A DECISION SUPPORT SYSTEM FRAMEWORK FOR LOCALISATION INVESTMENT SELECTION

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ABSTRACT

Formulating localisation strategies is crucial to ensuring the development of local suppliers, which in turn results in job creation, increased export earnings, and local and national economic growth. The aim of this article is to present a generic decision support system (DSS) to guide localisation decision-making. Multi-criteria decision analysis (MCDA) is used to develop the model, which is then applied to a biometric identity management system (BIMS) case study that places the study within the context of the tool, die and mould-making (TDM) industry of South Africa.

OPSOMMING

Die formulering van lokaliseringstrategieë is van kardinale belang om die ontwikkeling van plaaslike verskaffers te verseker, wat op sy beurt lei tot werkskepping, verhoogde uitvoerverdienste, en plaaslike en nasionale ekonomiese groei. Die doel van die artikel is om 'n generiese besluit ondersteunings stelsel (BOS) vir lokalisering besluitneming aan te bied. Multi-kriteria besluitneming analise (MKBA) word gebruik om die lokalisering besluit ondersteuning stelsel te ontwikkel. Die model is van toepassing op 'n biometriese identiteit bestuur stelsel (BIMS) gevallestudie, wat die studie plaas binne die konteks van die 'tool, die and mould-making' (TDM) bedryf van Suid-Afrika.

1 INTRODUCTION AND PROBLEM STATEMENT

Globalisation and the rise of the multinational enterprise have driven rapid advances in technology, and created pressure on new market entrants and the possibilities of accessing new markets [1]. This in turn has sparked the policy drive to focus on the development of local industries and value chains [2][3]. To this end, local value chain development goes hand-in-hand with economic development and acts as a major driving force in both job creation and skills development. From here on termed 'localisation', this process entails the process of organising a business or industry so that its main activities occur in local areas rather than importing from international locations [4]. Given its important place in driving growth, informed localisation strategy development and decision-making are critical to ensuring success. This also makes it important to understand the drivers behind a firm's localisation investments, and the influence of those decisions on a geographical location [5].

There is an urgent need to identify sectors and projects in South Africa that have local content opportunities, and to leverage these in collaboration with multinationals [6]. In order to invest in the development of local content and suppliers, a structured approach to localisation decision-making is required [2]. This approach involves determining what the important factors are when making localisation decisions, and to place them in a framework to facilitate easy and efficient decision-making. The challenges presented are to strategise and devise plans for overcoming uncertainty about what products to source locally, and what products to source from foreign locations [5].

Tooling, also known as 'machine tooling', is the process of acquiring the manufacturing components and machines needed for production. The direct tooling industry in South Africa amounts to a R13 billion market [7]. The manufacturing and tooling sector has a 17 per cent contribution to gross domestic product (GDP) in South Africa, equivalent to R282 215 million in 2010 [8]. It is a valuable and prominent industry, and contributes greatly to job creation, export earnings, and economic growth.

However, the South African tool, die and mould-making (TDM) and precision machining industry has lost significant capacity over the past 25 years and, with it, its global competitiveness and ability to enhance job creation. Local companies have failed to evolve and adopt new technology; and ageing skills capacity has led to a skills shortage in the TDM industry. As a result, local content satisfies less than 15 per cent of the local TDM demand and less than one per cent of international TDM demand [6].

With future tooling demand expected to grow in the various tooling sectors, South Africa needs to identify the growth potential in the tooling industry and to use the opportunity to expand the tooling environment to improve global competitiveness and penetrate international markets [9].

The primary objective of this article is to present a generic decision support framework to guide the decision-making process in selecting optimal localisation investment opportunities. To achieve the primary objective, it is necessary to identify the relevant factors that are important when making localisation decisions [10]. The generic decision support framework consists of different criteria to evaluate a project against the various factors that are important to support localisation decisions, and that ultimately determine the direct influence on local society, the environment, and the economy.

2 A BRIEF LITERATURE REVIEW

2.1 Localisation policy imperatives in South Africa

The South African National Industrial Policy Framework (NIPF) states that its vision for the industrialisation of South Africa's economy should be achieved through diversifying beyond reliance on traditional commodities and non-tradable services, intensifying industrial process and the knowledge economy, developing more labour-absorbing industrialisation, economic transformation, and developing productive capabilities [11].

