OPIM (Process Management) – Overview of Situational Models

Course Theme: Better Matching of Supply and Demand Yields Competitive Advantage

Model	Key Formulas	Points of Note
Newsvendor Cases: ▪ O'Neil ▪ Lands End	Expected Lost Sales = σ * L(Z) Expected Sales = μ – Expected Lost Sales Expected Left Over Inventory = Q – Expected Sales Expected Π = (C_U * Expected Sales) – (C_O * Expected Leftover Inventory) Expected GM % = 1 – (Cost / Expected Revenue) ▪ Expected Revenue = (P*Expected Sales) + (V * L/O inventory) ▪ Cost = C * Q Expected Fill Rate = Expected Sales / Expected Demand (μ) In-Stock Prob = F(Q) (~ distribution function) Out of Stock Probability = 1-F(Q) [i.e., 1- in stock probability]	***use when*** – only one production / procurement opp. - short sales season w/ uncertain demand - single order opportunity before season starts - left over inventory is salvaged below cost - **unmet demand is lost** ***key steps for profit maximizing order Q*** – **i)** gather financial inputs (data) **ii)** generate demand model / forecast (choose distribution function) - source – history, opinions, etc **iii)** choose objective (~ maximize Π) **iv)** choose order Q to achieve objective ***Process (if NOT normal distribution)*** - 1) find & rank A/F ratios in ascending order - 2) calculate empirical distribution [F(A/F) = % = rank / total # AF ratios] - 3) match critical ratio to A/F distribution % - 4) Q = Forecast * matched A/F ratio ***Process (if normal distribution)*** - 1) Expected A/F ratio = avg of all A/F ratios - 2) σ of A/F ratio = σ of all ratios - 3) Expected Actual Demand = E(A/F) * Forecast - 4) Expected σ = σ of A/F ration * Forecast - 5) find Z based on critical ratio - 6) Q = E(Actual Demand) + [E(σ) * Z]

Model	Key Formulas	Points of Note
Make / Assemble to Order **(Quick Response w/ Reactive Capacity)** Cases: ▪ Dell ▪ Nat'l Bicycle	Mismatch Cost ▪ = (C_O * Expected L/O inventory) + (C_U * Expected Lost Sales) ▪ = Maximum Π – Expected Π ▪ caused by demand uncertainty at time of order Maximum Π = (P-C) * μ Mismatch Tax Rate = [f(Z) / F(Z)] * (σ / μ) ○ *is higher as critical ratio is smaller* ○ *is higher if COV is higher (b/c demand less predictable)*	***use when*** – justified by high mismatch costs **AND**… Assemble to Order (Dell) - customers know what they want - customers are willing to wait - labor is small component of total cost (~ assembly is fast / easy ~ modular design) - inventory is expensive to hold (high carrying cost, short product life cycle, component P deflation Mass Customization (Nat'l Bicycle) - customer willing to pay more (fit is important) - large variety and high demand / supply mismatch cost - low incremental labor content for customization - e.g., bikes, PCs, apparel, windows ***Key to success*** = operational efficiency
Reactive Capacity Case: ▪ Sport Obermeyer	C_O = same as Newsvendor C_U = premium paid for not ordering in earlier round Initial Order = Newsvendor's Optimal Order Q Maximum Π – see Newsvendor Expected Π = Maximum Π – (C_O * Expected L/O inventory) - (C_U * Expected Lost Sales) Expected Replenishment Q = Newsvendor's Expected Lost Sales	***use when*** – have ability to make 2^{nd} replenishment ***Assumptions*** - don't stock out before second replenishment + after observe initial sales → can predict Demand perfectly (may be close to true depending on historical results) + order once constraint for each product (ensures firm can get above - and can ignore - the minimum order Q in replenishment) ***1^{st} Order*** = items w/ lowest mismatch quantity ratio (~ mismatch cost / Q)
Centralized Inventory ▪ Amazon		***use when*** – following factor(s) are present . . . - customers willing to wait for product - idle capacity is inexpensive (so as to minimize customer wait time) - location pooling benefits can be captured

