“Advances in Continuous Replenishment Systems”

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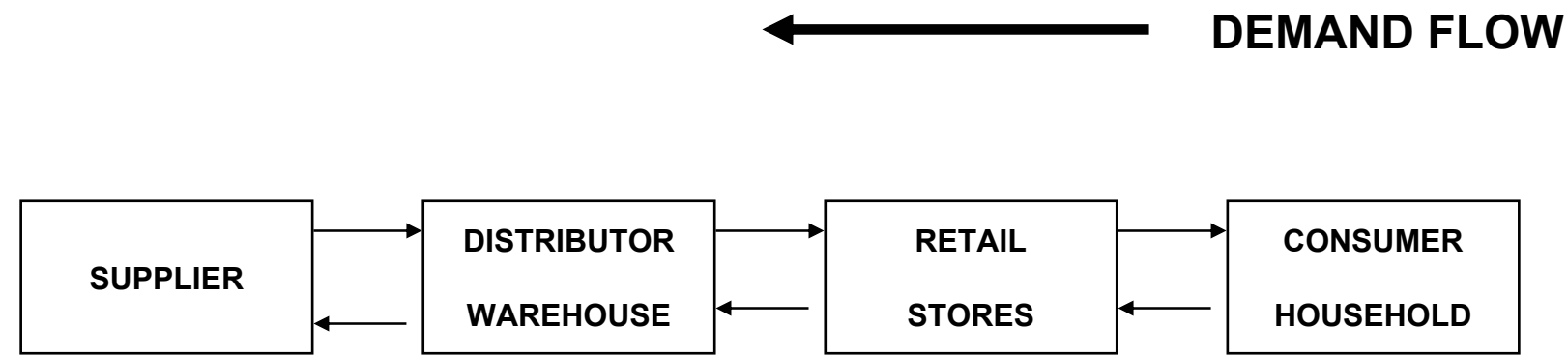
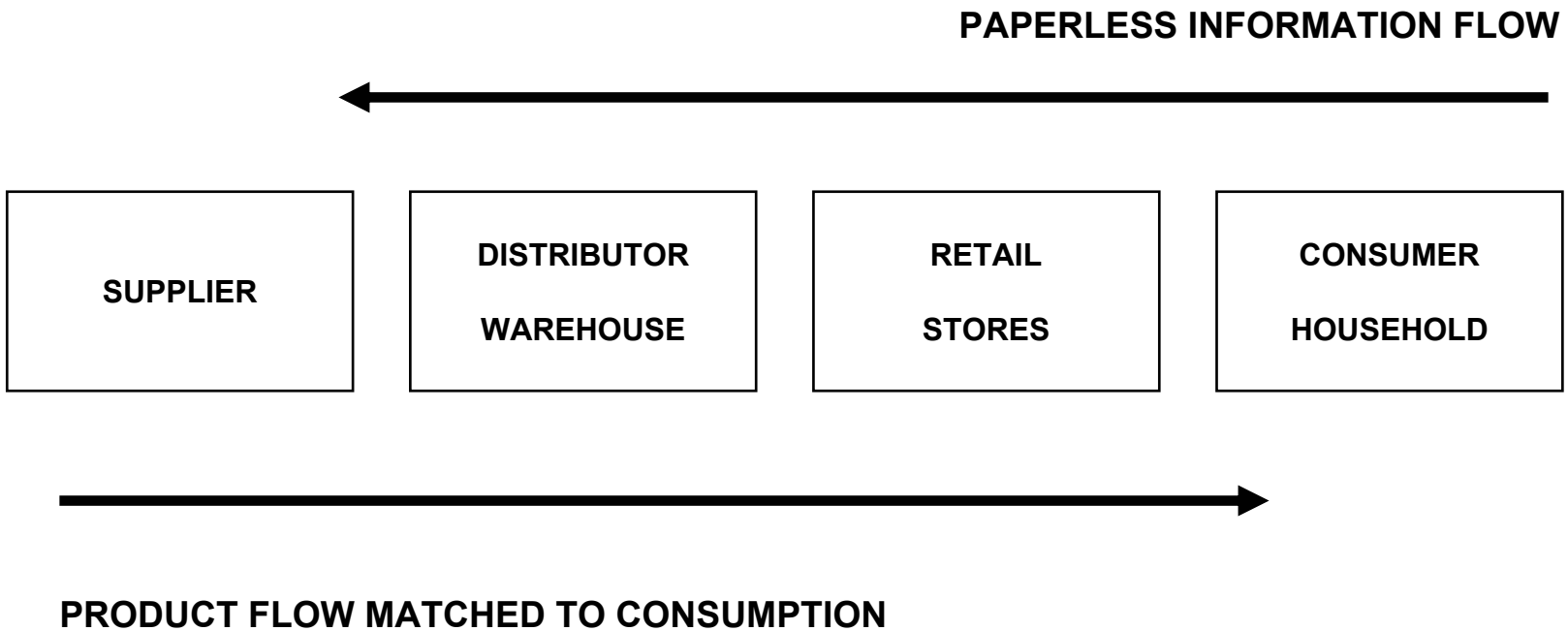
TRADITIONAL REPLENISHMENT SYSTEM



