

1. You have been appointed as a technology manager for a multinational food and drink firm and have been asked to see what technologies could be used to reduce the environmental impact of the firm and its suppliers over the coming 5-10 years.

- a) Describe what activities you would recommend the firm uses to *identify* and *select* specific technologies that have the potential to be deployed to reduce your firm's environmental impact.

[25%]

- b) The identification and selection activities reveal one specific technology that has the potential to have a significant impact on reducing energy consumption across your firm and its suppliers' manufacturing operations. Discuss the pros and cons of *acquiring, protecting* and *exploiting* this technology by:

- i) Working in collaboration with a UK-based university research lab;
- ii) Partnering with a fast-growing technology start-up based in Sweden;
- iii) Developing the technology within your own company's R&D labs.

[75%]

Basic answer

- (a) The basic answer would give a **generic description of the identification and selection activities** as initially described in Gregory (1995) and discussed in detail in the module. The basic answer should be able to list a reasonable number of specific activities that could be undertaken under both headings, e.g.

- Identification: internal and external scanning; academic papers, attending conferences, structured on-line searches, use of consultants, etc.
- Selection: alignment with existing capabilities, fit with strategy, position on roadmaps, etc.

- (b) The basic answer should be able to **demonstrate clear understanding of what activities are encompassed within each activity** (acquire = internal and external, exploit = different business model options, protect = range of registered and non-registered IPRs plus non-IP routes), **demonstrate understanding of the implications of these three distinct paths** (two external, one internal). To do this, there will need to be **evidence of awareness of the characteristics of each context**:

- University – leading edge knowledge but might not have things that are ready for implementation. Acquisition could therefore be quite slow; exploitation – technology might need lots of extra development; protection could be straightforward but risk of leakage of knowledge within academic context.
- Start-up – potentially quick way to access ready-to-go solutions, but acquisition could be complicated by all the operational issues of asymmetry (culture, processes, structures, etc) well-covered in the module; exploitation would need to consider benefit of having partnership as low risk way to test use of the technology, drawing upon the experience start-up might have of working with other partners but could be challenges of managing level of embeddedness and reliance upon potentially commercially unstable external

source; protection could be straightforward if a transactional approach taken, but this may get more complex if MNC becomes increasingly reliant on this technology and wishes to develop own capability.

- Internal development – given this is an MNC, there are likely to be substantial internal R&D capabilities that could be deployed to the ‘acquisition’ (meaning in this case, development) of this technology. However, depending on the nature of the technology, these R&D capabilities might not be relevant for the new technology (e.g. if the technology is largely software based, this food and drink MNC might only have limited software development capabilities). For exploitation, doing things internally would allow close coupling between the different teams within the firm (R&D, IP, strategic, production, procurement), and hence accelerate the consideration and implementation of different exploitation options. For protection, the fact that this is internal is likely to allow relatively tight control to be kept over the use of the technology. However, as the question also highlights that this technology is also to be used within suppliers, there are risks of external ‘leakage’.

Good answer

(a) A good answer would build upon the above, but **make reference to the specific context** within which this question is posed, i.e. MNC with access to **substantial resources** to implement these activities, but also challenge of managing internal identification and selection due to **organisational complexity**. Given this is an MNC, it is likely that there will already be in place technology strategies and roadmaps, and so better answers should demonstrate awareness of how such existing knowledge and processes will impact activities targeted at finding a new technology.

(b) A good answer would build upon the above but add depth through demonstrating awareness of factors including:

- **Key issues identified related to ‘Technology Acquisition and Protection’** readings that supplemented the in-module sessions on IP management and technology acquisition. For stronger answers, this will include demonstration of awareness of factors relating to the characteristics of the technology, of each of the organisations, and of the transfer process itself.
- **Recognition that the external options can be structured as open innovation (OI) approaches** and hence the challenges of OI discussed in the module can be applied to this situation.
- **Awareness of likely cultural issues (see Fig)** should be demonstrated, e.g. as discussed in the module in relation to university/industry and MNC/startups. Reference could also be made in relation to the use of internal R&D to the cultural challenges that might exist between R&D and other teams within the MNC and its suppliers (especially, in this context, production and procurement given the reference in the question of the potential to deploy the solution with suppliers). Reference

Partnership Building
Balancing Industry & Academic Culture

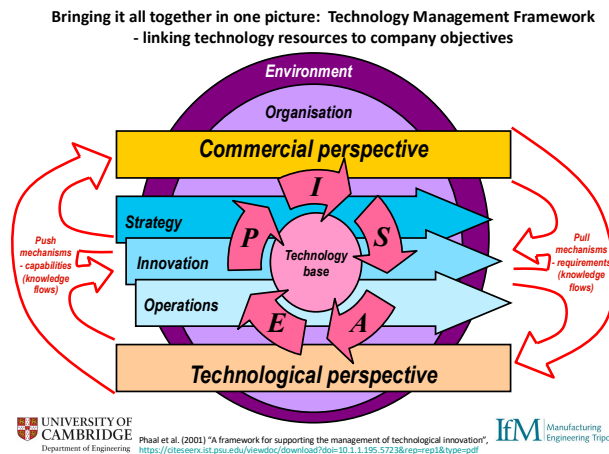
Industry Culture	University Culture
Proprietary knowledge as asset	Open publication / knowledge exchange
Employees	Students, post docs, and junior faculty
Project management	"Organized anarchy"
Risk management	Cutting-edge / novel research
Applied research / Short term focus	Basic research / Longer term focus
Company-specific skills development	Education
Focus on "bottom line" profits (£)	Focus on generation of new knowledge

With thanks to Dr Eoin O’ Sullivan, University of Cambridge Centre for Science, Technology and Innovation Policy

could also be made to the potential impact of the location of the university and start-up that might, depending on the location of the core team implementing this project.

Excellent answer

- (a) An excellent answer could build upon the above to present an **integrated view** that could be structured around the system view of technology management (as shown in the Phaal's framework below) but also emphasise the importance of considering the time-based dimensions of identification and selection (e.g. TRMs) within the context of the MNC's evolving strategy and operations, and its competitive position.



