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Development of a Supply Chain Benchmarking Tool Using a Novel Redesign of Porter's Value Chain

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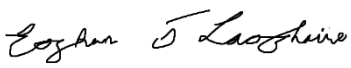
Signed:  Date: 20/12/2023

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Nomenclature

VCA	Value Chain Analysis
LTV	Labour Theory of Value
KPI	Key Performance Indicator
VBA	Visual Basic for Applications

1 Introduction

1.1 Background

This report details the design and approach to use of a novel benchmarking tool built in excel, using VBA, macros, and other functionalities of the program. The theoretical basis of the tool is a redesign of Porter's Value chain based on the necessity to include modern day megatrends in the evaluation of a company's performance in the present. Porter's Value Chain is a graphical representation of Michael Porter's approach to Value Chain Analysis, first introduced in 1985 (Porter, 1985), which revolutionized the approach to value chain analysis. Prior to Porter's Value Chain, VCA was largely conducted using rudimentary summation of costs, that did not accurately reflect the growing complexity of interactions within the actual supply chain, namely a company's activities and processes and how they overlap to create value, at the time of Porter's publication.

In the almost 40 years since the introduction of Porter's Value Chain approach, the world has radically changed. Global disruptions to the supply chain are becoming more common due to increasingly volatile political situations and conflicts in Europe and the Middle East, as well as trade issues between world superpowers, climate disasters, and restrictions due to unanticipated pandemics. This means that methods of analysis of the supply chain and therefore the value chain have to evolve to reflect these changes.

Other issues facing modern supply chains is a growing awareness of consumers about ethical and sustainability issues within supply chains which can negatively affect the value margins of a company due to boycotting and potential loss of market share to other more ethical suppliers.

The rapid growth in the use of AI is also changing the landscape of competitive industry, with productivity that is often greater than human or manual processes and automation abilities that were previously impossible.

A company seeking to effectively benchmark their supply chain must consider all of these trends when evaluating their performance against a competitor or outstanding player in their industry. Failure to include these ideas in a benchmarking process could lead to companies believing their performance is near identical to another company without explaining for potentially large discrepancies in their margins, due to leaving out potential sustainability, Digitisation, and ethical considerations that their competitors are practicing.

1.2 Objectives

The primary objective of this project was to create a novel benchmarking tool which could be used to evaluate and contrast the performance of two companies using a redesign of Porter's Value chain that includes modern megatrends. Microsoft's Excel program offers a large range of functions that make it ideal for such a task.

The secondary task of this project was to conduct a compact literature review that includes all of the most relevant aspects of classic value chain analysis as well as considerations for changes to the modern supply chain in the last 40 years.

In summary the overall project goals were:

- To build a working tool in excel
- To automate as much of the benchmarking process as possible
- Redesign Porter's Value Chain to reflect current Megatrends.
- Conduct a review of literature relevant to the modern supply chain.
- Link the design of the tool to topics discussed in the accompanying literature review.

Of these goals, all were met to a satisfactory degree *except for automation*. The final design does include automation but is lacking in compared to the potential for automation that such a tool could have.

2 Literature Review

2.1 Value Chain Analysis & Porter's Value Chain

The concept of modern value chain analysis was first developed and popularized by Michael Porter beginning in 1985 for manufacturing applications. Porter's approach proposed assessing the intra-influence of the connectivity of different supply chain elements to identify opportunities to create added value, or situations which cause value to be lost, as opposed to the traditional approach of analysis with value being a product of the sum of a supply chain's elements individual values. This approach is summarized in Porter's Value Chain (See Figure 2-1 below) and was developed further as a concept for inter-company use and industries outside of manufacturing to reflect the growing complexity of supply chains due to mega trends in the economy such as globalization (Porter, 1985, Porter, 1996, Piboonrungroj et al., 2017).

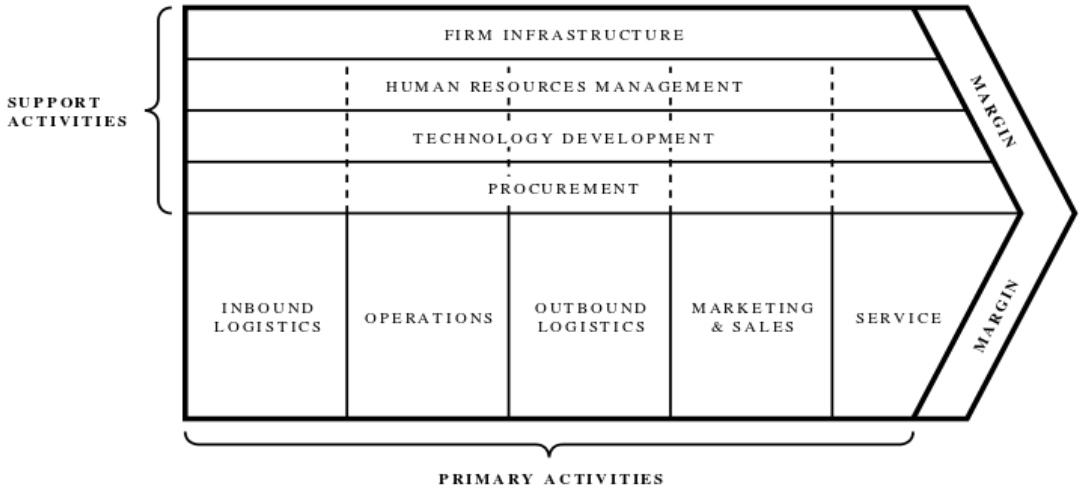


Figure 2-1 Porter's Value Chain CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)

The value chain itself describes the relationship between suppliers, manufacturers/producers, and the customer, with value being defined as the "maximum amount a customer is willing to pay to procure a good or avoid something undesirable from the provider". It also defines value as a product of the manufacturer's *Primary activities*, *Support Activities,* and their relationship to one another (Pitelis, 2009, Porter, 1985).

2.1.1 Primary Activities

The primary activities of a company are defined by Porter as:

Table 2-1 Porter's Primary Activities

Inbound Logistics	Operations	Outbound Logistics	Marketing & Sales	Service
Processes relating to the transport and storage of raw material input	The processes that turn raw material input into a product	Activities that distribute a product to a consumer	Promotion of products to potential customers, retailers….	Customer Service, Repair etc…

2.1.2 Supporting Activities

The supporting activities of a company are defined by Porter as:

Table 2-2 Porter's Support Activities

Firm Infrastructure	Human Resources	Technology Development	Procurement
Physical infrastructure as well as administrative operations	Hiring, Training, staff development etc….	Technological Development that assists the performance of activities	Raw Material Acquisition

Note that supporting activities take place concurrently to primary activities but may have varying amounts of interaction, procurement for example will overlap heavily with inbound logistics but may interact very little with marketing & sales.