THE FUTURE


PAPERLESS INFORMATION FLOW
SUPPLIER
DISTRIBUTOR
WAREHOUSE
RETAIL
STORES
CONSUMER
HOUSEHOLD
PRODUCT FLOW MATCHED TO CONSUMPTION

Continuous Replenishment Systems

- One cycle re-point point
- Some systems use DRP methodology
- Dynamic re-order point
- Simple logic
- Require “extra” work

Forecasting Customer Demand

- Use live data on customer withdrawals
- Focused forecasting (best fit from moving average, exponential smoothing, Holt's method and history)
- Time series methods lag the trend
- forecast bias causes a problem
- See Krupp, J.A.G., 1982, "Effective Safety Stock Planning," *P&IM*, Third Quarter.

Advanced Forecasting Methods

- Box-Jenkins
- Complexity of model must be justified
- Neural networks enhance time series methods
- L.L. Bean (see Andrews and Cunningham, 1995)

HIERARCHY OF PRODUCTION DECISIONS

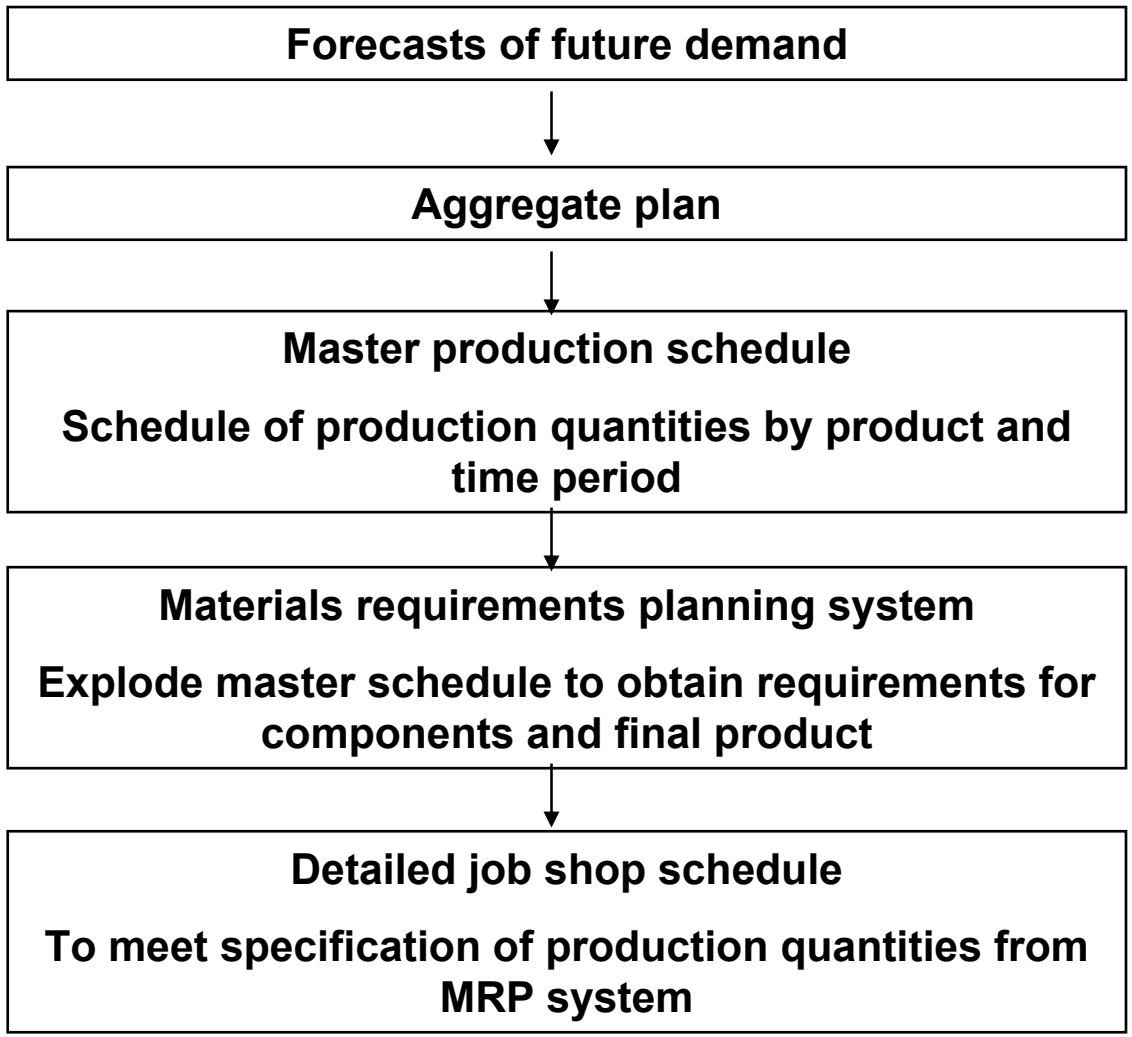
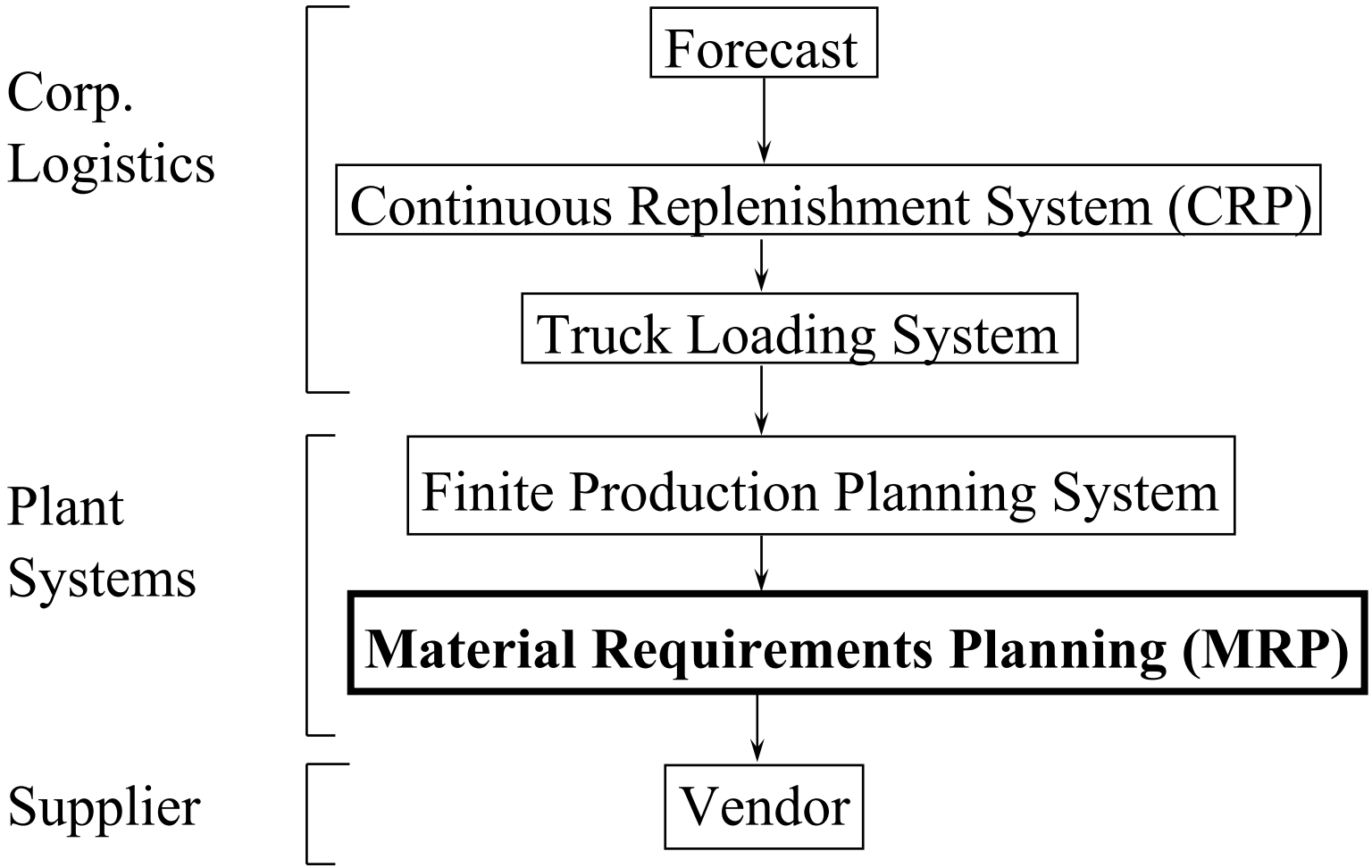


