1 Inventory has been described as both 'dead material' and a 'substitute for information'.

(a) What is the role of inventory in manufacturing systems?

[30%]

(b) In order to calculate the cost of holding inventory, which costs would you consider?

[10%]

(c) How would you go about reducing inventory? Justify your approach.

[20%]

(d) Just-in-Time manufacturing was initially often described as 'Zero Inventory Production'. Discuss to what extent you agree or disagree with this description.

[15%]

(e) Briefly describe any ordering policy you consider suitable for C-parts. Justify your choice.

[15%]

(f) Briefly outline the impact of variability on the throughput time of a process.

[10%]

Model answer:

a. Inventory has two main functions: as cycle and as buffer stock.
As cycle stock it is required to maintain throughput (Little's Law). Here, the throughput rate and the process lead-time determine the minimum stock required.
As buffer stock is buffers against uncertainty (supply, throughput, demand). Here it provides additional cover against unforeseen events, and thus ensures supply

- Supply: here raw material/component inventory provides cover against unreliable or poor quality suppliers
- Throughput: here WIP provides cover against breakdowns
- Demand: Inventory can also serve as a "response buffer" at FGI level

As such, inventory is needed to maintain any operation, however, the amount of additional buffer needed is largely a function of the uncertainty the system faces.

b. The following costs should be considered:

- Cost of capital (opportunity cost)
- Depreciation and obsolescence
- Quality degradation
- Handling and storage
- Insurance

c. The general points that should be made are:

- Inventory is generally there for a reason, namely to cover against uncertainty
- Furthermore there is a minimum amount of WIP needed to allow for the flow (Little's Law)
- Thus if one were to reduce inventory rapidly, one would expose problems quickly, and most likely start a cycle of fire-fighting. Instead the inventory level needs to be gradually reduced, in order to expose the problem, solve it, before reducing inventory further.
- A good model to discuss how best to reduce inventory is the "rock-boat-analogy"

d. "Zero" inventories is of course a misnomer, as kanban system in JIT require small amounts of inventory to "pull" from. These are called "kanban supermarkets". However, in comparison to traditional batch-and-queue production systems, JIT will hold far less inventory due to small batch sizes and frequent replenishment. This created the impression of "zero" inventory.

e. Any reordering policy (s,Q; s,S; R, S; R,s,S; etc) would be applicable here. The key aspect is to automate the replenishment, based on actual consumption.

f. Variability has the main impact of lengthening the wait time, either through variation in service time, or in arrival time. Good students will recite the Kingman Formula for G/G/1 queues here.

2 Manufacturing and service operations generally follow several distinct forms.

(a) Why is this the case? Use diagrams to illustrate your arguments.

[30%]

(b) Describe the basic forms of manufacturing operations, and outline their key distinguishing features. [20%]

(c) Describe the basic forms of service operations, and outline their key distinguishing features. [20%]

(d) What are the likely implications if an inappropriate process layout is chosen for any type of manufacturing operation?

[15%]

(e) It is said that: 'An efficient resource is not necessarily a productive one'. Discuss to what extent you agree or disagree with this statement.

[15%]

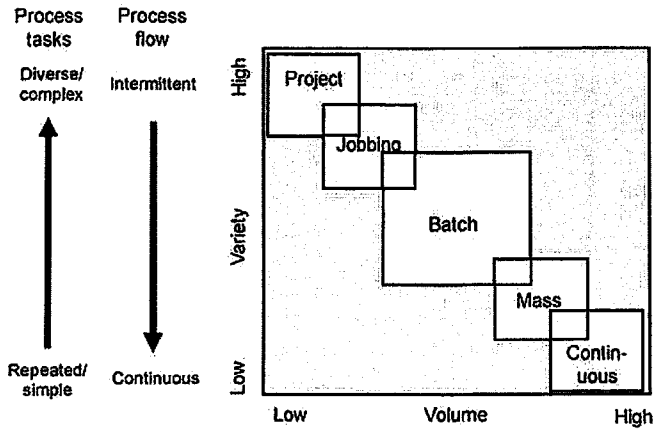
Model answer.

a.