2.1.3 Labour Theory of Value

Other theories that define the nature of value exist, such as the Labour Theory of Value. In LTV, value is defined as the product of constant capital and depreciated value (c), value used to purchase labour (v), and surplus value (s) added to create the overall value (W) with manufacturers and merchants work together to create surplus value (Fine, 1975).

$$c + v + s = W$$

1.) Equation of the Labour Theory of Value

These concepts are not inherently contradictory if we view Porter's Value Chain as an analysis of the amount and effectiveness of *Labour* required to get a product to the customer as the LTV broadly defines value as a function of total labour hours.

2.2 Supply & Value Chain Quantification

Quantification of a value chain analysis is not a simple task, and it is important to note that it is not the same as supply chain quantification. It has been noted that measurement of profit within a value chain is usually only able to be defined in abstract terms (Raikes et al., 2000). Supply chain metrics are well defined (Bhagwat and Sharma, 2007, Kleijnen and Smits, 2003), but there is a dearth of validated metrics for the performance of value chains. Proposed methods of value chain quantification include scorecard balancing (Rich et al., 2011). Rich et al. also state that the "data requirements to characterize relationships between discrete actors in a value chain can quickly become overwhelming", an issue that may be overcome in the near future due to developments in the field of artificial intelligence with machine learning already being applied for the use of quantification of supply chains (Momenitabar et al., 2023, Hosseinnia Shavaki and Ebrahimi Ghahnavieh, 2023).

2.2.1 Scorecard Balancing

Balanced scorecards require the definition of value chain goals and methods of measuring these goals, such as Key Performance Indicators (KPIs), and using these metrics to create a balanced scorecard (Kaplan and Norton, 1992). For supply chain analysis, this is a relatively simple task, given that the KPIs are well defined. It is a more difficult task to create scorecards for VCA due to the lack of defined KPIs.

2.2.2 System Dynamics Approach

A study on the Ethiopian beef export trade used IEES's STELLA tool to conduct a quantitative analysis, mostly of the downstream side, of the Ethiopian export beef value chain (Rich et al., 2009). This was done by mapping the system dynamics of the value chain.

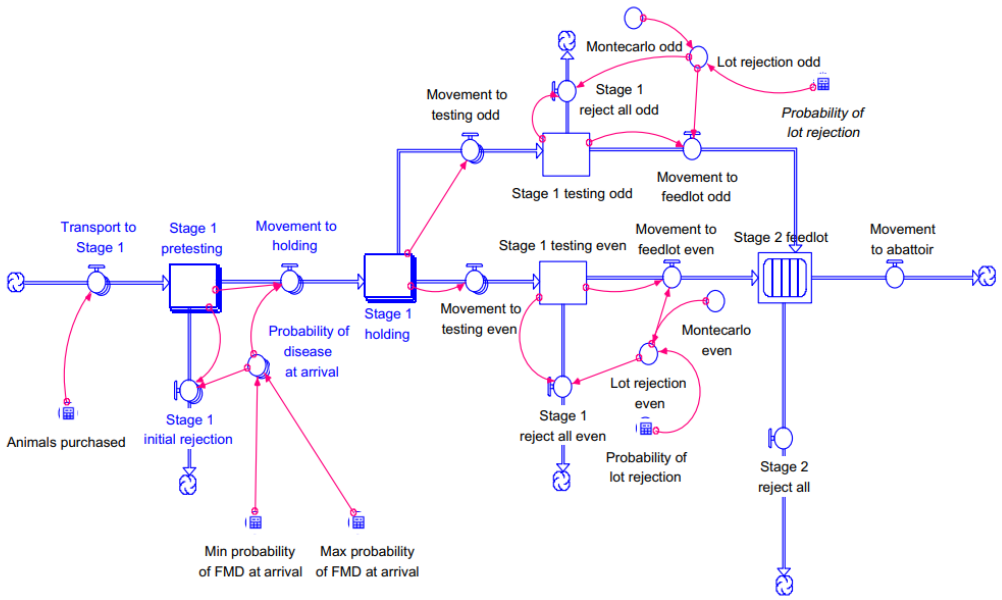


Figure 2-2 STELLA diagram of the two-phase SPS certification process. (Rich et al., 2009)

According to the authors, the advantage of such an analysis is the ability to map quantitative actions to the actors and internal governance of the value chain responsible. It also allowed the authors to simulate value chain interventions which could result in improved outcomes, such as reducing the costs of live animal stock, which had in reality been elevated at the time (Rich et al., 2011). It is clear however that a system dynamics approach does not generalize well, it requires custom models to be built for any given value chain analysis. The aforementioned scorecard balancing method, could be generalized easily, but will likely be more abstract than it is quantitative.

2.3 Supply & Value Chain Benchmarking

Benchmarking in supply and value chain management is the process of analysing the performance outcomes of processes in use by industry leaders and their competitors, where that information may be available, and comparing it with the performance of competitors and of the internal operations of the organization conducting the benchmarking. This is generally done as a quality improvement strategy (Hong et al., 2012). Hong et al. define the benchmarking process as a cyclical one.

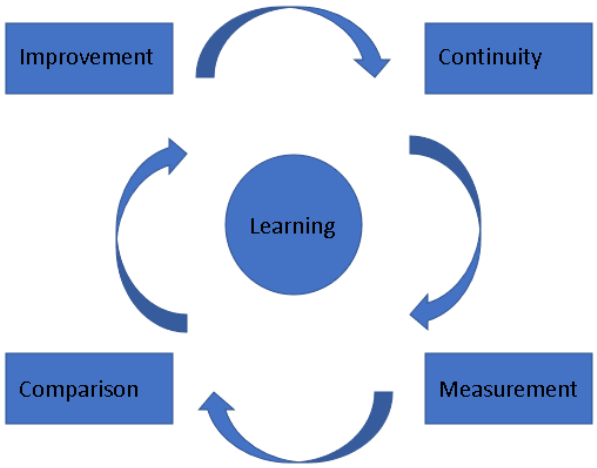


Figure 2-3 The Benchmarking Cycle, (Hong et al., 2012)

Hong et al. also defines 4 types of benchmarking:

- Organizational Strategy Based
- Operational Effectiveness Based
- Technical Efficiency Based
- Macro Benchmarking

Where Macro-benchmarking may refer to benchmarking of different industries, countries, or trading blocks, such as the EEA, US-MEXICO-CANADA etc. This type of benchmarking has

particular relevance as markets become increasingly globalized.