- (b) The strongest answers will reflect upon issues of factor that could include:
- a. **The nature of the technology.** The question does not specify what the technology is, and so there are a wide range of additional factors that will, in the 'real world' context, need to be considered. The best answers are will be able to demonstrate awareness of the different issues to be considered depending on whether this is a 'standalone' single technology, or a complex bundle of multiple technologies brought together to deliver a system level solution.
 - b. **The impact of the MNC's 'path dependencies':** i.e. what is the level of competence in each of the options that the MNC can draw upon from its past experience? Given the organisational complexity inherent in any such organisation, how to find out what the past experiences have been, and who has and can share the relevant learnings?
 - c. **There is unlikely to be a 'single point' solution:** in a situation such as this, it is very likely that a combination of approaches will be used, involving a combination of internal and external approaches (i.e. true 'open innovation'). The challenge is about managing these blurred boundaries to ensure that internal and external capabilities are harmonised to allow effective acquisition, exploitation and protection.

2. As the recently appointed Chief Technology Officer of MotorManufacturer, a large, long-established UK-based car manufacturer, your key aim is to develop the technology strategy which allows the firm to leverage emergent digital technologies and adapt to fast changing trends in the firm's environment. By applying technology and innovation management principles and tools, and by providing illustrative examples, discuss:

a) The *trends* and *uncertainties* you expect will impact on the strategic plans of MotorManufacturer.

[40%]

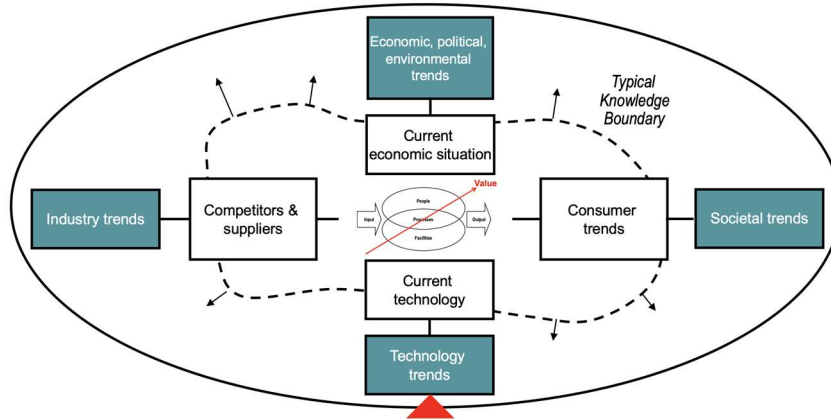
b) How you would suggest that MotorManufacturer designs and implements activities to *identify* relevant technological trends

[60%]

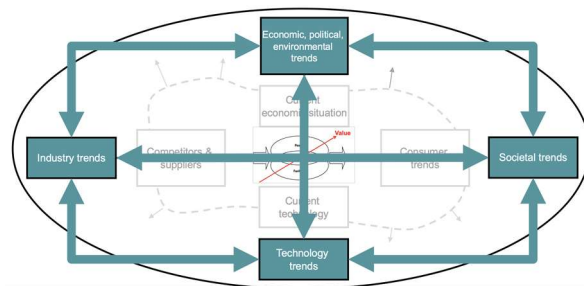
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To be able to answer satisfactorily, the students are expected **to use models explained in the Technology and Innovation Management module and contextualise them for a UK-based manufacturer of automobiles in the evaluation of digital technologies**. It is ok to make assumptions or to base these on real knowledge of a UK Car manufacturer. The capability of the students to build on the frameworks learnt, whilst contextualising them with examples for a company with the characteristics above will be taken as the main assessment criterion. The answers could vary from the descriptions given below as there is a broad number of examples which could be generated and frameworks which could be integrated in the discussion (e.g. PESTEL, SWOT methods, integration with strategic planning

- (i) **Basic answer:** the student should refer to the "inner" and "outer" rings of the figure below (highlighting the difference between the current status and trends vs the need to broaden the understanding of trends to interpret the future. Using the backbone of the diagram below the student might describe the various trends type (economic, market, industry, technology) and the different levels of uncertainty (trends of the inner ring are less uncertain as the firm at the centre of the diagram is more aware of what happens in current trends / within their industry). Examples of important trends should be given and discussed to some extent for the automotive sector as examples (e.g. Brexit changes, need for meeting sustainability targets, consumer trends such as change of transportation needs, desire to own cars, changes in customer behaviour due to Covid, technology trends, such as the emergence and maturing of technologies such as robotics, artificial intelligence, virtual and augmented reality....etc).



Better answer: on top of discussing the above trends at a generic level, the students will be able to infer about the interplay of these trends and about why some trends are important (and some less) for an automotive company in this geographic region and the repercussions these might have for the firm.



Excellent answer: the best answers will try to interpret the trends using some of the models described in the TM module, such as in the evolution lecture, in the strategic planning lecture and in the identification lecture. They could discuss for instance how, in their search for digital technologies trends, MotorManufacturer should be aware of the industry lifecycle. For example, very emergent technologies, like virtual or augmenting reality (AR/VR), are likely to be offered by many firms all competing to offer different versions of the technology. This is because the AR/VR industry is likely to be in an era of ferment and the dominant design for these technologies is likely to have yet to emerge. Tracking the number of companies which offer these technologies and noticing reduction of these in the market over time might signal that the dominant design has emerged and whether technologies are maturing. Also, students might pick on the understanding of how the readiness level of a technology could be interpreted via analysing the technology performance against time. The resulting chart, an s-curve, could be showing a steep increase in one or more technology performances (e.g. a rapid improvement of the wearability of the VR/AR kits, or of frames/second) might indicate that the technology has reached an increased maturity (i.e. the technology is pacing). Further considerations might relate to the interpretation of the rate of adoption of a technology across industries, and students might suggest that MotorManufacturer needs to follow the trends by monitoring the early adopters in other sectors to be able to

appreciate incoming new applications of the technology and new needs of the market.