Furthermore, South Africa has a number of national policies that include in their objectives the development of local content. Firstly, the Industrial Policy Action Plan (IPAP) drives public and private procurement, leveraging South Africa's resource endowment, and supporting manufacturing exports [12]. Secondly, The Professional Development Programme (PDP) aims strategically to develop, promote, and manage international relationships, opportunities, and Science and Technology (S&T) agreements that strengthen the National System of Innovation (NSI) and enable an exchange of knowledge, capacity, and resources between South Africa and its regional and international partners. The PDP programme also supports South African foreign policy through science diplomacy [13]. Thirdly, the New Growth Path (NGP) is adopted as a framework to drive South Africa's job strategy. The NGP presents a dynamic cooperative vision to achieve a more cohesive, democratic, developed, and equitable economy and society that continuously promotes sustainable growth [14]. Fourthly, under South Africa's Preferential Procurement Policy Framework Act and Regulations (the latest revision having been released in December 2015), the government has 'designated' certain manufactured goods. In other words, the goods in question must reach a certain minimum threshold of local production and content if they are to be accepted for use in government-initiated projects.

Returning to the vision of the NIPF, the focus is on developing industrial capacity in the tradable sector [11]. The tradable sector of a country's economy typically consists largely of sectors that are part of the manufacturing industry, while the non-tradable sector consists of locally rendered services such as construction, health care, retail, and education, which rely on traders and consumers to be in the same location, rather than across borders. The tradable sector is directly responsible for tradable demand, and as a result it is the industry sector whose direct outputs account for most of a country's international trade.

The Department of Trade and Industry (DTI) identified 10 important factors when dividing sectors into tradable and non-tradable goods. For an industry, project, or venture to support tradable demand, the factors that need to be considered include growth prospective, job creation prospects, size of the sector (employment), degree of market failure, sectoral multiplier, responsiveness of the sector, export potential, import-replacement potential, maturity of the sector, and national priority [15].

2.2 Sustainable development

Larson (1986) defines ‘sustainable development’ in a technical context as “balancing the fulfilment of human needs with the protection of the natural environment so that those needs can be met not only in the present, but in the indefinite future”. The United Nations (UN) defines development as “an increase in well-being across the members of a society between two points in time” [16]. The concept of sustainable development adopts a holistic approach that reflects economic, environmental, and social dimensions [17]. Sustainability recognises that all three dimensions must be considered and tightly integrated to achieve lasting prosperity [18]. For any development to be verified as sustainable, the development must actively engage sustainability under each of the dimensions of sustainability [16].

Sustainable development can be used as a concept to guide the support of industry development effectively. Sustainable development presents a multi-faceted approach to ensuring growth, while simultaneously supporting skills development and transfer, employment, and sustainability for a country to achieve long-term social, environmental, and economic success [19].

A range of measurement frameworks has been introduced in the literature to guide sustainability assessments. Three of these were reviewed for the purpose of this paper.

Table 1: Comparison of sustainable development frameworks

Measure of sustainability	Appeal of the measure	Limitations of the measure
Triple bottom line (TBL)	The TBL measure incorporates the areas of a business (or project) that are performing, along with the areas that require improvement. TBL reporting exhibits a drive towards increased transparency, which meets the concerns shown by stakeholders, and reflects higher levels of accountability by management. Reporting on sustainability provides a benchmark for the future [20].	The guidelines of TBL can be difficult to maintain, in terms of its practical usefulness and its validity [21]. If TBL reporting is applied as a measure of sustainable development, the additional time may initially negatively affect their (financial) bottom line, by increasing the task complexity of their operations [22].
The capital theory approach (CTA)	The attractiveness of the capital theory approach is that it advocates simple steps to ensure sustainability and relatively simple indicators of sustainability. In practice, most applications of the CTA have supported green accounting [23].	The CTA itself provides an exclusive framework for approaching a policy for sustainable development. The CTA does recognise complexities at lower scales of analysis [23].
The green national net product (GNNP)	The GNNP supports an understanding of the wellbeing that an organisation experiences, or the damage it is suffering. Policy-makers can assess the projects for maintaining environmental services or declining environmental degradation by using the GNNP accounting value [24].	The GNNP measure of sustainability accounts for the financial dimension of sustainability, but fails to account for the environmental stewardship dimension, and only partially accounts for the social progress dimension [24].