Hong et al. also reference five barriers to effective benchmarking taken the from Harvard Business Review (Szulanski and Winter, 2002).

1. Uncooperative Sources
2. Strained Personal Relationship
3. Internal Competition
4. Overemphasis on Innovation
5. Cranky Copiers

2.4 Current Supply Chain Megatrends and Their Relevance to VCA

The term Megatrends is typically used to refer to overarching changes in industries, economies or technology that have industry-wide or even global consequences for the supply chain and consequently the value chain. Megatrends can be good, i.e., increased productivity due to advancements in AI (Hosseinnia Shavaki and Ebrahimi Ghahnavieh, 2023), digitization (Vendrell-Herrero et al., 2017), virtual integration (Bowersox et al., 2000), or bad, i.e., disruption due to the proliferation of large conflicts (Jagtap et al., 2022), climate change (Chonnikarn and Toffel, 2013), and pandemics such as COVID-19 (Guan et al., 2020, Alabi and Ngwenyama, 2023) Some megatrends also have connotations for ethical and climate initiatives that are integral for the creation of sustainable supply chains. For the purpose of this literature four prevailing Megatrends are discussed, this is not an exhaustive list.

2.4.1 Digitization

It is easy to forget that the digital era is still in its relative infancy, and that many industries, businesses, and governments are still in the process of adopting digitization. Digitization is an umbrella term that refers to the use of digital platforms to sell goods and store information, but also the conversion of formerly physical products into digital ones and upstream owners becoming dependent suppliers on digital platforms that control consumer interaction. Therefore, digitization presents excellent opportunities for cost reduction, enhanced efficiency, and the ability for manufacturers to disintermediate retailers and sell directly to consumers, but also can create dependencies that are not necessarily mutually beneficial and cannibalize physical avenues of production. (Vendrell-Herrero et al., 2017).

2.4.2 Artificial Intelligence

Deep learning algorithms have the potential to revolutionize the supply chain. Deep learning methods have been used for trend forecasting, (Sales, Demand, Price…) Quality management, financial management and have the potential to out-perform human

managers at these tasks (Hosseinnia Shavaki and Ebrahimi Ghahnavieh, 2023).

2.4.3 COVID19

The COVID19 virus showed the vulnerability of the supply chain to disruption caused by global pandemics. The most significant internal impacts of the pandemic on the supply chain were the operational, logistical, and service disruptions caused by things like social distancing, lockdowns and barriers to international movement that had not previously been present. It also presented a unique learning opportunity for companies to develop resilient supply chains (Alabi and Ngwenyama, 2023, Guan et al., 2020).

2.4.4 Climate Change

The most significant challenges the global supply chain is the impact of disruption due to increasing occurrences of climate disasters as well as being subject to increasing regulation which may have adverse effects on the supply chain. Improving the climate action of a company has also been shown to increase brand value in some circumstances (Chonnikarn and Toffel, 2013).

2.5 Ethics, Sustainability, and the Circular Economy

2.5.1 Ethics

Responsible supply chains are important due to the negative effects that the shirking of ethical responsibility has on people living and working in the areas where the sourcing of raw materials takes place. The responsibility not only lies on suppliers to act ethically but also on manufacturers to insure that they source ethically, so as to avoid the 'outsourcing of responsibility' by engaging in anti-labour practices, the use of forced labour, child labour and dangerous working conditions (Blowfield, 2003, Calvão et al., 2021). The greatest barrier to the implementation of ethical sourcing is the requirement for producers to take at least some responsibility for the actions of third parties, which they may not be willing to do (Blowfield, 2003).

2.5.2 Sustainability

Supply chain sustainability scandals are a growing concern for firms, who are increasingly seen by the public as being responsible for the detrimental environmental and societal effects of their internal operations, such as child labour use by Nike and unsustainable waste disposal (Chonnikarn and Toffel, 2013, Koberg and Longoni, 2019). Sustainability scandals can affect the demand for products from a particular company and unwanted outcomes such as the boycotting of products by consumers. In the context of VCA it is important for companies to identify opportunities for sustainable practices to be implemented to maintain value.

2.5.3 Circular Economy

The concept of the circular economy is a production cycle which reuses materials and eliminates the waste that occurs at every step of the supply chain. The circular economy is a trending topic in supply chain management as it is seen as a feasible actualization of sustainable practices, that is less ambiguous than simply encouraging "sustainability" (Kirchherr et al., 2017). The circular economy is illustrated in Figure 2-4 below.

Figure 2-4 The Circular Economy Cycle, source: EU Research Service

2.6 Assimilation

Value chain analysis is an important tool for producers in creating surplus value for the customer. Porter's value chain is a tool which helps companies visualize the relationships between their primary and support activities and how those relationships can create or reduce value, by defining the value chain as the internal process that create a product and get it to the consumer. The tool can also be used to benchmark a particular company's value chain performance against industry leading practice. The beneficial and disruptive effects of Megatrends such as COVID19 response, and Digitization are discussed, as well as ethical and sustainable practice in the supply chain.

2.6.1 Literature Approach

A broad-narrow approach was taken in the writing of this literature review. The broad concept of value chain analysis was introduced first, followed by possible approaches to quantitative analysis, benchmarking, megatrends, and finally ethical and sustainable practices. The purpose of structuring the literature review in this way is to ensure foremost that a potentially unfamiliar reader is comfortable with the concept of Porter's Value Chain and VCA prior to introducing concepts such as benchmarking and quantification, which would be largely meaningless without an understanding of what VCA is. A second reason for structuring the literature review in this manner is to give the reader the ability to link ethical

considerations, sustainability, and megatrends back to the concepts of VCA introduced at the beginning of the review.

This is a relatively compact literature review. Concepts such as megatrends, sustainability and ethics could be elaborated on further as there is no shortage of megatrends or ethical problems in the global supply chain, however it was deemed that intimate knowledge was not necessary to convey a good understanding of the relevance to value chain analysis.