- (ii) **Basic answers:** students are expected to draw from the technology intelligence lecture and use the TI Model - (comprising 4 modes: mine/rawl/target and scan – see fig 1) as a structure to give examples of activities that could be used to plan the identification of new trends in technology. This question builds on one of the activities carried out in class. The students should concentrate on the external modes (Target and Scan), but make appropriate comments about the establishment of the internal modes to make sure MotorManufacturer is able to store and utilise the information on trends over time. The question requires a discussion, and so it is not enough to regurgitate the basic structure of the TI System in a generic way to gain marks, but it is expected that the students evaluate how the TI system should connect to information sources and discuss which might be more appropriate for the case study, given the current circumstances (e.g. universities vs start ups, which geographic area etc). The students, based on examples provided during the class and from the material shared as follow up, should be able to give an idea of what the company is likely to have already established, in terms of mechanisms for gathering knowledge of external technological trends. For instance, the students could expect MotorManufacturer to have good connections in the industry and in the UK. (e.g. the manufacturer is likely attending trade fairs, reviewing patents, the R&D group likely to have established connections in mechanical engineering departments in the UK etc.). A basic discussion about the sources of information which the company is likely to need on top would be required (e.g. in order to identify emerging trends the company might need to complement its mechanisms to tap into sources outside the industry – e.g. to monitor VR/AR application in medical contexts...).

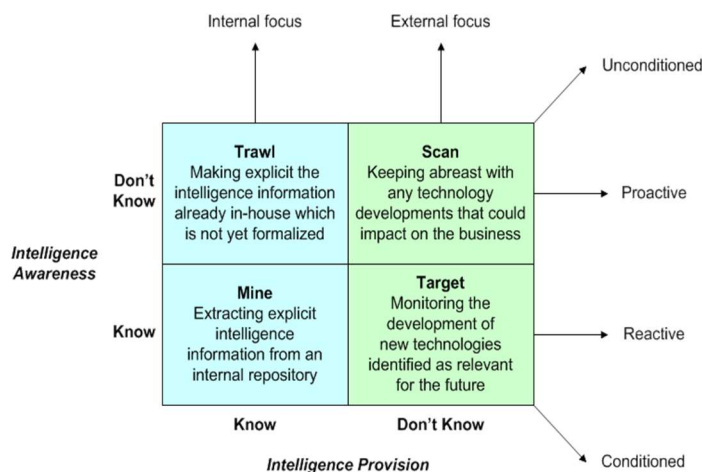


Fig 1: The TI Model, comprising 4 modes. Kerr et al. 2006

Better answers: will follow the pattern above, but on top will be:

- more complete (e.g. rather than one example per mode, the answers discuss a number of examples of types of sources to triangulate the information) or/and

- discuss the resources necessary to establish the full TI system (i.e. what skills/infrastructure would be required to connect to the sources and digest the meaning of the trends identified. For example, to be able to analyse patents, patent analytic techniques would be necessary. If these are not already in house, the company might need to engage a specialist consulting company).

Excellent answers: will connect the description of the TI system/source pattern and the type of insight acquired to the strategic planning tools. The student will discuss how the information acquired will feed the strategy (e.g. via being encompassed in roadmapping exercises) and how the message about the meaning of the technological trend needs to be communicated appropriately to be used in strategy-making. Students will in this case make examples of how different types of information about digital technologies might be interpreted differently and accepted more or less well as part of the strategic discourse. For example, the insight about technology which would substantially change the company current business (e.g. the 3D printing of cars) might be potentially considered threatening by MotorManufacturer and, as such, they might be hard to be adequately taken in consideration in the building of the firm strategy. Tactics for mitigating the barriers to knowledge interpretation could be also suggested by the student.

3. ManuVR is a UK-based start-up firm whose core business is the provision of low-cost Virtual Reality (VR) systems to help manufacturing firms train their production line employees. ManuVR's business model is based around the design, implementation and support of VR solutions, and buys all its technology from suppliers in China and the US. The firm is five years old and has grown from 3 to 50 staff during that period. It has received Venture Capital (VC) funding and sales are now growing very fast, particularly in Europe. A large European industrial automation company (IndustrialAuto) is very interested in partnering with ManuVR. IndustrialAuto does not have expertise in VR, but recognises the increasing demand for VR systems from its current customers.

1) Discuss the typical people management issues ManuVR is likely to have faced during its first five years of operations.

[30%]

2) From the perspective of ManuVR's management team, discuss the main people-related issues that they should be aware of as they set up and manage the partnership with IndustrialAuto.

[30%]

3) For IndustrialAuto, the partnership with ManuVR represents two changes: working with new people, and working with a new technology. What advice would you give to the CEO of IndustrialAuto to ensure that these changes are managed successfully?

[40%]

Basic answer

(c) The basic answer would cover the **standard elements of people management** (recruitment, training, performance measurement, retention, retrenchment), and demonstrate some awareness of how these need to be **managed in the context** of a relatively **small** organisation (e.g. limited resources), a relatively **new** organisations (e.g. may lack experience) but also one which is **growing fast** (e.g. little time to deal with implementing systems, yet failure to do so is likely to create further problems). Challenges about setting up supply chains internationally could be also mentioned.

(d) The basic answer should demonstrate awareness of the **generic issues of managing partnerships**, but also acknowledge the specific challenges of **asymmetric partnerships** that this case illustrate (e.g. asymmetries relating to scale, age, speed, complexity, formalisation etc). The basic answer can talk about general partnering issues (challenges of setting up/managing/evolving, aligning of strategies and operations) but **must focus on the people-related issues** to some degree. These will include issues such as challenges arising from, e.g. different profile of staff in each company (age, tech literacy, 'start-up' versus 'corporate' mindsets, etc)

(e) Basic answer should be able to describe a basic model of change (such as Kotter's 8-stage model) to frame these two issues. Describing the model alone will get minimal credit, but rather it should be used to position issues of an organisational and a technological/capability change. These two issues should be described to

demonstrate awareness of how organisational and technological change happens, and how they are inevitably interdependent.