Model	Key Formulas	Points of Note
Order up to Model Case: ▪ Medtronic	Order Quantity per period = **S – Inventory position** ▪ = last period's demand Expected λ = **(£ + 1) * μ per period** σ of λ = **$(£ + 1)^{0.5}$ * σ per period** In-stock Probability **= Prob [λ ≤ S]** ▪ = 1- Stock-out Probability ▪ Probability = Poisson (S, λ, 1) → see table ▪ Expected demand over (£+1) periods = λ = (£+1) * μ demand per period Stock-Out Probability **= 1-Prob [λ ≤ S] = Prob [λ > S]** ▪ *works better if service level target is high (~ stock outs are rare)* Expected Backorder$_{EOP}$ - if λ > S → **= λ - S** ▪ = [λ – S] + sum$_{S-1}$ [prob (λ ≤ (S-1)] ▪ = σ * L(z) ~ expected NV lost sales ▪ for Poisson Distribution → look up in Poisson table for Expected λ Expected Fill Rate**= 1 – [E (B/O) / E (D for one Period)]** ▪ ignore S = 0 → F/R of 100% is unreasonable ▪ theory ~ # of 1 period customers = μ in one period → # customers not served in period = E(B/O) → [E(B/O) / E(Demand)] = fraction of customers not served → 1-[E(B/O) / E(Demand)] = fraction of customers that are served ▪ remember – lead time influences number of customers not served (numerator) / does not influence demand in one period (denominator) Expected Inventory$_{EOP}$ **= S – λ + E(B/O)** [cf pg. 31] ▪ if S > λ → = S – λ ▪ @ BoP = E(D in one period) + E(inventory)$_{EOP}$ ▪ @ Random pt = [E(Demand in one period) / 2] + E(inventory)$_{EOP}$ Expected on-order inventory **= E (D for one period) * £** ▪ = pipeline inventory ▪ cf Little's Law ~ Inventory = FR * FT ▪ excludes inventory sitting in central warehouse Cost minimizing order Q – satisfies → **Prob (λ ≤ S) = C_U / (C_O + C_U) = b / (h+b)** Optimal In-Stock prob = critical ratio	***use when*** – need to minimize inventory costs while maintaining very high service target - long sales season / life cycle products - random demand BUT multiple replenishment opportunities - left over inventory is carried to next period - **unmet demand is backlogged (NOT lost)** ***Assumes*** – demand is random + same demand distribution applies in all periods + replenishment is at beginning of period (before any demand) + order always received in £ periods + no limit to Q + no obsolescence in inventory + all demand is filled eventually + all unmet Demand is backordered + no seasonality in Demand [expected demand (μ) is same for all periods] ***Key Terms*** ▪ period ~ an order interval (assume all are same) ▪ λ = Demand over (£+1) periods ▪ lead time = £ ~ number of periods required to receive orders (~ matches frequency in which orders can be made/orders received) ▪ backorders = negative on-hand inventory ○ ~ when demand arises and no units in current inventory ○ caused by – excess demand over short time (temp supply / demand imbalance) ○ causes a stock out (see below) ▪ inventory position = on-order inv. + on-hand inv. ▪ inventory on-order ~ ordered in prior periods but not received (may be 0, negative only if returning inv) ▪ inventory on-hand = S – [μ (£+1)) ○ = order up to level - expected avg demand over (lead time + 1) ○ = units in inventory - backorders ▪ order up to level = S = base stock level ○ ~ max # units willing to have (on-hand + on order) = BoP inventory ▪ Poisson distribution – defined by mean (not σ); BUT σ = $(\mu)^{0.5}$ ▪ stock out → arises if both (a) out of stock and (b) demand arrives (→ if at least 1 backorder) ▪ out of stock – when have no inventory on-hand ▪ in stock – if inventory available to meet all demand