In summary, this literature review:

- Introduces the concept of Value Chain Analysis.
- Provides a high-level explanation of Porter's Value Chain.
- Discusses Quantification and Benchmarking techniques for VCA.
- Contextualizes Supply Chain Megatrends, ethics, and sustainability with respect to VCA.

The literature review uses Harvard referencing style as it was deemed more appropriate for a management focused paper than engineering styles such as IEEE. DOIs and URLs are provided where they are available. Marx's Capital (Fine, 1975) was read in print.

2.6.2 Use of AI

Supporting Artificial intelligence tools, such as ChatGPT, were not used in the course of writing this literature review.

3 Methodology & Design

The first step of the design process was to develop a new iteration of Porter's value chain that takes Digitisation, Artificial Intelligence, Sustainability and Ethics into account. These topics were identified as key issues for the modern supply chain based on the literature review. Digitisation and AI were grouped together as there is significant overlap between the two topics. Similarly, Sustainability and Ethics were also grouped together in the redesigned Value Chain. See Figure 3-1 below.

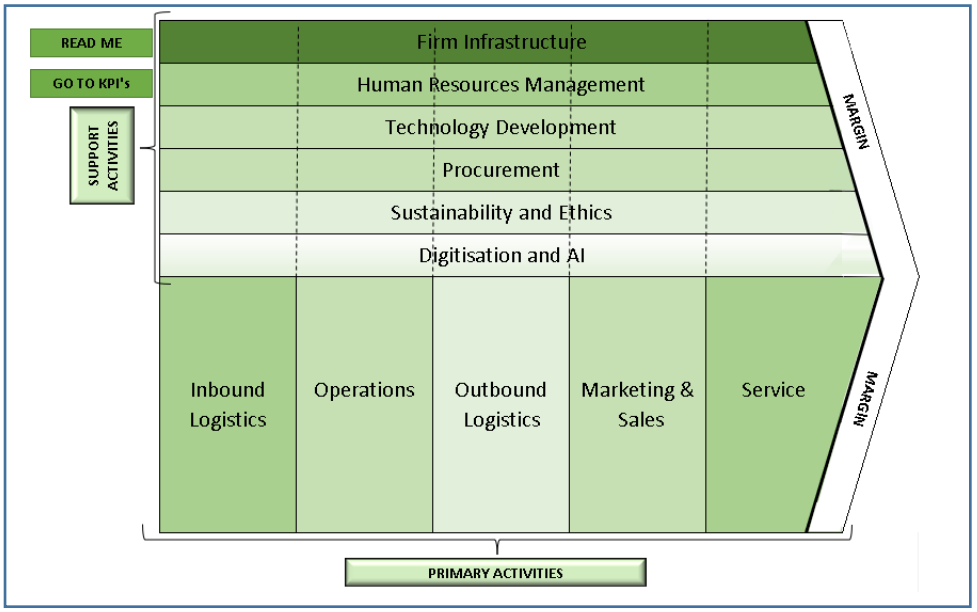


Figure 3-1 Redesigned Porter's Value Chain

The goal of the design process was to create a tool which is:

- Accessible, Adaptable, and Easy to use.
- Takes Internal and Competitor KPI data input from the user.
- Uses input data to assign performance scores to the primary activities.
- Uses input data to assign scores to the support activities involvement in each primary activity individually.
- Calculates an average score to assess the overall performance of Support activities.
- Uses automation.

3.1 Tool Description & User Flow

The tool consists of eight sheets in an excel workbook:

Sheet 1:

Hub page that displays an interactive redesigned Porter's Value Chain which redirects to pages for Primary Activities, buttons to navigate to a brief Read-Me and KPI input page. Also contains a table of scores for all activities.

Sheets 2-6:

Pages for each individual primary activity where the user must input data for specified KPIs of all the supporting activities. These sheets aslo include an interactive normalizer that the user can use to calculate normalized values where comparison of metrics requires normalization.

Sheet 7:

Primary activity KPI input page. The KPIs on this page can be modified by the user and copied to sheets 2-6 using the specified macro.

Sheet 8:

A brief read me that explains how to use the tool.

See Figure 3-2 below for the user process flow chart, with automatic collation and calculation of scores shown in green.