Good answer

- (c) A good answer would, in addition, explore the impact of **all key stakeholders** in talent management, e.g. the role of the VC investors, non-executive directors, and external consultants that could support talent management. There should also be discussion of the challenges resulting from the fact that firms like ManuVR are in **competition for talent** with 'more stable', longer established employers (who can offer a clear career path and support), as well as from other start-ups working on similar technologies (who can potentially offer some other benefits).
- (d) Good answers would ensure that there is **clear primary focus on the people-related issues** but for these to be positioned within a demonstrated understanding of the general partnering issues. A good answer could also consider these issues from the **life cycle and longer-term** focus, i.e. what could such a partnership lead to, and what might it mean for ManuVR? For example, on a positive side this could be a pathway to acquisition; on the negative, this might lead to loss of competitive advantage as the ManuVR's core competence gets transferred to the new partner.
- (e) A good answer would build upon the basic description of a model of change management applied to the two parallel issues, but also reflect on the **context specific challenges** of doing this, and the **mitigation strategies** required to help ensure success. E.g. for the challenges of integrating new staff via the collaboration, ensure the process of new team formation described in the lectures could be applied here; for the challenges of adopting a new technological capability, this could explore issues of alignment with existing capabilities and skills within IndustrialAuto and how to address potential hostility arising from 'not invented here' responses.

Excellent answer

- (c) An excellent answer could explore the **business and technology context** of their talent management issues, and comment upon issues such as fact that the market within which ManuVR is operating in is technology-driven and fast moving. Given that many manufacturing firms that make up their customer base might be quite traditional and risk averse, ManuVR needs to ensure that it can recruit not just those who are VR technology capable, but also those who understand the world of manufacturing. As such, they face the classic problems of **liability of newness** that all young firms face when they seek to recruit, but also recruiting from two very different domains and seeking to integrate people into their team who may have very different views of the world.
- (d) An excellent answer would (i) demonstrate clear awareness of **generic partnering** issues, highlighting **specific issues of this particular partnership**; (ii) **major on discussing the people-specific issues** as they would concern the management team of ManuVR – and discuss what **mitigation strategies** could be put in place; and (iii) include reference to what this means for **all ManuVR's stakeholders** (management team, employees, investors, partners, etc) and both **positive** and **negative** terms (e.g. opportunity to grow market, demonstrate value to potential acquirer, etc, but also risk of diluting value, getting slowed down by bureaucratic processes, loss of control/autonomy). There could also be reference to the implication that ManuVR's

offering is largely about product-service system delivery, and how deeply embedded – and hence hard to transfer - such capabilities are within the ManuVR team.

- (e) An excellent answer would have all of the above, but also discuss the broader issues of how such a partnership would /should be used either to **address an immediate capability gap**, in which case, want to make sure that people related issues are minimised – just treat as a contractual (transactional) – or is this **about longer term capability development**, in which case they would need a plan for how ManuVR's capabilities could become integrated with IndustrialAuto's. The success of such longer term integration issues would dictated by the reaction of ManuVR's leadership team and their investors.

4 a) The literature indicates that there are several different schools of strategy.

(i) Compare and contrast how the *Market-Based approach* to strategy championed by Porter, and the *Resource/Capability-Based approach* championed by Penrose can be used to develop a Sustainable Competitive Advantage. Discuss with examples why companies might prefer to adopt one approach over the other.

[40%]

(ii) Explain how the two approaches named above could be combined to achieve Strategic Alignment (i.e. Strategic Fit and Strategic Reconciliation).

[20%]

b) Identify three aspects of their business where companies are experiencing problems as a result of the Covid-19 pandemic. Discuss and give examples of what actions they might consider to recover and develop a new Sustainable Competitive Advantage.

[40%]

Crib

a) (Context – Porter’s Market-Based approach is covered in the marketing lectures at the beginning of the module. The Resource-Based approach is covered in the Strategy lectures at the end of the module. Hence the “compare and contrast” of the question.)

- Weak answers will simply regurgitate strands of the lecture notes (not sufficient marks)*
- Ok answers will demonstrate personal understanding and interpretation of the lecture notes*
- Better answers will coherently compare and contrast the two approaches and identify weaknesses*
- Strong answers will demonstrate clear understanding of the 2 approaches and suggest cases where either approach may be adopted*

i) Porter (1985) is generally credited with developing the concept of Competitive Advantage – developing and implementing a value creation strategy that is different and difficult to copy by existing or potential competitors. The Market-Based approach is better known and some might argue more intuitive. Business Schools have taught it for longer. Over the years this model has developed into the concept of Sustainable Competitive Advantage. Porter introduces the 5-forces model centred on competitive rivalry within an industry. And then argues that companies should adopt one of the 3 Generic Strategies. This Market-Based approach school of thought argues that the organisation must focus on the external environment, the attractiveness of the market, the rivalry of the Industry etc (similar to the external Opportunities/Threats of the SWOT analysis). The concept of value added within the firm can be linked back to Porter’s Value Chain and the ability to identify the resources and capabilities and how these can be leveraged to gain competitive advantage over competitors. This approach has some Disadvantages: it is a one sided view and assumes that competitive advantage comes solely from the external competitive environment and that resources are homogeneous and mobile.

The Resource Based approach argues that the organisation should focus on the internal resources that are within the firm (Strengths and Weakness can be identified by a SWOT analysis). Concentrates on the internal resources and

capabilities of the firm rather than the external environment. The concept of value added within the firm can be linked back to Porter's Value Chain and the ability to identify the resources and capabilities and how these can be leveraged to gain competitive advantage over competitors. It concentrates on the internal resources and capabilities of the firm rather than the external environment. The company needs to define resources and the firm's ability to control, improve, develop them. Resources are tangible and intangible – human, physical & organisational. This school assumes resources are heterogeneous, scarce and imperfectly mobile –almost the opposite of the Market-Based assumptions (and probably more realistic). The central tenet of the resource-based approach is that firms must be able to acquire and control resources and capabilities that are valuable, rare, inimitable and non-substitutable (VRIN), and have the appropriate organisation. Examples: If a business is considering launching a new product the emphasis will be on determining if there is a market and what's already there – market size, competitor analysis, attractiveness. But If a business is competing in a large mature market with big players a market-based approach will not add much value. However, the company may analyse its internal resources and capabilities and realise that they can leverage these to competitive advantage in another market.