2.3 Value-added analysis

The activities and actions that result from an investment decision can create or destroy value. Value-added analysis aims to identify the value-adding activities of a project and/or investment, and to measure the amount of value added. It captures the total value of the investment by translating the social, economic, and environmental objectives into financial and non-financial measures. When conducting a total value analysis, a much broader concept of value is measured and accounted for. It is crucial to improve the overall well-being by incorporating the social and environmental costs and benefits to ensure long-term sustainability [25].

Social return on investment (SROI) is a method for analysing and understanding the social and environmental value being created, in addition to the financial value being generated by an investment. The SROI uses cost-benefit techniques to measure whether rthe benefits outweighs the cost of the initial investment [26]. SROI can be broadly defined as the ratio of the net present value (NPV) of the benefits to the NPV of the investment [27].

Table 2: Comparison of value-added analysis frameworks

	Application	**Difficulties**
Cost-benefit analysis (CBA)	CBA is used to analyse a single investment to determine whether the total social and environmental benefit exceeds the cost. The CBA technique can also be used to compare alternative investments, to determine which one achieves the greatest overall benefit for society [28].	CBA technique requires placing dollar values on all (or most) costs and benefits. Some benefits , however, are not measurable in terms of dollar value [28].
Cost effectiveness analysis (CEA)	The CEA is useful when the desired outcome is clear and a decision needs to be made to determine which investment will achieve the most favourable outcome. It is also applicable to cases where outcomes are intangible or difficult to monetize [28].	The CEA technique provides no direct value for the output, leaving some degree of judgement in the decision-maker’s hands [29].

2.4 Risk assessment for investment in the South African TDM industry

‘Risk’ can be defined as a function of the likelihood and impact of the occurrence of an unplanned event. Investment decisions cannot be made without a certain degree of risk being associated with them [30]. ‘Impact’ (also referred to as ‘consequences’) refers to the extent to which the occurrence of a risk event might affect a company, project, and/or industry. When assigning an impact rating to a risk, it is crucial to assign the rating for the highest impact anticipated [31]. ‘Likelihood’ represents the possibility (or probability) that an event will occur. It can be expressed using quantitative terms – as a frequency, or as a percentage probability [31]. The universal risk assessment measure is the relationship between the likelihood and the impact of the identified risks. When risks are evaluated, the assessment criteria should be concise [32]. Without a standard comparison it is not possible to compare and aggregate risks across a project [31].

The three main risk categories considered in this article are economic, societal, and technological risk. Economical risk is a reality of the economic environment, and cannot always be anticipated or foreseen [33]. South Africa’s economy has shown growth, but at a slower rate than projected in the 2012 budget. Initiatives are in place to support economic growth. However, far more support and investment is required to reach the target growth rate [34].

The following economic risk factors are crucial to the development and success of the TDM industry in South Africa:

- The economic slowdown: Global factors contribute to the current economic climate in South Africa. Some of these include falling oil prices, China’s economic slowdown, and the expected tightening of monetary policy in the United States [35].

The societal risk category captures risks related to social stability, and includes risk factors such as skills shortages and uncertain labour relations that prevent the expansion of the TDM industry.

- Skill shortage: The skill shortage is blamed on the emigration of high-skilled workers, immigration restrictions on high-skilled foreigners, and an education system that is not providing labourers with the adequate skills to function in the TDM workplace [35].
- Increasing labour action: South Africa is faced with regular work stoppages because of strikes [35].

The technological risk category has the highest likelihood of major impact on the TDM industry in South Africa. The risks include those related to the growing centrality of information and communication technologies to individuals, businesses, and governments [35].

- Lack of innovation: For the South African TDM industry to be competitive in the global economy, it is critical that it support continuous innovation.

- Inefficient energy supply: South Africa continues to face power disruptions and supply constraints.

3 METHODOLOGY

Many techniques and processes are available to formulate a methodology for the development of a generic decision-making framework. Three methods – the rational model, the multi-criteria decision analysis (MCDA), and the conceptual framework analysis (CFA) – are reviewed to provide a structure for the development of the decision support framework that will guide localisation decision-making.