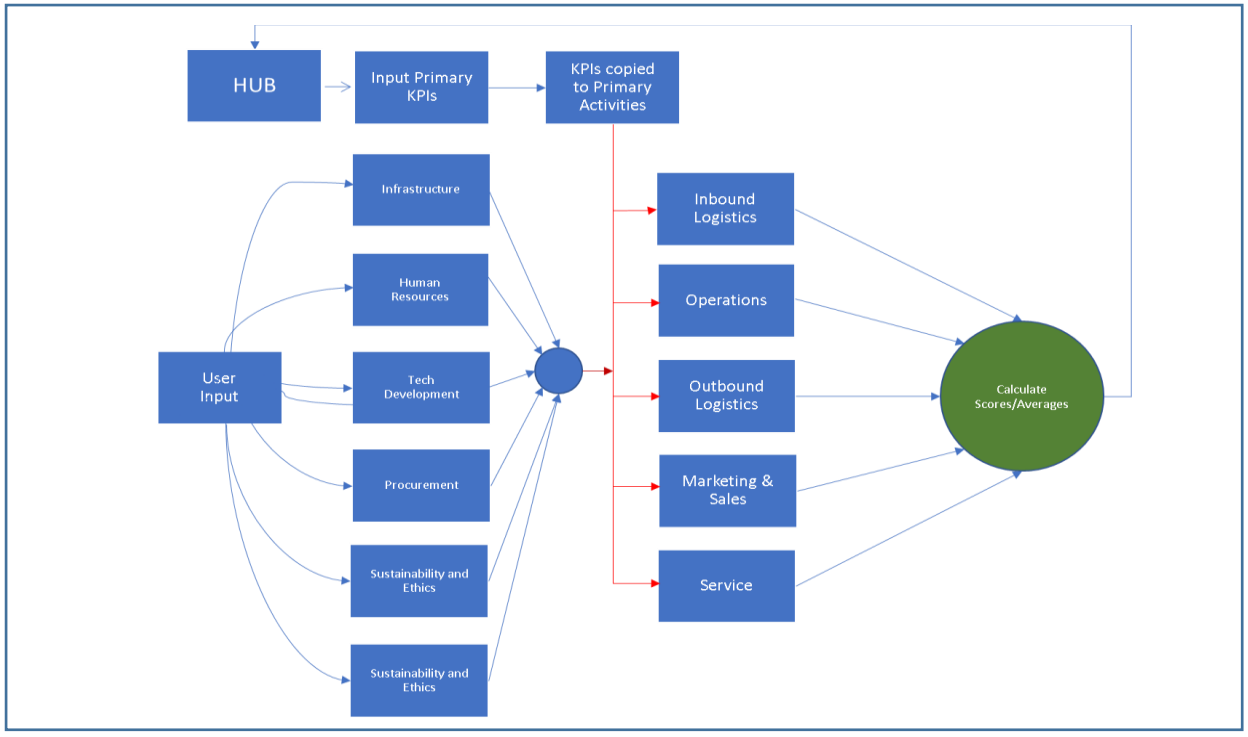
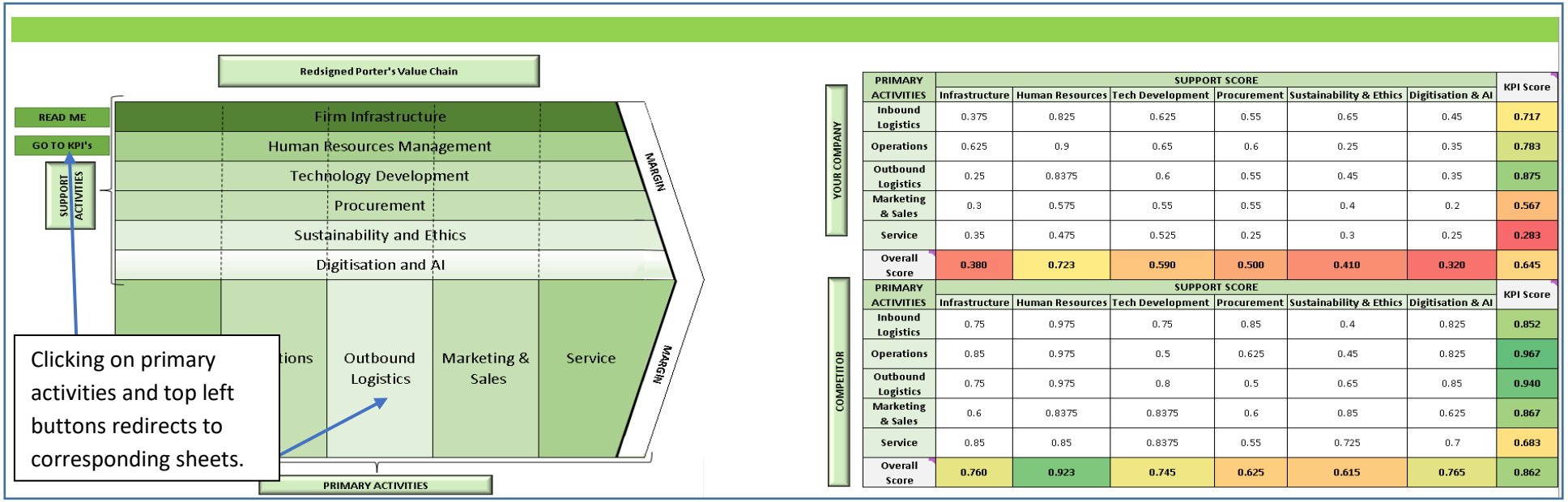


Figure 3-2 Tool User Process Flowchart

4 Tool Development

4.1 Hub Page

Inclusion of an interactive graphic of Porter's Value Chain serves to remind the user of how to approach Value Chain Analysis using Porter's methods. The table on the right displays the performance scores for the user's company and a competitor's, with the summed average values colour coded for ease of comparison between the two companies. The values are automatically obtained from the activity sheets and use Excel's AVERAGE function for the relevant KPIs. See Figure 4-1 below.



PRIMARY ACTIVITIES	SUPPORT SCORE						KPI Score
	Infrastructure	Human Resources	Tech Development	Procurement	Sustainability & Ethics	Digitisation & AI	
Inbound Logistics	0.375	0.825	0.625	0.55	0.65	0.45	0.717
Operations	0.625	0.9	0.65	0.6	0.25	0.35	0.783
Outbound Logistics	0.25	0.8375	0.6	0.55	0.45	0.35	0.875
Marketing & Sales	0.3	0.575	0.55	0.55	0.4	0.2	0.567
Service	0.35	0.475	0.525	0.25	0.3	0.25	0.283
Overall Score	0.380	0.723	0.590	0.500	0.410	0.320	0.645

PRIMARY ACTIVITIES	SUPPORT SCORE						KPI Score
	Infrastructure	Human Resources	Tech Development	Procurement	Sustainability & Ethics	Digitisation & AI	
Inbound Logistics	0.75	0.975	0.75	0.85	0.4	0.825	0.852
Operations	0.85	0.975	0.5	0.625	0.45	0.825	0.967
Outbound Logistics	0.75	0.975	0.8	0.5	0.65	0.85	0.940
Marketing & Sales	0.6	0.8375	0.8375	0.6	0.85	0.625	0.867
Service	0.85	0.85	0.8375	0.55	0.725	0.7	0.683
Overall Score	0.760	0.923	0.745	0.625	0.615	0.765	0.862

Figure 4-1 Benchmarking Tool Hub Page

Figure 4-2 below shows the code that allows the interactive use of the Value Chain graphic. It works by selecting the range of cells where the shape for each Primary Activity is located and redirects to the corresponding pages.