But the truth is that it's likely to be a bit of both....

(ii)

(Context: The concept of Strategic Alignment can be traced back to Sun Tzu 400BC – “Know the enemy and know yourself; in a hundred battles you will never be in peril. When you are ignorant of the enemy, but know yourself, your chances of winning or losing are equal. If ignorant both of your enemy and yourself, you are certain in every battle to be in peril.” This quotation was used in both the Marketing and Strategy lectures. Clearly in business we need to adapt ‘enemy’ to Customers & Competitors.)

- Weak answers will mention alignment of internal resources and the external environment/market/customers, probably using the SWOT analysis*
- Better answers will go into more detail and show a deeper understanding of the theory and the need to overcome the limitations of the separate approaches as developed in 1) above.*
- Stronger answers will discuss implementation and note that operations strategy is the most suited strategy level for reconciliation. They will discuss the conflict that often exists between marketing & operations in many manufacturing businesses.*
- Outstanding answers will recognise the need for ‘reconciliation’ – resolution of conflict and need for trade-offs and compromises between marketing and operations – as opposed to just ‘alignment’ and ‘fit’ which do not portray the effort required. Examples from experience would be a bonus but will be difficult this year with remote working, perhaps cases!*

Strategic Alignment is the process and result of linking a top-down approach and a bottom-up approach to building strategy. It is essentially a reconciliation of a strategy that is driven by the market view with that which would be driven by the company's resources and capabilities. The aim of strategic alignment is to build an optimised strategy that enables a company to compete within certain market conditions while realising the strengths and weaknesses of their underlying resources and capabilities.

- Some candidates may mention STP of the 1990s,*
- Some candidates may mention Kenichi Ohmae's 3C model*

- *There should be a mention of the top down-market approach of Porter*
- *There should be a mention of the bottom-up market approach of Penrose*
- *There should be a mention of Operations Strategy (Slack and Lewis) as the bedrock of strategy reconciliation*

b) Part b) will demonstrate the students' ability to apply teaching material to real world cases, think on their feet!

- *Weak answers will mention 1 or 2 challenged areas – probably sticking with SC & Demand*
- *Better answers will discuss 2 areas and attempt examples*
- *Strong answers will discuss all 3 areas and give examples of digitalisation (digitalisation was only covered briefly in the module)*

3 areas that have been challenged/disrupted are:

- *Supply Chain Management*
- *Interpretation of the Demand*
- *Digital Assets*

However, students might point to further areas, beyond the three identified here. Well-argued and substantiated answers will be accepted and the crib will be updated accordingly after marking.

Supply Chains - have become increasingly long and complex. Now recognised that SCs are vulnerable to disruptions and environmental and social unrest. Eg Tohoku earthquake - Fukushima accident – Toyota UK slowdown. Covid has accelerated the trend – answers will discuss and give examples of resilience, localisation, dependability etc

Demand – rapid changes, unpredictable, volatile and changing bargaining power of customers. Answers will need to discuss and give examples of agility, simplification, reconfigurability.

Digital – Volume/Variety/Velocity. Answers will discuss the step changes in use of digital technology that are taking place in all the business systems.

4. CCI, a small manufacturing firm, makes a single product through a plastic extrusion process: disposable coffee capsules. These are manufactured from a single material, in two parts: a lid and a cup. Plastic waste from CCI includes rejected products from the quality check, as well as various losses of raw material and finished products. About 1% of both lids and cups are rejected for being of incorrect dimension. Single units made of one lid and one cup are sold on to a downstream customer, DDH. DDH fills the cups with coffee, puts on the lids, and wraps each filled capsule in aluminium foil. These are then sold to retailers and then to consumers. At end-of-life, capsules are landfilled, as the contamination with the coffee grounds makes recycling difficult. Key statistics for CCI in 2020 are summarised in Table 1. Stocks of material and finished product at the beginning of the year 2020 can be assumed to be negligible.

Total Food-Grade Plastic Purchased	255,000 kg
End of Year Food-Grade Plastic Stock	45,000 kg
Design Mass (Lid)	2.35 g
Design Mass (Cup)	4.20 g
Total Production (Lids)	33,772,662 Lids
Total Production (Cups)	27,607,599 Cups
Rejection rate (Quality)	1.00 %
Sales (1 Capsule = 1 lid + 1 cup)	25,604,000 Capsules
End of Year Product Stock	1,950,000 Capsules

Table 1

(a)

- i. Zero Loss Yield has been proposed as a suitable metric to analyse the material efficiency of the CCI process. Why is this an appropriate approach? Comment on how one would go about gathering the appropriate data in a real-world example. [15%]
- ii. Identify and comment on the main sources of potential material loss for CCI, stating any assumptions you make. [40%]

b) Using the concept of Value Uncaptured, discuss the pros and cons of the three following options for sustainability improvement, for the whole cradle-to-grave process cycle:

- i. The mass of plastic in the cups produced can be reduced by 25% by redesigning the product. This will require new moulds for the injection moulding line. [15%]
- ii. Current materials (the aluminium foil and the plastic capsule) can be replaced with a biodegradable alternatives to allow the product to be composted after use. [15%]

- iii. A 'Just-in-Time' production process will ensure that no stock of raw material is held on site at any time. [15%]

CRIB

- a) i) **Basic answers** will identify Zero Loss Yield as the material efficiency metric taught on the course (it is specifically defined as such in the syllabus) and select this as the appropriate starting point to analyse the material efficiency. They will identify that Zero Loss compares the total material consumption with the theoretical minimum amount of material required to meet customer needs. Other tools taught on the course (such as life cycle analysis or carbon footprinting) are not material efficiency tools, and as such are not appropriate for the specific question.

Better candidates will mention that the data for sales and raw material should be obtained from invoices, receipts and other financial records. The design mass should be taken from original designs, or bill of materials. This ensures accuracy of the data with minimal additional data collection required.

