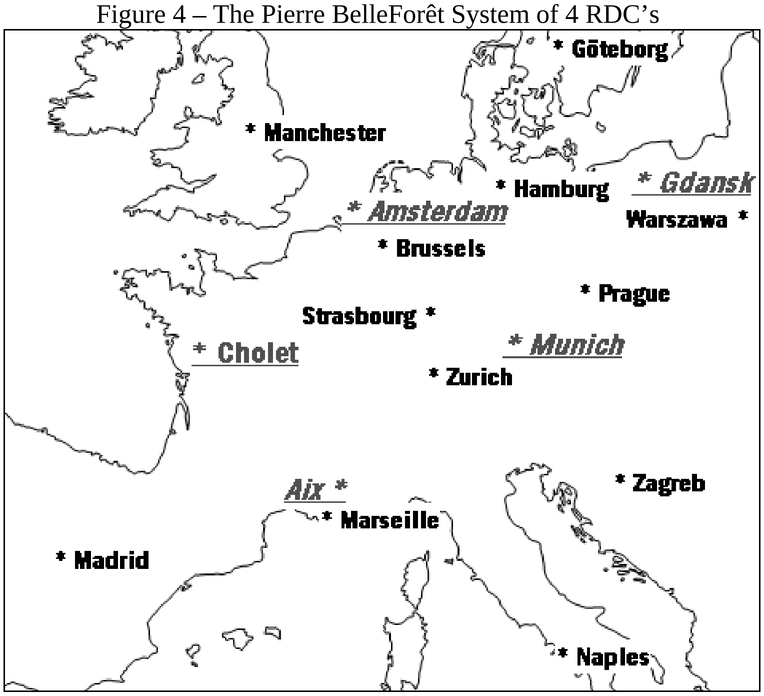
EOQ = 3.46 containers / order

Total cost = EOQ x C_h

Total cost = 3.46 x 33,000

Total cost = $114,315 a year per RDC

Figure 4 – The Pierre BelleForêt System of 4 RDC's



With an EOQ of about 3.5 containers per order and per RDC, the number of orders per year increased to 42 and the cover decreased to less than 9 days stock. Eventually, the **global cost** was reduced to about **$457,261 a year for the 4 RDC's**, which proved again that the implementation of the theory of inventory centralization was generating **savings** of about $\mathbf{[\ 1\ /\ \sqrt{12/4}\ \ ]-1}$, that is to say roughly a **42% reduction** ($334,739 a year exactly).

3. Managerial perspectives : the limits of the Square Root Law

The **theory of inventory centralization** is at the moment somewhat **questioned**. Indeed, as we can see with the Pierre Belleforêt Society case, the outbound transportation cost is now payable by the retailer. If the manufacturers have well reduced the product's selling price (because their transportation costs have decreased), **nothing proves that the saving is great enough**… Moreover, the costs of transportation are increasing, particularly with the regular increases in petroleum prices… So, this is why **stocks could be redistributed** (and therefore less centralized) over different sites…

So, if the hypothesis of a constant C_h (holding cost) does not constitute a problem, one could not say the same for the **hypothesis of a constant C_o** (order cost)… This is why, through this research forum, we question the Square Root Law: "**C_o cannot be considered any more as a constant data** in different scenarios". In fact, **C_o depends on the number of sites**. On this point, there is a known trade-off between warehousing and transportation: **as the number of sites is high, the cost of operating them is also high, but the outbound transportation operating cost is low**, because the different sites are close to the customers, and *vice versa* (Cooper & *alii*, 1991).

For that, we can consider two scenarios. In the first scenario (d depots), the order cost is less than the order cost of the second scenario (w warehouses), which includes the outbound transportation from the RDC to the customers. So, the order costs of the two scenarios are not equal as in the traditional model of the Square Root Law, because **transportation between warehouses and final customers constitute a new cost** which is **payable by the retailer**.

The order cost of the decentralized system (d depots) is called "$\mathbf{C_{o\ d}}$" and the order cost of the more centralized system (w warehouses) is called "$\mathbf{C_{o\ w}}$". Our research proves that:

$$\mathbf{if\ C_{o\ w} > (d / w) \times C_{o\ d}}$$

the theory of the Square Root Law could be questioned, if the reduction in selling prices is slack.