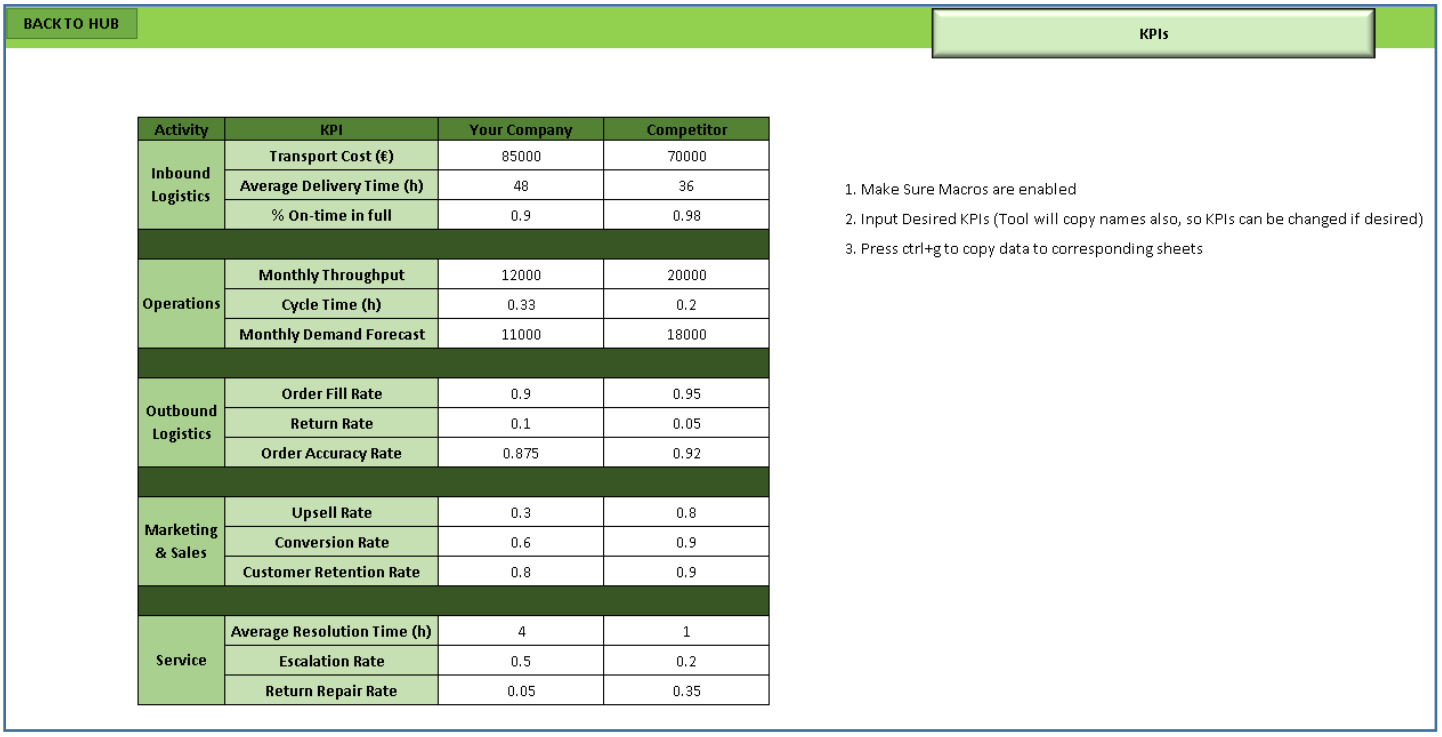
```
Private Sub Worksheet_SelectionChange(ByVal Target As Range)

    'Selects range of cells where the primary activity shape is located, and redirects to corresponding sheet on click

    If Not Intersect(Target, Range("C19:C30")) Is Nothing Then Application.Goto Worksheets("Inbound Logistics").Range("A1"), True
    If Not Intersect(Target, Range("D19:D30")) Is Nothing Then Application.Goto Worksheets("Inbound Logistics").Range("A1"), True

    If Not Intersect(Target, Range("E19:E30")) Is Nothing Then Application.Goto Worksheets("Operations").Range("A1"), True
    If Not Intersect(Target, Range("F19:F30")) Is Nothing Then Application.Goto Worksheets("Operations").Range("A1"), True

    If Not Intersect(Target, Range("G19:G30")) Is Nothing Then Application.Goto Worksheets("Outbound Logistics").Range("A1"), True
    If Not Intersect(Target, Range("H19:H30")) Is Nothing Then Application.Goto Worksheets("Outbound Logistics").Range("A1"), True

    If Not Intersect(Target, Range("I19:I30")) Is Nothing Then Application.Goto Worksheets("Marketing & Sales").Range("A1"), True
    If Not Intersect(Target, Range("J19:J30")) Is Nothing Then Application.Goto Worksheets("Marketing & Sales").Range("A1"), True

    If Not Intersect(Target, Range("L19:L30")) Is Nothing Then Application.Goto Worksheets("Service").Range("A1"), True
    If Not Intersect(Target, Range("M19:M30")) Is Nothing Then Application.Goto Worksheets("Service").Range("A1"), True

End Sub
```

Figure 4-2 VBA Value Chain Graphic Redirection Code

The “Read Me” and “KPI” buttons (See Figure 4-1 on previous page) on the hub page use Excel’s hyperlink function to redirect to their respective pages.

4.2 KPI Input Page

The KPI input page requires the user to input Primary Activity KPIs. This page is meant to be adaptable and so the KPIs can be changed if the user desires. The page makes use of macros to automatically copy the KPI names and values to the corresponding pages for each activity.