The best candidates will explain that the sales and raw material input should be adjusted for changes in stocks. Increases in stock/inventory are treated as a loss: they are included in raw material purchases, but not in sales figures, lowering the overall yield. A Zero Loss analysis would typically take place between two stock checks to ensure accurate figures for materials and finished products in stock.

ii) Candidates should then analyse the material flow and use the data provided to identify the following sources of loss. Calculations are provided for clarity, but candidates who make reasonable assumptions and get numerical answers that are close to those given below should receive full credit.

In addition, candidates who do not identify Zero Loss Yield as the appropriate tool, but derive answers similar to the below from first principles should be given credit.

Candidates who instead use a purely qualitative approach should receive minimal marks.

The formula for Zero Loss Yield (quoted from lecture notes) is as follows:

$(\text{Design mass} * \text{Sales}) / \text{raw material purchased}$

- Annual purchases of material is 255,000kg
- The minimum material required to make the final product is $(2.35\text{g}+4.2\text{g})\times 10^{-3} \text{ Kg} \times 25,604,000\text{units} = 167,706.2\text{kg}$

Zero Loss Yield Analysis applied correctly in this case:

$(2.35+4.2)\times 10^{-3}\times 25,604,000 / 255,000 = 0.657$ which means that the Zero Loss Yield is 65.7% and hence 34.2% of material is not used in the products/is not sold.

- **Raw Material Stock.**

- o Most candidates should:

- Infer from the table that raw material stock has increased from 0 at the beginning of the year to 45,000kg
- Therefore a significant proportion of the material purchased is being held as stock/inventory
- Stronger candidates may identify some or all of the following points:
- 45,000kg represents 18% of purchased material ($45,000/255,000 = 0.176$)
- 45,000kg represents ~27% of the material required to make the finished/sold product. ($45,000\text{Kg} / 167,706 \text{ Kg} = 0.268$)
- Applying Lean principles to this implies that there is a Lean waste (inventory waste) here.

- o **Very strong candidates** may identify some of the environmental and financial risks associated with this excess stock:

- Financial risks include tying up cash flow, storage costs, potential wastage of material if it gets damaged
- Environmental risks include the embodied carbon/energy in material kept in stock. These can be separated into a one-off energy/carbon cost required to build up this stock, and any additional losses of material (expiration/change of supplier/wastage/damage).

- **Excess Lids**

- o **Most candidates** should identify that the number of lids being produced is far higher than the number of cups (by ~22%), even though lids and cups are sold together as a single capsule, and that the final product stock is also given in terms of capsules (full units).

- o **Stronger candidates** will calculate that this represents ~14,500kg of material, and equate this to 6% of annual purchase or 8% of material required

- o **Very strong candidates** will:

- Identify this as a form of inventory loss, and the associated financial/environmental risks associated with inventory losses: e.g. material as a capital stock, costs of storage, risk of spoilage, risk of leftover material in event of product cancellation etc.
- Suggest reasons for this state of affairs: poorly balanced production lines, poor stock control etc.

- **Final product stock**

- o **Most candidates** should identify that the buildup in stock of final product accounts for some of the material

- o **Stronger candidates** will identify this as ~5% of material purchased, or ~8% of the minimum material required.

Final product Mass = number of products stored × mass of one product
 $= 1,950,000 \times (2.35\text{g} + 4.20\text{g}) = 12,773 \text{ kg}$

- o **Very strong candidates** will identify this as a potential inventory loss, but will also discuss whether ~8% of annual sales is a large amount, or a reasonable buffer – this would depend on the circumstances of the factory, which is unknown to the candidate, so a firm

recommendation is not required. However, the strongest candidates will conclude that there are other potential issues that should be addressed first.

- **Quality rejection loss**

- o **Most candidates** will observe that quality loss is relatively small at 1% of finished products
- o **Stronger candidates** will calculate that this accounts for ~2000kg of material, or 0.8% of total material purchased.

Material lost in quality reject = rejection rate × [(number of lids produced × Mass of lid) + (number of cups × mass of cups)] = 1% × [(33,772,662 × 2.35g) + (27,607,599 × 4.2g)] = 1953kg

- o **Very strong candidates** will notice that the very round number of losses (1.00%) may indicate that this level is a deliberate rejection threshold, rather than an underlying random problem, which may indicate opportunity to reduce losses by only disposing of products that fail a quality check.

- **Missing capsules**

- o **Most candidates** should observe that the numbers of capsules produced/sold/stored don't quite add up
- o Number of capsules produced is equal to the number of cups produced (excess lids dealt with above)
- o **Stronger candidates** will determine that this only accounts for 351kg/year and deprioritise the issue

Missing Capsules = entire capsules produced – sales – inventory = 27,607,599 - 25,604,000 - 1,950,000 = 53,599 capsules.

Mass lost = number of missing capsules × mass of capsules. = 53,599 × (2.35g + 4.20g) = 351kg

- **Unknown material losses**

- o **Most candidates** should identify that there is a substantial amount of material loss that cannot be traced from the available data. Some candidates may guess this is the case from the fact that waste streams are not measured, but good candidates will prove it through calculation.
- o **Stronger candidates** will identify that this equates to 12,729kg or 5% of purchase. Error should be carried forward if they have made a mistake in calculating any of the other identified losses.