FIGURE 1

The Supply Chain Model



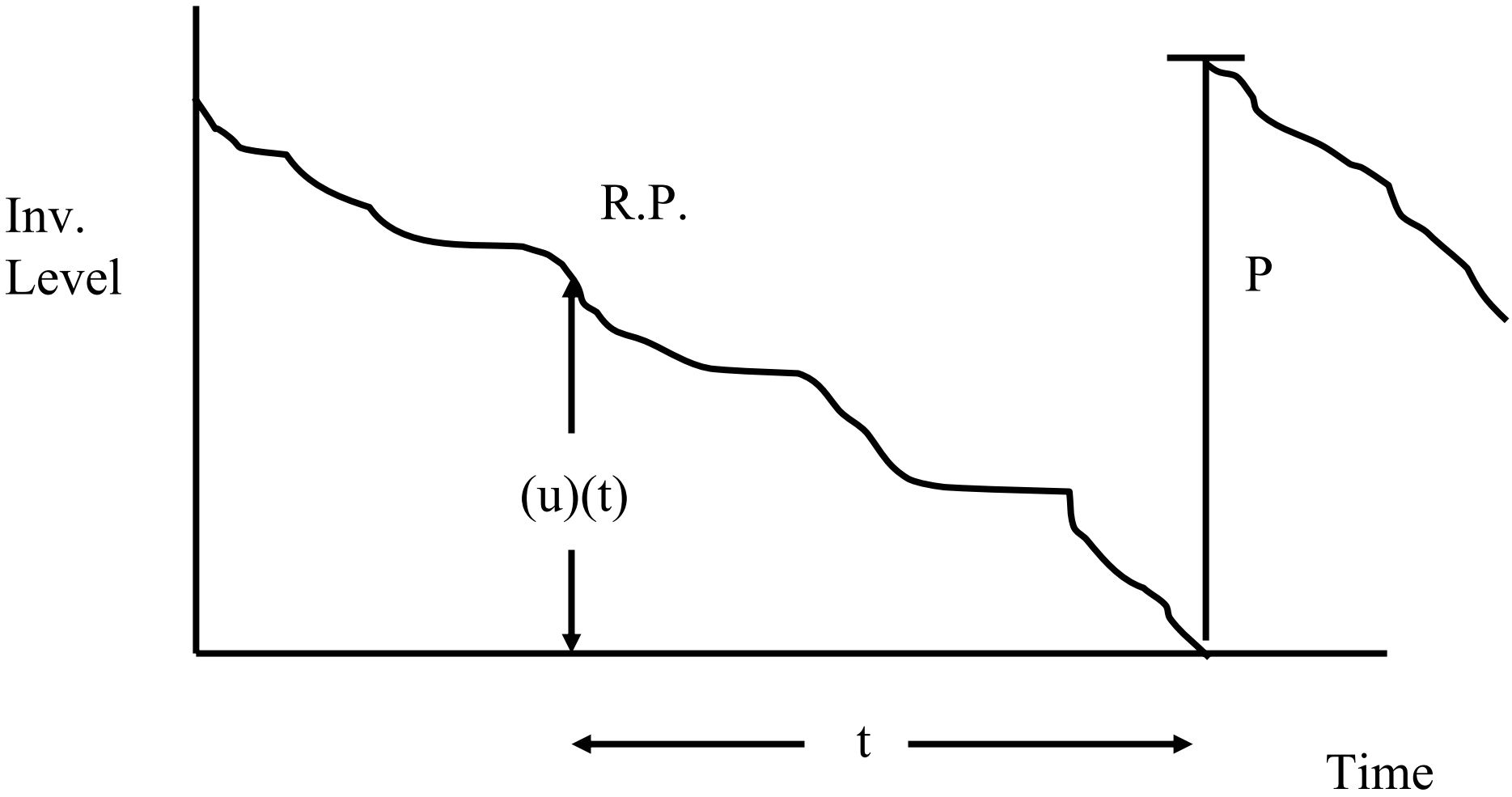
Supply Chain Dynamics

- Production planning and scheduling
- Lot sizing
- MRP
- Continuous Replenishment Systems
- System Dynamics (the “beer game” and MIT)
- “Fits and Starts”