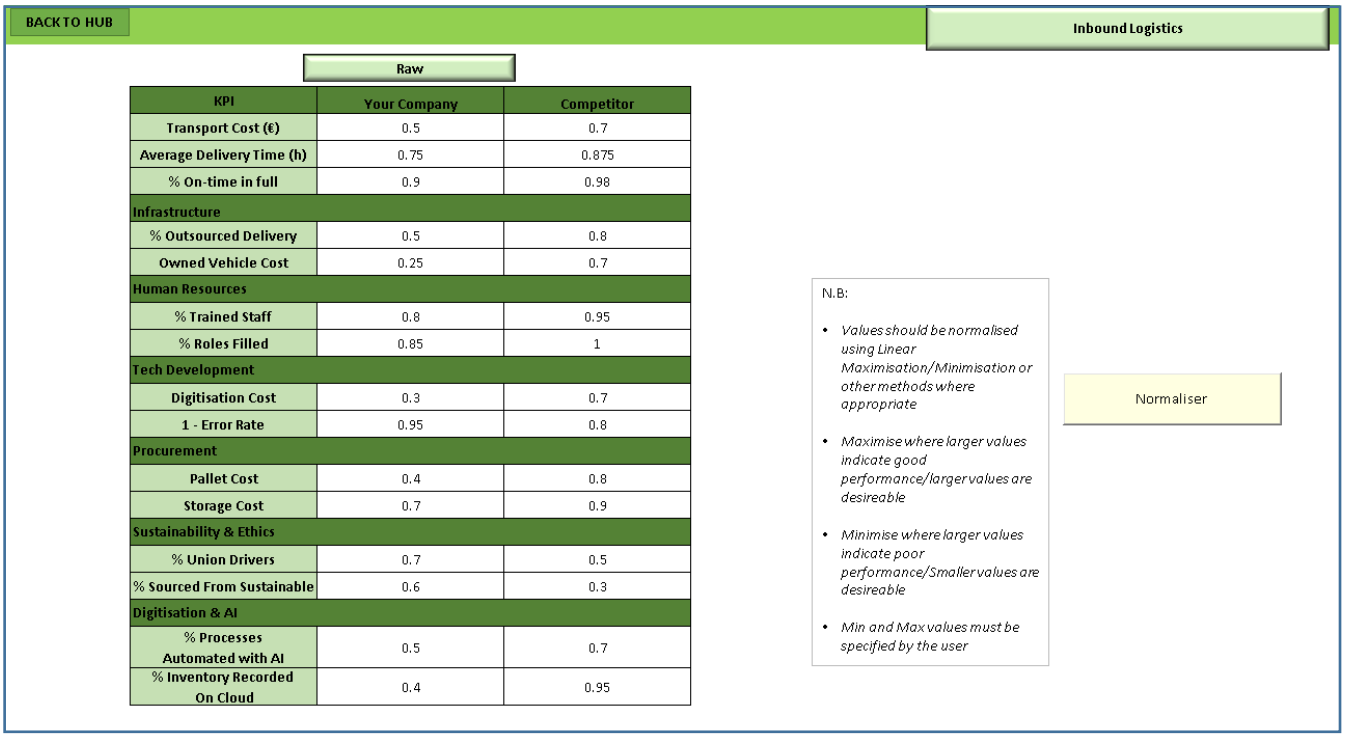
Activity	KPI	Your Company	Competitor
Inbound Logistics	Transport Cost (€)	85000	70000
	Average Delivery Time (h)	48	36
	% On-time in full	0.9	0.98
Operations	Monthly Throughput	12000	20000
	Cycle Time (h)	0.33	0.2
	Monthly Demand Forecast	11000	18000
Outbound Logistics	Order Fill Rate	0.9	0.95
	Return Rate	0.1	0.05
	Order Accuracy Rate	0.875	0.92
Marketing & Sales	Upsell Rate	0.3	0.8
	Conversion Rate	0.6	0.9
	Customer Retention Rate	0.8	0.9
Service	Average Resolution Time (h)	4	1
	Escalation Rate	0.5	0.2
	Return Repair Rate	0.05	0.35

Figure 4-3 Primary Activity KPI input page

All pages, except for the hub page, feature a “BACK TO HUB” button in the top left corner which redirects the user back to the main page, where they can easily navigate between pages or view collated results.

4.3 Primary Activity Page (Inbound Logistics)

Figure 4-4 below shows an example of a primary activities page. The KPI values in the first three rows are copied from the KPI input page. The KPIs for supporting activities are based information from the literature review and are meant to quantify the performance of supporting activities as much as possible. As noted in the literature review, quantification of some value chain activities, such as ethics, can be difficult and is usually defined in the abstract. (Raikes et al., 2000) It is important to note that Digitisation cost is seen as being positive when the cost is higher. This is to reflect the fact that a greater percentage of Digitisation in a company is seen as a positive but will of course necessitate a higher Digitisation cost than having few digital processes.



KPI	Your Company	Competitor
Transport Cost (€)	0.5	0.7
Average Delivery Time (h)	0.75	0.875
% On-time in full	0.9	0.98
Infrastructure		
% Outsourced Delivery	0.5	0.8
Owned Vehicle Cost	0.25	0.7
Human Resources		
% Trained Staff	0.8	0.95
% Roles Filled	0.85	1
Tech Development		
Digitisation Cost	0.3	0.7
1 - Error Rate	0.95	0.8
Procurement		
Pallet Cost	0.4	0.8
Storage Cost	0.7	0.9
Sustainability & Ethics		
% Union Drivers	0.7	0.5
% Sourced From Sustainable	0.6	0.3
Digitisation & AI		
% Processes Automated with AI	0.5	0.7
% Inventory Recorded On Cloud	0.4	0.95

Figure 4-4 Inbound Logistics Page

4.4 Normaliser

Some KPIs require normalization for comparison. For example, cost and the rate of on-time in full orders. A normalizer is provided for this. It requires the user to specify their own desired maximum and minimum values and to copy the result to corresponding cell manually. See Figure 4-5 below.

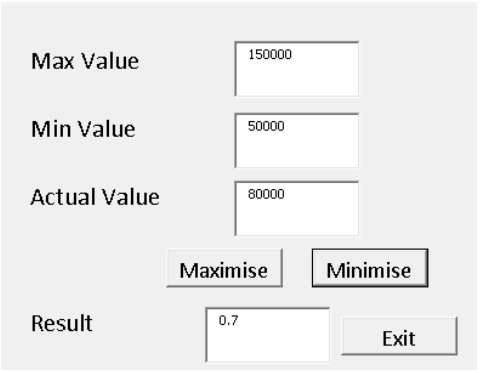


Figure 4-5 Linear Minimisation in the Interactive normaliser.

The normaliser is displayed using a button labelled “Normaliser” in each activity page.

```
Private Sub CommandButton1_Click()

UserForm1.Show

End Sub
```

Figure 4-6 VBA Code to display the interactive normaliser.

The normaliser features two options, linear maximisation, and minimisation. This requires the user to have at least some knowledge of which option is appropriate for their specific needs.

```
Private Sub CommandButton1_Click()

' Linear Maximisation
TextBox4.Value = (TextBox3.Value - TextBox2.Value) / (TextBox1.Value - TextBox2.Value)

End Sub

Private Sub CommandButton2_Click()

' Linear Minimisation
TextBox4.Value = (TextBox1.Value - TextBox3.Value) / (TextBox1.Value - TextBox2.Value)

End Sub

Private Sub CommandButton3_Click()

' Close Form
Unload UserForm1

End Sub
```

Figure 4-7 VBA Code for Interactive Normalizer Operations

A prompt is given in each page to remind the user of the need for normalisation, with some simple guidelines for what is appropriate.