The nature of the manufacturing and service tasks differs considerably between firms. The two key variables for manufacturing operations are volume and variety, and for services, degree of customer contact and the degree of customisation. These determine the layout, the dedication of equipment, and the level of training of the workforce.

- Defines types of job design required
- Defines necessary tools and technology
- Defines cost structure
- Defines relationship with suppliers
- Establishes customer expectations - cheap or customised

(Diagram of product-process matrix and/or service-process matrix)



b. Here a good answer would comment on the product, process and workforce implications

- Project: specialist workers, one-off, resources brought to location (often), general purpose machinery:

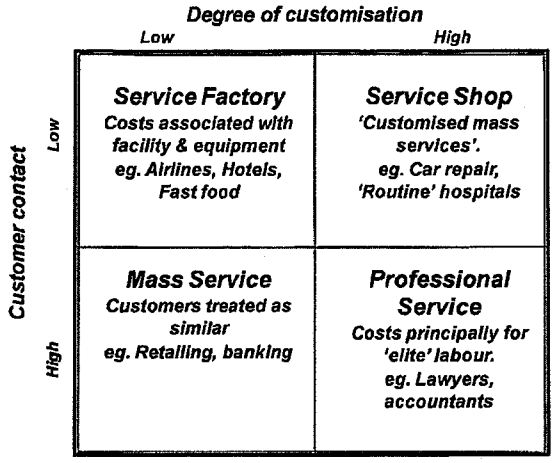
- Job shop: specialist workers, few of a kind, general purpose machinery, complex routing

- Batch: higher volume, so setup-times justify batch production, dedicated equipment but no rigid automation, variable speed, similar products

- Line: dedicated and rigid equipment, high volume with clear line speeds, low skill requirements, high repetition, very similar products

- Continuous: no clear distinction between products, very rigid and automated equipment, low labour requirement (only as control engineers)

c. Service operations follow a similar setup, depending on (1) degree of customisation, and (2) degree of customer contact. A diagram or list may be appropriate here of the four main categories:



d.

The main implication is one of potential inefficiency:

- Either the equipment is too slow/general-purpose, and thus runs slow OR the equipment is too specific, and thus unable to efficiently operate on lower volumes
- The same applies to the workforce, either training is unused or poorly trained workers perform tasks they are not trained for, with potentially detrimental quality implications

e. The problem with "efficiency" is that it is relative to a standard, or time. So one could improve efficiency by improving over a very poor starting point, or by comparing it to a poor benchmark. Even worse, if one compared efficiency to an industry average, and that standard went down, then efficiency would improve without any actual improvements, i.e. productivity stayed the same. The basic problem here is that efficiency is only a relative measure, while productivity is an absolute one.

3 Cambridge Ales Ltd. is reviewing its production policy for one of the specialist ales that it produces, 'Cam Brew'. In the past year, average sales for 'Cam Brew' have been 10,000 litres per week (you may assume a 52-week year). The setup cost for changing the brewing vats over to another type of ale is £500, while the annual cost of keeping one litre in stock is 20% of its value. The production system operates at a fixed speed of brewing 20,000 litres per week, and the production cost of one litre of ale is £0.40.