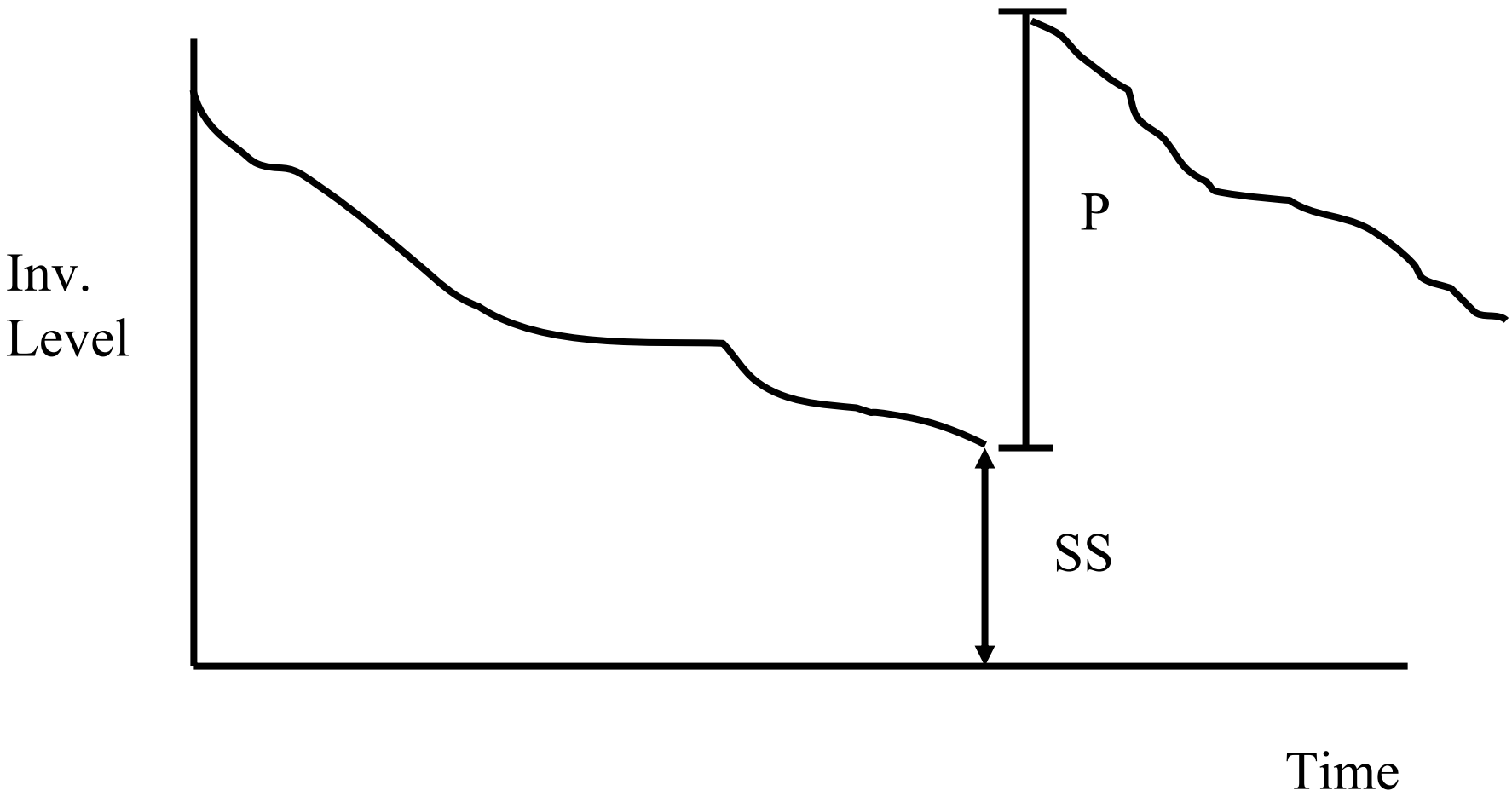
The Supply Chain Model

- Characterized by dynamic inventory swings
- Inventory swings often dramatic
- “System Dynamics” (see Sterman, 1992)
- Minimize deviations in the supply chain
- A mix of models may prove the best solution to this problem (see Cleaves and Masch, 1996)

R.P. Without Safety Stock



R.P. With Safety Stock



The Truck Loading Problem

- Provide an even run-out of all sku's in a customers warehouse
- Reduce air weight
- Enhance plant warehouse efficiency

Step 1. When a single SKU at a customer warehouse drops below its re-order point, start procedure.

Step 2. For each SKU in the customers warehouse, net existing inventory from the daily demand forecast.

Step 3. After netting out inventory, convert into weight per day for each SKU.

Step 4. Sum the weight per day for all SKU's to get a total weight per day

Step 5. Calculate the cumulative weight per day. When cumulative weight per day is just shy of a full truck load, stop

Decision Variable:

x(i) = number of layers of product i

Constants:

w(i) = weight per layer for SKU i
(pounds/layer)

c(i) = total weight of SKU corresponding to run-out calculated in step 5 (pounds)

t = total weight of order (pounds)

An Example From Welch's CRP System

Step 1 - Assuming a SKU has dropped below its re-order point, we move to step 2

Step 2 - Table 1 shows beginning inventory netted against forecast