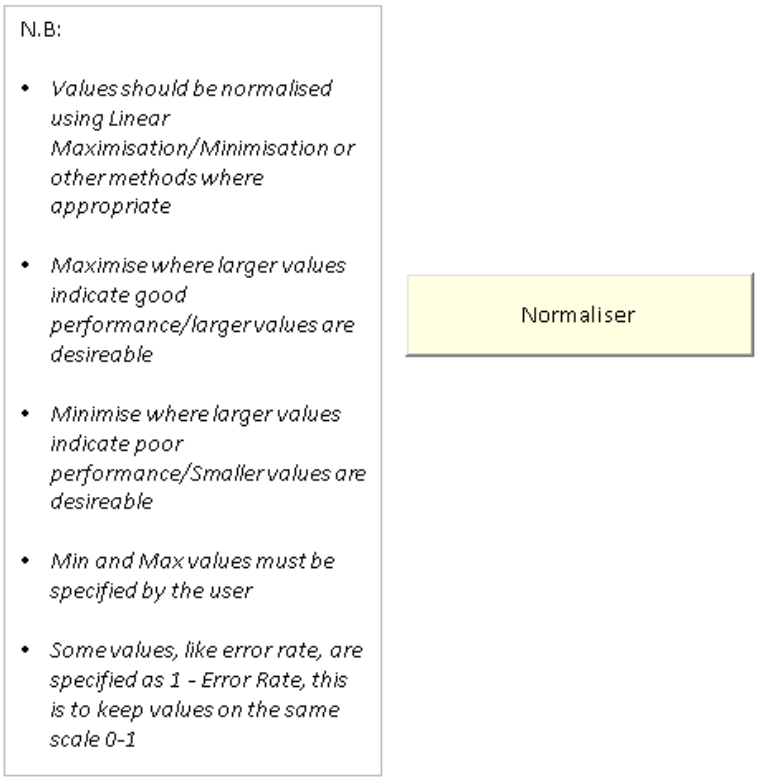


Figure 4-8 Note to inform users about the need for normalisation.

4.5 Benchmarking Table

The benchmarking table is featured on the Hub page. It uses functions in each cell to get the relevant values from the pages/cells required to calculate averages for each score.

	PRIMARY ACTIVITIES	SUPPORT SCORE						KPI Score
		Infrastructure	Human Resources	Tech Development	Procurement	Sustainability & Ethics	Digitisation & AI	
YOUR COMPANY	Inbound Logistics	0.375	0.825	0.625	0.55	0.65	0.45	0.717
	Operations	0.625	0.9	0.65	0.6	0.25	0.35	0.783
	Outbound Logistics	0.25	0.8375	0.6	0.55	0.45	0.35	0.875
	Marketing & Sales	0.3	0.575	0.55	0.55	0.4	0.2	0.567
	Service	0.35	0.475	0.525	0.25	0.3	0.25	0.283
	Overall Score	0.380	0.723	0.590	0.500	0.410	0.320	0.645
	PRIMARY ACTIVITIES	SUPPORT SCORE						KPI Score
		Infrastructure	Human Resources	Tech Development	Procurement	Sustainability & Ethics	Digitisation & AI	
COMPETITOR	Inbound Logistics	0.75	0.975	0.75	0.85	0.4	0.825	0.852
	Operations	0.85	0.975	0.5	0.625	0.45	0.825	0.967
	Outbound Logistics	0.75	0.975	0.8	0.5	0.65	0.85	0.940
	Marketing & Sales	0.6	0.8375	0.8375	0.6	0.85	0.625	0.867
	Service	0.85	0.85	0.8375	0.55	0.725	0.7	0.683
	Overall Score	0.760	0.923	0.745	0.625	0.615	0.765	0.862

Figure 4-9 Benchmarking Score Table from Tool

The supporting activity scores are divided for each primary activity to represent the fact that they will have different levels of involvement and impact depending on the activity. The layout of this table allows ease of comparison between two companies.

The scores are on a scale of 0 to 1, where 1 is the maximum, and are colour coded to reflect how close they are to the maximum.

An overall average of support scores and KPI scores is not calculated as the individual performances provide better insight to the user than an overall average which would be largely meaningless.

5 Conclusions

5.1 Functionality, Limitations and Potential Improvements

5.1.1 Functionality

The final design is a fully functional benchmarking tool which assigns quantifiable values to each activity represented on the redesigned Porter's value chain. It also allows for the user to simulate certain interventions, such as lower transport costs for example, to see the effect that this has on their overall scores. The tool also allows the user to quantify individual overall scores for their supporting processes and primary activities which can help identify correlation between areas where their company falls short, and competitor excel.

5.1.2 Limitations

The tool has a number of significant limitations. It requires the user to have access to a large amount of competitor data, which may not be available to them for myriad reasons (Szulanski and Winter, 2002, Hong et al., 2012). It also requires the user to be knowledgeable about certain mathematical conventions such as normalisation for the tool to function correctly. A user with a weak background in mathematics and statistics could easily make mistakes while using this tool. It also only allows the user to benchmark against a single competitor at a time, something that could make benchmarking slow if the user desires to compare multiple parties. The tool requires a large amount of user input, this is largely unavoidable due to the variable nature of the user's potential intentions.

Other limitations are the relatively ambiguous nature of analysis of supporting activities like sustainability and ethics. Every effort was made to think of quantifiable metrics for these things however the number of ways in which a company can fail in these areas is vast and sometimes unknowable.

5.1.3 Potential Improvements

The design could be greatly improved by increasing the amount of automation in use. The number of KPIs evaluated could also be extended to allow for a more in-depth analysis as in its current iteration the analysis is relatively shallow. The tool could also be extended to allow for comparison of a larger number of competitors. The inclusion of lookup tables could also improve the tool by making it more adaptable, if the user has a large amount of

KPI data available. The tool does not have the ability to store the results of a particular benchmarking session for future reference, so this functionality could also be added. Future iterations of the tool should seek to include all of these improvements.

5.2 Comparison to the Literature

The design of the tool reflects every aspect covered in the literature review to some degree, and in particular the elements that were not present in Porter's original design. The inclusion of KPIs for the new support activities such as,

- % of Union Drivers
- % Of repairs using recycled material
- % Processes Automated using AI

Are meant to reflect Sustainability, Ethics, the Circular Economy, Digitisation and AI.

The tool also allows the user to engage in the cycle of benchmarking specified by Hong et al, although it does not offer functionalities that are conducive to storing information for the learning, improvement, and continuity functions of the cycle. Users have to record this data themselves and insure that they are benchmarking effectively.

Something that is not reflected in the tool is benchmarking for emergency response to supply chain disruptions due to large international conflicts, unexpected pandemics such as COVID-19 and climate disasters. These could be accounted for with changes to some of the KPIs.

5.3 Summary

The final design is a functional but limited tool, that is probably best suited for small or medium enterprises. It reflects all of the necessary requirements for modern supply chain analysis and benchmarking identified in the literature review and uses partial automation to speed up the benchmarking process.

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