Rational decision-making can be defined as the process through which a decision is made, using a systematic approach, in solving a problem in a logical, practical and objective manner [36]. The model aims to follow a systematic process to define a problem, identify and evaluate alternative solutions, and so reach the best solution [37].

MCDA is a decision support tool used to make decisions that involve multiple dimensions and/or criteria [38]. MCDA, sometimes also referred to as 'multi-criteria evaluation' or 'multi-criteria decision modelling', is relevant when there are difficult decisions to be made with multiple and often conflicting objectives that decision-makers might value differently [39]. MCDA provides a broad framework for supporting situations with complex decisions, using three basic steps: problem structuring, model development, and model approval [39].

Conceptual framework analysis (CFA) aims to develop concepts, integrate concepts, and ultimately reach an optimal solution. Each concept has its own attributes, characteristics, limitations, assumptions, distinct perspectives, and specific functions within the conceptual framework, which clarifies the scenarios represented by the concepts themselves [40].

The three research methodologies are evaluated against criteria based on the research objectives the project aims to achieve.

Table 3: Comparison of research methodologies considered

Criteria	**The rational model** [37]	**MCDA** [39]	**CFA** [40]
The methodology makes provision for qualitative research.	√	√	√
The methodology can be used to solve problems in complex decision environments.	√	√	x
The methodology enables the decision space to take multiple criteria into account.	x	√	x
The methodology is flexible and can be adapted specifically to the problem at hand.	x	√	√
The methodology provides a systematic approach to developing a logical decision-making model.	√	√	√
The methodology includes a validation phase to approve the model.	x	√	√

The MCDA was identified as the most appropriate methodology, given its systematic approach to scenarios where multiple criteria should be taken into consideration [41]. The phases of the MCDA method were broken down into seven sequential steps, with relevance to the localisation model being developed in this article. Section 4 below unpacks the structure and methods used to develop each step of the localisation decision-making framework.

Following the development of the framework, the article presents the model validation process that was supported through primary data-gathering by means of a series of interviews, a survey, and a case study.

Table 4: Summary of model validation steps undertaken

Type of validation	Purpose of validation	Method of validation
Tool and context validation	The validation process helped to keep the approach to developing the framework dynamic and the tool relevant with valuable inputs throughout the development of the framework. Input was obtained, inter alia, to place the framework in the context of local supplier development.	Validation, with a tooling expert at Stellenbosch University, by conducting interviews at multiple points in time during the development of the tool.
Tool validation	To determine the relevance and importance of the localisation DSS framework to industry.	At a workshop session during the Global Conference of Sustainable Manufacturing 2016, the research project was presented, and surveys were handed out to tooling experts, with 20 responses received.
Case study	To test the functionality of the localisation DSS and its ability to reach accurate localisation solutions when applied to a case study.	The DSS framework was applied to the BIMS case study. The project manager provided the information required by answering a questionnaire, derived from the data collection guideline.

4 TOWARDS A LOCALISATION DECISION SUPPORT FRAMEWORK

This section presents the development of the decision support framework that will act as a tool to guide the decision-making process along a set of seven sequential steps, as discussed below.

4.1 Phase 1: Problem structuring

Step 1 - Tradable demand: To determine whether the project falls within the tradable sector, the project is evaluated against the DTI's 10 factors that are relevant to tradable demand: growth prospective, job creation prospects, size of the sector (employment), degree of market failure, sectoral multiplier, responsiveness of the sector, export potential, import-replacement potential, maturity of the sector, and national priority [15]. The evaluation matrix method was regarded as the most appropriate for allocating relevant weights (scores) to each factor, and ultimately to score the project against the tradable criteria [42]. Each factor forming part of the criteria is prioritised, with greater weighting given to items of greater importance [43].

Step 2 - Project breakdown: In order to apply the following steps, the project needs to be broken down into different parts and/or components.

4.2 Phase 2: Model development

Step 3 - Localisation policies: Three localisation policies – IPAP [44], PDP as part of DST [45], and NGP [14] – were identified as relevant to the localisation process. A heat map was used to evaluate the degree (using a colour scale) to which a project conforms with and is supported by local policies [46]. Heat maps were used to visualise matrices, with a colour corresponding to each factor's magnitude [47]. The diverging scale heat map method is especially useful when a range of quantitative values are sensibly distributed into two categories, such as negative and positive values, or conformance or non-conformance [46].