Step 3 - Table 2 converts case forecast (Table 1) into weight per SKU, per day

Step 4 - At the bottom of Table 2, we sum the weight per day for all products

TABLE 1 - Forecast Netted for Inventory (all values in cases)

Product Code	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13
4180021100	0	0	0	0	0	0	0	0	0	0	15	15	15
4180022800	0	0	0	0	7	7	7	6	6	6	6	6	6
4180022900	0	0	0	0	0	0	0	0	0	0	0	18	18
4180050200	0	0	0	0	0	0	0	0	0	0	0	0	5
4180050300	0	0	0	0	0	0	0	7	7	7	7	7	7
4180050500	0	0	0	0	0	0	0	0	0	0	0	6	6
4180050701	0	0	0	0	0	0	0	0	0	0	3	3	3
4180055200	0	0	0	0	0	0	0	0	0	0	0	14	14
4180055300	0	0	0	0	0	0	0	0	0	0	0	3	3
4180056300	0	0	0	0	0	0	0	0	0	0	0	4	4
4180070500	0	0	0	0	0	0	0	0	0	0	0	14	14
4180010300	0	0	0	0	0	0	21	20	20	20	20	20	20
4180010900	0	0	0	0	0	0	0	0	32	32	32	32	32
4180011500	0	0	0	0	0	0	60	54	54	54	54	54	54
4180011600	0	0	0	0	0	0	0	40	40	40	40	40	40
4180011700	0	0	0	0	0	0	0	52	52	52	52	52	52
4180011900	0	0	0	0	0	0	0	0	65	65	65	65	65
4180012800	0	0	0	0	0	0	0	0	17	17	17	17	17
4180013300	0	0	0	0	0	0	0	0	0	0	54	54	54
4180013500	0	0	0	0	0	0	0	0	0	61	61	61	61
4180013600	0	0	0	0	0	0	0	0	52	52	52	52	52
4180014000	0	0	0	0	0	0	0	47	47	47	47	47	47
4180014500	0	0	0	0	0	0	0	0	20	20	20	20	20
4180015000	0	0	0	0	0	0	0	0	19	19	19	19	19
4180015100	0	0	0	0	0	0	0	0	0	0	0	9	9
4180018100	0	0	0	0	0	0	0	15	15	15	15	15	15
4180018200	0	0	0	0	0	0	0	17	17	17	17	17	17