Model	Key Formulas	Points of Note
Risk Pooling Cases: • Medtronic • O'neill • Amazon	Days of Demand in inventory = **Expected Inventory (in units) / pooled territory's expected daily demand** ▪ *should go down (while in-stock prob remains same) as more territories are location pooled* ***Assuming*** – product Demand is independent and pooled products have same distribution (same μ and σ) → ▪ $\mu_{\text{pooled products}}$ = # pooled products * $\mu_{\text{independent}}$ ▪ $\sigma_{\text{universal}}$ = (# pooled products)$^{1/2}$ * $\sigma_{\text{independent}}$ ▪ Q* universal = $\mu_{\text{universal}} + \sigma_{\text{universal}}$ * (z statistic) ▪ CoV of Pooled Demand = [σ / μ] * [0.5 * (1+correlation)]$^{1/2}$ ▪ All other formulas - the same as Newsvendor.	**Use when** – generally use risk pooling when . . . - can redesign the supply chain to reduce or hedge demand uncertainty - total demand uncertainty is lower than of individual products ***Key Concepts*** ▪ Location pooling **–** reduction in the number of stocking points (~ pull back from reps) ○ no impact on pipeline inventory ○ reduces D uncertainty b/c reduces CoV ○ most benefit captured w/ few territories ○ BUT moves inv away from customers + reps lose efficiency + storage / spoilage ○ Alts ~ virtual pooling + drop shipping ▪ Product pooling **–** universal product design ○ **use when** – consumers need similar functionality + not expensive to combine functionality in one product + using fewer parts lowers cost by increasing parts' EoS + brand / P segmentation not needed ○ main bene if CoV of pooled product < CoV of individual products ○ lower CoV = only if D for products is independent ○ negative correlation in D lowers $\text{CoV}_{\text{pooled}}$ ▪ Lead time pooling ~ consists of either ○ centralized inventory w/ DC ▪ more effective if ~ Ds are negatively correlated + supplier £ ~ long & DC £~ short ▪ maxes ability to get quantity discounts ▪ better access to EoS in transport ▪ BUT increases total £ & adds pipeline inv. b/w DC & stores ○ delayed differentiation – stocking generics + differentiate @ sale time ▪ same π as product pooling ▪ **use when** – customers demand variety + less uncertainty re total demand than product demand + variety c/b made late in process + variety c/b added quickly & cheaply relative to generic ▪ Capacity pooling **–** flexible manufacturing ○ **use when** – capacity ~ E(Demand) + capacity is neither very hi or low + flexibility is cheap relative to capacity ○ increases capacity utilization & E(sales) ○ 20 links ~ as good as total flexibility ○ flexibility maximized thru long chains ○ BUT if flexibility = expensive → add cap

Model	Key Formulas	Points of Note
Revenue Management <u>Case:</u> • Hyatt	<u>Overage Penalty</u> = C_O * L/O Inventory ▪ $C_O = r_L$ <u>Underage Penalty</u> = C_U * lost sales ▪ $C_U = r_H - r_L$ <u>Optimal Protection Level</u> → F(Q*) = critical ratio ▪ critical ratio = $C_U / C_U + C_O = r_h - r_l / r_h$ <u>Optimal Low Fare Limit</u> = Total – Q* <u>Expected Revenue</u> = (r_h * Expected Sales) + (r_l * Q*) <u>All other formulas</u> = the same as Newsvendor.	**Use when –** when supply is fixed and you want to change demand to meet supply - when can segment high / low pay customers - when can limit customers buying at low P - rigid and perishable resource or capacity - decision is made before D uncertainty resolved - same unit of resource c/b used for different segments - acceptable to discriminate b/w customers ***Goal*** – max rev by controlling # sold at low P ***Key Terms*** - booking limit – number willing to sell at low P - protection limit – number reserved for high P ***Reality*** – no shows + cancellations + no penalty for full fare customers ***Solution*** – sell more seats / rooms than capacity
Supply Chain Coordination <u>Case:</u> ▪ Video Vault	<u>All formulas</u> = the same as Newsvendor.	**Use when –** when profit can be increased with different supply chain management ***Key Pts*** ▪ optimal Q → MR = MC ▪ goal = grow pie for all ▪ issues – monitoring costs + supplier π becomes variable & delayed + diversion risk costs π + reduces retailer incentive to increase sales ▪ double marginalization – issue is how to max total π of two independent parties in a chain when they have different motivations ○ <u>incentive misalignment</u> - makes supply chain inefficient ○ <u>issue</u> – retailer sets Q ○ <u>solution</u> – = coordination → supplier incentivizes retailer to order the chain's optimal Q (Q discount + rev / π sharing + buy back K + supplier managed inventory)
Reducing Demand Uncertainty <u>Case</u> ▪ HP		**Use when –** need to reduce inventory while maintaining service level ***Issue*** – Inventory mgmt as sales increase ***Solutions*** – ▪ reduce service commitment ▪ reduce lead times / cycle times (~ Kanban, local, air ship) ▪ reduce uncertainty (~ improve forecasts) → delayed differentiation allows pooling bene