Step 4 - Sustainability: Sustainable development is measured through the triple bottom line approach. The TBL is the most extensive measure of sustainability reviewed, and the indicators can be adapted to project specifications. The T-chart technique (binary assessment) is used to assess the TBL, and the prioritisation method is applied to determine whether the project is primarily socially, economically, or environmentally driven [22], [48], [49] [50], [51].

Table 5: Summary of triple bottom line dimensions [22], [48], [49] [50], [51].

Sustainability category	Indicators considered in the framework
Economic growth	Innovation, capital efficiency, risk management, margin improvement, growth enhancement, total shareholder return
Socio-economic	Job creation, skill enhancement, local economic impact, social investments, business ethics, security, fair trade, workers' rights, sponsorships, training and development
Social progress	Diversity, human rights, community outreach, indigenous communities, labour relations, equal opportunity, education
Socio-environmental	Safety and health, environmental regulators, global climate change, access to potable water, crisis management, environmental justice, natural resource stewardship
Environmental stewardship	Pollution prevention (air, water, land), emission reduction, zero waste releases and spills, biodiversity conservation, conservative natural resource use, permit and licence compliance
Eco-efficiency	Resource efficiency, product stewardship, life-cycle management, renewable energy, improved technology

Step 5 - Value-added analysis: Social return on investment (SROI) analysis is used to determine the social benefit of manufacturing a part locally with reference to the initial capital investment. SROI calculations include the NPV of the benefits and investment respectively, as well as the payback period.

The second part of the value-added analysis uses cost-effectiveness analysis (CEA) to determine which investment will achieve the most favourable outcome. CEA is a technique that relates the cost of an investment to the key outcomes and/or benefits [28], and provides guidance about investments with regard to practicality and feasible in a given social and economic environment. It supports the selection of the preferred investment based on the cost effectiveness (CE) ratio [28], [52].

Step 6 – Risk assessment: Technological, societal and environmental risks in the context of the South African tooling industry are rated in terms of their likelihood of occurrence and the impact if they do occur. The likelihood versus impact of each risk is plotted. Parts and/or components can be classified according to the quadrant of the opportunity matrix in which the majority of risks fall.

4.3 Phase 3: Model validation

Step 7 – Summary and conclusion: The final step entails constructing a quick reference summary of the integrated results of the localisation decision-making framework. A recommendation is made about which parts should be developed and manufactured by local suppliers, and which parts are economically and socially can more feasibly be sourced from international manufacturers. Furthermore, according to the summary, further investigation can be done to determine what must change in each step in order to localise other parts not initially identified as potential local content.

4.4 In conclusion: The synthesised DSS framework

Table 6 presents the complete formulation of the localisation investment decision support system (DSS) framework, and summarises the steps in the framework within the relevant MCDA phase with the required inputs and achieved outputs.

Table 6: Synthesis of localisation DSS framework

	Steps in the DSS framework	Input(s)	Output(s)
Phase 1: **Problem structuring**	Step 1: Tradable demand	Factors of tradable sectors: Growth prospective Job creation prospects Size of the sector Degree of market failure Sectoral multiplier Responsiveness Export potential Import replacement potential Maturity National priority	Knowledge about tradable demand, and confirmation that the project falls within the tradable sector.
	Step 2: Project breakdown	The structure of the project or product.	The project broken down into individual parts and/or components.
Phase 2: **Model development**	Step 3: Localisation policies	Local policies: IPAP PDP (as part of DST) NGP	Determines which parts conform to local policies that apply to supporting local TDM content development in South Africa.
	Step 4: Sustainability-ty	The TBL measures: Environmental stewardship Socio-environmental sustainability Social progress Economic growth Socio-economic sustainability Eco-efficiency	Determine the sustainability and long-term feasibility of the parts. Determine for which parts local manufacturing offers sustainable development and long-term social progress, environmental stewardship, and economic growth.
	Step 5: Value-added analysis	SROI: Stakeholders Inputs (investment) Outputs Outcomes Impact PV NPV CEA & efficiency: Cost/part Success rate	The stakeholders, the key activities, and the outcomes of manufacturing a part are identified. The social value of manufacturing a part is determined against the initial capital investment. The cost-effectiveness and efficiency ratios are calculated to determine the economic value of manufacturing parts locally rather than importing.
	Step 6: Risk assessment	Technological, environmental, and societal risk assessment based on likelihood and impact.	Determine which of the parts present high attraction investment opportunities for manufacturing the part locally.
Phase 3: **Model Validation**	Step 7: Summary and localisation recommendation	Integrated results from each step, colour-coded on the basis of the result from the criteria presented in each step of the DSS framework.	A recommendation on which parts to manufacture locally and which parts to source from international manufacturers. A comparison should be made for identified parts between changes in local manufacturers and sourcing from international manufacturers, to make further recommendations.