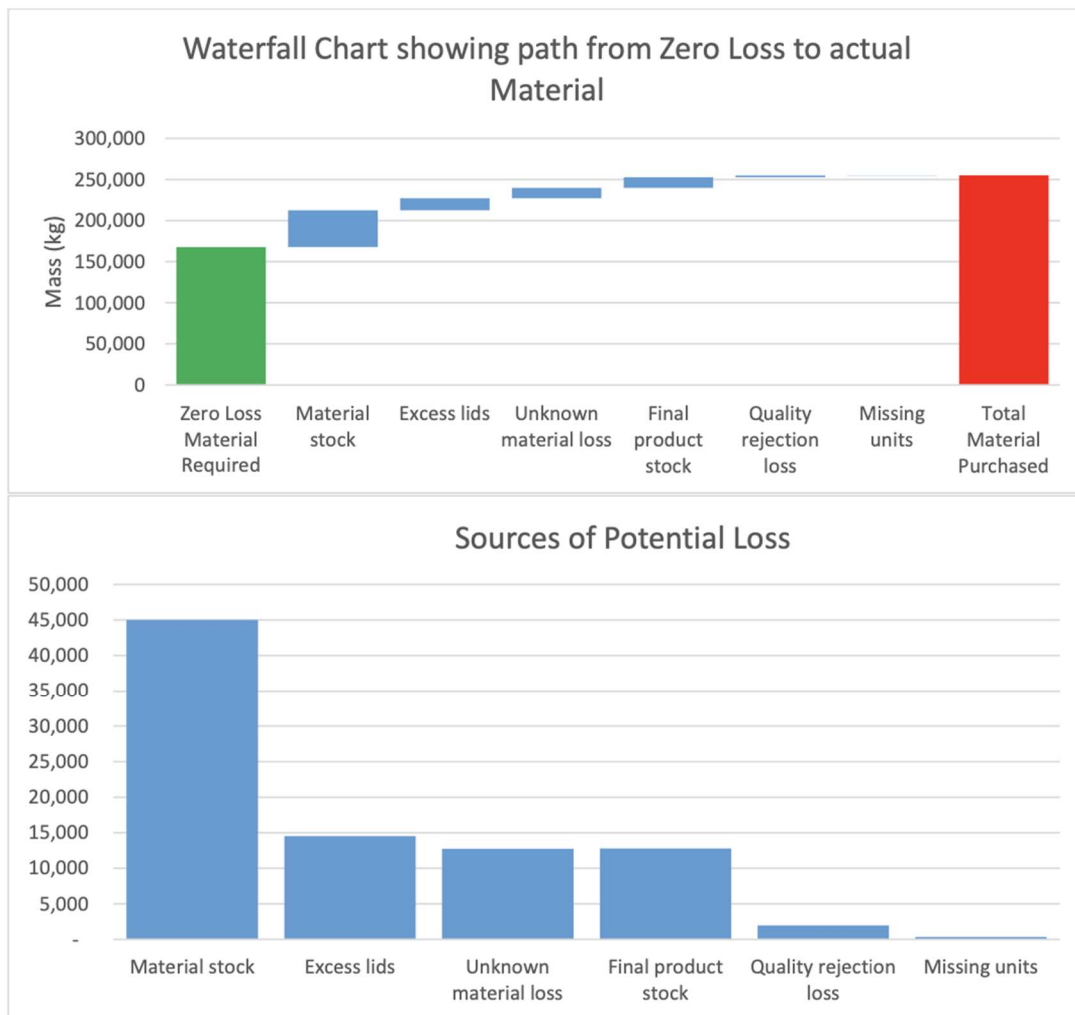
Unknown material loss = Purchased Material - ∑ other identified losses – useful material = 255,000 – (45,000 + 14,488 + 12,773 + 1953 + 351) – 167,706 = 12,729kg

- o **Very strong candidates** will deduce that one of four states must be occurring, and recommend further investigation:

- Figures for purchased material or sales must be incorrect (exceptional candidates will identify this as unlikely, as factory records tend to be better where financial records are involved)
- Mass of material going to recycling from CCI must be larger than believed

- Mass of product must be higher than design
- There is an unrecorded buildup of stock somewhere in the factory

The **very best candidates** may represent their findings visually to communicate the size of the issues relative to the overall material flows. Two possible options are below: a Pareto chart and a Waterfall chart. The latter is the better selection as it shows the potential losses in the context of the maximum and minimum material flows in the factory. If the candidates are working on paper, rough sketches of these graphs are perfectly acceptable as long as they are clear.



b) **Most candidates** will discuss the sustainability impact in general terms.

Better candidates will correctly identify the type of value uncaptured (in bold below) and outline the pros and cons of the three options.

- Option 1 would reduce the **value surplus** in the form of heavy capsules supplied to people with Coffee machines, when a lighter capsule would function just as well.
 - o Pro: this would reduce the raw material costs of production
 - o Con: consideration would need to be given to the cost/embodied energy of new moulds. Marketing benefit might be lower than having biodegradable capsules – consumers would be required to get used to a new product without seeing any direct benefit themselves.

The **best candidates** may try to quantify the relative benefits of the options: Option 1: reduction in purchased plastic required by ~29,000kg/year.

Reduction in Plastic required = number of cups produced per year × mass of cup × reduction
=27,607,599 × 4.2g × 25% = 28 987 kg

- Option 2 would reduce the **value destroyed** in the product ending up in landfill and sending it to compost instead.
 - o Pro: this reduces the mass of product being sent to landfill
 - o Con: the financial, energy and carbon costs of the biodegradable material are unknown/not stated. It would be necessary to perform a life-cycle analysis to determine if the change in material had a positive or negative impact

The **best candidates** may try to quantify the relative benefits of the options:

- Option 2: Up to 100% reduction in landfill (167,706kg in plastic/year – from part (a), plus aluminium foil and coffee grounds), zero financial benefit to manufacturer unless compostable capsule can be sold at a higher margin to similar numbers of people.

- Option 3 would reduce the **value surplus** in the form of stocks of materials sitting onsite unused.
 - o Pro: this reduces the mass of plastic in inventory, instead using it as a useful product. This also reduce the risk of having wasted material at the end of a production run, or if an order is cancelled. There may be second order benefits in not having to heat/light a storage space for the material.
 - o Con: the material savings are a one-off (once you have used up existing stocks, there is not more material saved every year). If the problem is shifted onto suppliers, then the suppliers may end up holding stock instead. More frequent material deliveries may increase traffic and fuel burn.

The **best candidates** may try to quantify the relative benefits of the options:

- o Option 3: A **one off** saving of 45,000kg: This is a smaller mass saving than option 1 if the product run is 2 years or more. Financial benefit to manufacturer if storage costs are more than the just-in-time programme costs.