(a) Explain the concept of Economic Production Quantity (EPQ), and derive its formula. Calculate the EPQ for the case above. [30%]

(b) List the assumptions you have made in (a). Are these assumptions appropriate? Justify your answer. [30%]

(c) Using the Period Order Quantity (POQ) model, and listing any further assumptions that you make, calculate how often an order is placed, and how much the brewery spends each year in setup costs. [20%]

(d) Cambridge Ales is a using a forecast-driven order fulfilment strategy. Discuss the key advantages and disadvantages of this approach. [20%]

Model answer:

(a) Here we start with the total cost formula:

$$T(Q) = \frac{Q}{2} C_H + \frac{D}{Q} C_S$$

As with the standard EOQ, except C_H is replaced by $C_H(1 - D/R)$ for the production rate:

$$EPQ = \sqrt{\frac{2DC_S}{C_H(1-D/R)}}$$

The EPQ in this case is: 114,017.5 litres

(b) Key assumptions include:

1. Demand is constant and steady, and continues indefinitely
2. EOQ assumes whole replenishment lot arrives at same time
3. Replenishment lead-time is known
4. Order size is not constrained by supplier, no min/max restrictions
5. Holding cost per item per period is a constant
6. Cost of ordering/setup varies linearly with replenishment size
7. Item is independent of others; benefits from joint reviews are ignored
8. Doesn't encourage us to decrease fixed ordering/setup costs

➔ Thus these assumptions are too rigid for practical use: demand is never stable, and the holding costs are generally underestimated, so EOQ-type calculations tend to favour (too) large batch sizes!

(c) The POQ calculation uses the same assumptions as the EPQ, but it calculates the number of batches, rather than the batch size!

POQ = D/EPQ = 4.56 batches per year.

The total setup cost is 4.56 * 500 = £2,280.35

(d) The main advantages are:

- Efficiency resource utilisation
- Stability in planning
- Shield from customer demand volatility
- Short OTD lead-time

The main disadvantages are:

- High risk of over- / understocking if the forecast is wrong
- Unresponsive planning (generally)

4 You are the operations manager at WingStar, a medium-sized aerospace supplier based in the UK. WingStar's board of directors is considering the outsourcing of several business functions.

(a) Outline the key advantages and disadvantages of outsourcing.

[40%]

(b) WingStar's board is specifically considering the outsourcing of its human resource (HR) function. What aspects of HR processes are most suitable for outsourcing, and which ones are not? Justify your answer.

[20%]

(c) As an alternative to outsourcing parts of the manufacturing operation, WingStar's board is considering offshoring some of its UK manufacturing operations to a low-cost country. Would the strategic risks be different for offshoring, compared to outsourcing?

[20%]

(d) Describe the 'bullwhip effect', and outline why global supply chains are more susceptible to this phenomenon.

[20%]

Model answer

(a)

Pros

- Focus on core competences
- Harness lower labour cost at supplier
- Access to technology at provider
- Stable and predictable financial planning in fee-for-transaction services
- Less investment risk

Cons

- Loss of control over process
- Limited ability to improve processes
- Risk of opportunistic behaviour of supplier
- Loss of human capital and tacit knowledge

(b)

- Most suitable are transaction based tasks, such as payroll and benefits.
- IT-based HR systems can be outsourced easily, call centres to some degree
- Recruitment maybe possible, but not at senior level
- Career planning, strategic HR development, and training are unlikely to work as outsourced function
- The key here is to consider what process requires "tacit" knowledge to function, as opposed to pure transactions.

(c)

- Essentially the risks are similar, as in both cases the local knowledge is lost as the UK workforce is replaced.
- In the offshoring case this may be kept still within the firm, but then incurs the danger of IPR losses in remote markets (e.g. China)
- Either way it would be hard to bring the process back in-house, as the capability has been lost!

(d)

- The bullwhip is an amplification of demand in a multi-tier system, which leads to dynamic distortions in supply chains, and in turn, to high inventories and stock-outs, and poor capacity utilisation at all tiers. The higher up in terms of tiers, the worse these become.
- It is caused by uncertainty in the first place (on the demand side), and then amplified by delays and hand-offs or decision tiers
- Global supply chains are longer, and thus the longer lead-time will mean that it is much less likely to quickly adjust to changes. As a result it will have to hold more buffer stock, and is more prone to stock-outs, obsolescence, etc.

END OF PAPER