5 RESULTS

5.1 Framework and tool validation

The localisation decision support framework was presented at a workshop session at the Global Conference of Sustainable Manufacturing 2016. Surveys were handed out to experts in the tooling industry. The surveys acted as a method of validation, to determine the relevance and importance of the core components of the localisation DSS framework to industry.

The survey featured questions referring to each step of the DSS framework and their importance when making localisation decisions. The importance of each step could be rated on a scale from '1' (not important) to '5' (very important). The table shows the detailed responses to the survey question about the importance of each criterion in the localisation DSS framework to making localisation decisions in industry (20 responses were received).

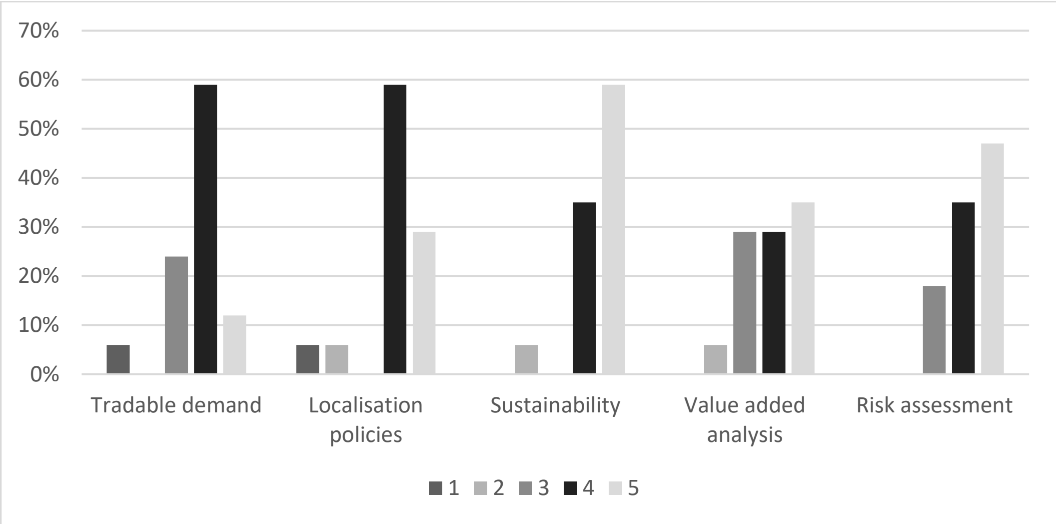


Figure 1: Ranking of importance of DSS framework categories

From an analysis of the responses shown in Figure 1, it can be concluded that the bulk of the respondents thought that it was important that all five dimensions of the DSS be included in the analysis. Sustainability was regarded as the most important factor to consider when making localisation decisions, with risk assessment a close second. The value-added analysis and localisation policies components have about the same level of importance. The tradable demand component of the DSS framework is regarded as the least important factor when making decisions about local content.

5.2 Biometric identity management system (BIMS) case study

The biometric identity management system (BIMS) is a device that assists in registering and verifying the identities of individuals. It is a finger print scanner that automatically connects to the Department of Home Affairs database to register, de-duplicate, and verify identities rapidly, to ensure effective and efficient services (e.g., at voting stations and banks) and actively to prevent identity fraud. The technology captures and stores individuals' fingerprints, iris data, and facial images. BIMS is more inclusive and accurate in matching an identity and de-duplicating multiple enrolment attempts. The localisation decision-making framework is applied to the biometric identity management system (BIMS) project.

5.2.1 Phase 1: Problem structuring

Step 1 - Tradable sector: The first step of the localisation DSS framework acts as a filter to ensure that the project falls within the tradable demand. The BIMS project was scored against the weighted criteria of the 10 factors of a tradable sector. A masters student at Stellenbosch University who was conducting research into local supplier development, together with a research stakeholder of the BIMS project, scored the project (see

Table 7).