6. You are the Chief Operating Officer of a large multinational firm that manufactures construction and mining equipment. Your firm's strategy focuses on delivering industry-leading products and services to customers, and achieving profitable growth for the shareholders. Considering the firm's strategy and by applying performance measurement principles, frameworks and tools:

- (a) Discuss and illustrate with examples five operations performance objectives for your manufacturing firm. **[30%]**

CRIB:

- i. **Basic answers (50%-60% - 15-18 marks).**
Contextualizing the answer for this type of manufacturing firm and its particular strategy, students should be able to provide a clear explanation of the five objectives, listing at least three dimensions per objective and give examples of their correspondent metrics.
The five operation performance objectives are quality, dependability, speed, flexibility and cost. Students should discuss their correspondent dimensions as shown in the example presented in class for 'Quality', but in the context of a multinational manufacturing firm operating in the construction and mining equipment which focuses on "delivering industry-leading products and services to customers". For example, the 'serviceability dimension of the quality objective' can be explained as – how easy is the product to "servicise" – and the example metrics could include: time spent in servicing the product, frequency of servicing of the product, the customer experience rating of the service provided, etc.
- ii. **Better answers (61%- 70% - 19-21 marks).** Students should be able to present a more complete version of the above in addition to a summary of these objectives and dimensions from the specific context of the company. E.g. a version was given in class for a Steel Mill
- iii. **Best answers (71%- 100% - 22-30 marks).** In addition, students discuss the relative importance of each dimension for the fulfilment of this firm's strategy. For this firm's strategy – delivering industry-leading products and services to customers, and achieving profitable growth for the shareholders via 'industry-leading products and services to customers - for example the delivery fantastic leading products and services, the flexibility of mass customization and personalisation, particularly for those high profitable loyal customers, might be crucial.

- (b) Discuss and illustrate with examples the purposes of the implementation of performance measures in your manufacturing firm. **[30%]**

CRIB:

- i. **Basic answers (50%-60% - 15-18 marks).** Students should be able to explain the four purposes of performance metrics for the firm and give examples of the metrics per each purpose, still keeping in mind the specific company and its strategy. For instance, it is expected that students will discuss the importance of '*Communication*' with key stakeholders such as dealers, customers, internal customers and key suppliers. Metrics include: Number of touch points with the customers from placing order to order delivery, Frequency of product support meeting with key suppliers. Other answers are expected to include the importance of '*Improvement*' to support the industry-leading position of the company. Supporting metrics for Improvement could include number of new product introductions per annum, number of green/black belts attained a year, etc.
- ii. **Better answers (61%- 70% - 19-21 marks).** In addition, students might add an explanation of the advantages and disadvantages of at least two purposes of performance measures in the context of the construction and mining equipment sector. For instance, students could decide to discuss the advantages and disadvantages of '*Control*'. Highlighting the positive and negative aspects of focussing on control. In the context of this firm, *Control* has several advantages: to keep operation process on time, standardise and strengthen individual operations and improve efficiency and reduce waste (cost, time, scrap levels). On the other hand, '*Control*' purpose might limit the creativity of the operator to try different methods and further improve the operations. Other discussion angles could be equally valid. For instance, some might argue about using '*Control*' in different functions of the company. While '*control*' in manufacturing operations has the positive purpose of reducing cost and time, and improve throughput, '*Control*' in new product development limits the ability of ideation and creativity.
- iii. **Best answers (71%- 100% - 22-30 marks).** Best answers will show a high level of maturity and understanding about how the generic strategy hints at the importance of continuous product innovation and improvement. Students will be able to discuss the trade-offs among some of five operations performance objectives in the context of

construction and mining equipment manufacturer as it is not possible for a firm to perform well at all five performance objectives. For example, the purpose of 'Improvement' is aligned to the continuous product/service innovation of the firm, particularly in driving improvement in customer facing operations such as maintenance services and new product development such as mass-customization of products. While the purpose of 'motivation' is positively related to target achievement and rewards. For example: for the OEM and key suppliers' sample metrics might include: number of critical operations under control or more than 92% of operations' targets and motivation is rewarded with bonuses, parties, etc. 'Motivation' is more difficult to influence and reward for other key stakeholders such as dealers and customers. Some examples of rewards include: annual dealers conferences hosted by the manufacturing firm offering a range of prizes for the best performing dealer, the most innovative dealer, etc.

(c) Explain and illustrate with examples *the balanced scorecard* for your manufacturing firm. **[40%]**

CRIB:

- i. **Basic answers (50%-60% - 20-24 marks).**
Using the context of the firm's manufacturing strategy, and the balanced scorecard (BSC) framework from Kaplan and Norton presented in class, students should be able to explain and illustrate with 'metrics' each of the four perspectives of the balanced scorecard for this manufacturing firm, operating in the construction sector with its correspondent balanced set of metrics (in a similar way as the example of metrics provided in class for a railway company)
- ii. **Better answer (61%- 70% - 25-28 marks).** Answers which in addition detail at least two perspectives of the balance scorecard with the 'objectives', 'measures' and 'targets' will be marked more strongly. For instance, in the 'innovation and learning Perspective of the BSC', the 'Objective' is to develop innovative products to support the environmental sustainability, such as electric battery products, to reduce the CO₂ emissions and increase the use of recyclable polymers in the body of the products. The 'Measures' of these objectives could include: number of products powered by electric batteries, % of recycled polymers in the body of a product. The associated 'Target' for these measures could include: increase by 20% the conversion of oil/gas powered to electric battery powered products by the end of

2021. 78% reduction of non-recycle polymers per product by the end 2025.

- iii. **Best answers (71%- 100% - 29-40 marks).** These answers will be the most complete. Taking into account the firm's strategy, the student should be able illustrate with relevant metrics each perspective. For example: it is expected that the product leader strategy of the company is strongly reflected in the innovation and learning perspective, with metrics including the number of new products released to the market a year and capital expenditure in research and innovation. For the 'finance' perspective, measures could include: percentage per sales per new product, % of profit invested on new product development. For the 'customer' perspective, rating of customer satisfaction for new product/service introductions, For the 'operational' perspective, % of units first time-passed the ultra-emissions tests.

END OF PAPER