TABLE 2 - Accumulated Weight Per Day (all values in pounds)

Product Code	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Cumulated Weight Per Product (12 Days)
4180021100	0	0	0	0	0	0	0	0	0	0	593	593	593	1185
4180022800	0	0	0	0	330	330	330	243	243	243	243	243	243	2204
4180022900	0	0	0	0	0	0	0	0	0	0	0	708	708	708
4180050200	0	0	0	0	0	0	0	0	0	0	0	0	157	0
4180050300	0	0	0	0	0	0	0	88	88	88	88	88	88	442
4180050500	0	0	0	0	0	0	0	0	0	0	0	128	128	128
4180050701	0	0	0	0	0	0	0	0	0	0	61	61	61	121
4180055200	0	0	0	0	0	0	0	0	0	0	0	468	468	468
4180055300	0	0	0	0	0	0	0	0	0	0	0	42	42	42
4180056300	0	0	0	0	0	0	0	0	0	0	0	46	46	46
4180070500	0	0	0	0	0	0	0	0	0	0	0	531	531	531
4180010300	0	0	0	0	0	0	526	489	489	489	489	489	489	2970
4180010900	0	0	0	0	0	0	0	0	417	417	417	417	417	1666
4180011500	0	0	0	0	0	0	751	675	675	675	675	675	675	4124
4180011600	0	0	0	0	0	0	0	521	521	521	521	521	521	2603
4180011700	0	0	0	0	0	0	0	650	650	650	650	650	650	3251
4180011900	0	0	0	0	0	0	0	0	817	817	817	817	817	3270
4180012800	0	0	0	0	0	0	0	0	215	215	215	215	215	861
4180013300	0	0	0	0	0	0	0	0	0	0	676	676	676	1352
4180013500	0	0	0	0	0	0	0	0	0	757	757	757	757	2271
4180013600	0	0	0	0	0	0	0	0	645	645	645	645	645	2582
4180014000	0	0	0	0	0	0	0	585	585	585	585	585	585	2925
4180014500	0	0	0	0	0	0	0	0	503	503	503	503	503	2013
4180015000	0	0	0	0	0	0	0	0	208	208	208	208	208	832
4180015100	0	0	0	0	0	0	0	0	0	0	0	99	99	99
4180018100	0	0	0	0	0	0	0	198	198	198	198	198	198	988
4180018200	0	0	0	0	0	0	0	222	222	222	222	222	222	1112
Total Wt./Day	0	0	0	0	330	330	1607	3670	6476	7233	8562	10584	10741	38793
Cumulated	0	0	0	0	330	660	2267	5937	12413	19647	28209	38793	49534	

Step 5 - As the cumulative weight per day approaches 44,500 pounds we stop. In the example this occurs at day 12. At this stage, all products have an equal run out, but we are just shy of filling the truck (at day 12, cumulative weight equals 38,793 pounds, at day 13 the cumulative weight is 49,534). We also do not have each product rounded to even case layers.

Step 6 - The total weight for each SKU found in step 5 becomes c(i). By solving the IP, we find the number of layers for each item that results in a truck weight as close to 44,500 pounds as possible.

The solution equals 44,483 pounds.

Improvements to CRP Software

- Time phased future orders (DRP)
- Better methods to plan safety stock
- Insure even run-outs for each sku in a customers warehouse
- Truck loading methods