If D is equal to 12,000 units a year, d to 50 depots, w to 10 warehouses, C_h to \$60 per unit for a year, and $C_{o\ d}$ to \$450 per order, then $C_{o\ w}$ cannot be greater than \$2,250 per order, that is to say:

$$(50 / 10) \times 450$$

otherwise the Square Root Law could be questioned, if the reduction in selling prices is slack…

Revised Pierre Belleforêt Society case

By way of example, we can take again the Pierre Belleforêt Society case, through the European distribution of a French furniture retailer. **Before 1997**, this distributor achieved its deliveries *via* a **network of 12 depots** located close to its customers. At first, the EOQ gave 2 containers per order and per depot, and a **global cost** about **\$792,000 a year**.

Wishing to reduce its logistic costs, Pierre Belleforêt was interested in the theory of inventory centralization and decided to go from a network of 12 depots to a more centralized **system only using 4 RDC's**, located in France, Germany, The Netherlands and Poland. So in 1998, the EOQ gave 3.5 containers per order and per RDC, and a **global cost** about **\$457,261 a year**, that is to say roughly a **42% reduction**.

In 2005, Pierre Belleforêt Society realized that because of the increase in transportation costs, the firm had to **differentiate** $\mathbf{C_{o\ w}}$, the order cost of the 4 RDC's system, **from** $\mathbf{C_{o\ d}}$, the order cost of the original network of 12 depots. So, for 2005, the furniture demand was about 200 containers a year per RDC, and the Pierre Belleforêt Society estimated that $\mathbf{C_{o\ w}}$ was equal to **$2,000 per order** and that C_h was about $32,000 per container for a year. Then, the costs were as follows:

$$EOQ = \sqrt{2 \times 200 \times 2{,}000 / 32{,}000}$$

EOQ = 5 containers / order
Total cost = EOQ x C_h
Total cost = 5 x 32,000
Total cost = $160,000 a year per RDC

With an EOQ of about 5 containers per order and per RDC, the number of orders a year was equal to 40 and the cover became 9 days stock. In the end, the **global 2005 cost** was estimated to be **$640,000 for the 4 RDC's**.

But, if the Pierre Belleforêt Society had kept its **original network of 12 depots** (as they had before 1997), the demand would have been about 67 containers a year per depot. Considering the **transportation cost coverage by the manufacturers**, Pierre Belleforêt estimates that $\mathbf{C_{o\ d}}$ would only be equal to **$540 per order**. There would be no change in the C_h (that is to say $32,000 per container for a year). So, the costs would have been as follows:

$$EOQ = \sqrt{2 \times 67 \times 540 / 32{,}000}$$

EOQ = 1.5 containers / order
Total cost = EOQ x C_h
Total cost = 1.5 x 32,000
Total cost = $48,000 a year per depot

With an EOQ of about 1.5 containers per order and per depot, the number of orders a year would have increased to 45 and the cover would have decreased to 8 days stock. In the end, the **global 2005 cost** was **estimated to be $576,000 for the 12 depots**.

In this case, we can see that the **the Square Root Law can be questioned**. Indeed, if we **differentiate** $\mathbf{C_{o\ w}}$ **from** $\mathbf{C_{o\ d}}$, the **global**

cost of the 4 RDC system was equal to **$640,000 a year** and the **global cost of the 12 depots system** would have been estimated to be **$576,000 a year**, that is to say a **10% saving** ($64,000 a year exactly). Therefore, **the original network of 12 depots would have been the best way of minimizing the global cost**. But, this is true conditionally…

Conclusion

The **theory of inventory centralization** is at the moment somewhat **questioned**. Indeed, as we could see with the Pierre Belleforêt Society case, the outbound transportation cost is payable by the retailer. If the manufacturers have well reduced the product's selling price (because their transportation cost has decreased), **nothing proves that the saving is great enough**…

In Pierre Belleforêt Society case, for example, we see that the original system of 12 depots was better than the more centralized system of only 4 RDC's, as it would have generated a 10% saving. Now, we have to clarify that, in the more centralized system, **the selling price by the manufacturers** to Pierre Belleforêt Society **has decreased by about 1%** because the transportation cost payable by the furniture producer has decreased. But, the **total 2005 turnover** achieved by these **manufacturers** would have reached **$5.5 million** before the **selling price reduction**, estimated at about **$55,000**. So, this **saving** is **less than the $64,000 saving** achieved by the 12 depot system over the 4 RDC's system. Therefore, with a $9,000 advantage, the **depot network remains the best way for optimizing the distribution**. So, **the theory of inventory centralization has reached its limits**…

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