Step 2 - Breakdown into parts: In partnership with the Stellenbosch Technology Centre (STC), five local suppliers were identified to assist in manufacturing the various components of the BIMS device. The primary supplier of the moulds manufactures the moulds, and then they are distributed to the other suppliers to oversee the production of the individual parts. For the validation of this study, the 11 parts manufactured and produced by the primary supplier were used (see

Table 7).

Table 7: Outcomes of steps 1 and 2

Step 1: The tradable demand score for the BIMS project

Factor	Score
Growth prospective	4
Job creation prospects	3
Size of the sector	2
Degree of market failure	2
Sectoral multiplier	2
Responsiveness	2
Export potential	4
Import-replacement potential	4
Maturity/degree of governance	2
National priority	3
Total	**28**

Step 2: BIMS project parts breakdown

Part #	Description
1	Display casing
2	Keyboard housing cover
3	Keyboard housing front face
4	Keyboard housing rear
5	Keyboard screen housing front
6	Keyboard screen housing rear
7	Inner ethernet cover
8	Outer ethernet cover
9	Battery cover
10	SIM card cover
11	Printer cover

5.2.2 Phase 2: Model development

Step 3 - Localisation policies: Each of the parts identified in

Table 7 is assessed against the criteria of the three localisation policies. The assessment also included the degree to which the different aspects of the localisation policies are applicable to the manufacturing of the parts and, in the case of the BIMS project, are relevant to the project as a whole. The analysis of the PDP policy indicates alignment throughout, which can be credited to the research contribution and support from Stellenbosch University to the BIMS project. Both undergraduate and postgraduate students are actively involved in different research and skill development aspects of the project.

Table 8: Outcomes of localisation policy analysis

Criteria	Compliance with policy?
Industrial policy action plan (IPAP)	
Does the production of the part facilitate diversification beyond the current reliance on traditional commodities and non-tradable services?	√
Does the production support the long-term intensification of South Africa's industrialisation process, and movement towards a twenty-first century economy?	√
Does the production promote more labour-absorbing industrialisation paths, with an emphasis on tradable labour-intensive goods and services that catalyse employment creation?	X
Does it promote a broader-based industrialisation path characterised by greater levels of participation by historically disadvantage economic citizens?	√
Does it contribute to industrial development in Africa, with emphasis on building regional productive capabilities?	√
New growth path (NGP)	
Pursuing a strategy of redistribution of income, wealth, economic power, and resources.	X
Creating productive, decent work for all South Africans.	X
Pursuing a strategy of industrialisation; identifying sectors and building linkages between sectors.	√
Meeting the basic needs of the people: housing, water, energy, education, healthcare, and social protection	X
Promoting fair and equitable trade, industrial and social development across the Southern African region.	√
Promoting an environmentally sustainable social and economic development strategy.	√
Professional development programme (as part of the DST)	
Does it leverage innovation and research at public research institutions, science councils, and national facilities in South Africa, through the implementation of science and technology-related skills development?	√

Does it enable recently qualified doctoral graduates to gain research experience in a research institution, science council, or national facility, thereby improving their prospects of permanent employment in the science and technology sector?	√
Does it attract and retain young scientists and professionals of the highest calibre in order to complement senior researchers' influence on the current science and technology research system?	√
Does it support young scientists and professionals in basic and applied research, and promote innovation?	√

Step 4 - Drivers for sustainable development: The sustainability of each part is measured with the use of the triple bottom line (TBL) concept. The six dimensions of the triple bottom line are presented in matrix form to determine the parts for which local manufacturing offers sustainable development and long-term growth potential. The six matrices are populated with either a '1' (yes) or a '0' (no). The results from the sustainability step of the DSS framework are illustrated in Figure 2. The TBL matrix shows that parts six to eleven are marginally less sustainable, as these parts are the smaller and less expensive moulds. The lack of sustainability can be credited to the lower profit margins and the little skill development and enhancement that the small parts offer, as opposed to the more complex moulds. The matrix determined that for, parts one to five, there remains a higher degree of sustainable development and long-term growth potential. Part one, the display casing, achieved the highest sustainability score. The display casing is the body of the BIMS device, and required more innovation and technical input than the other more general parts.

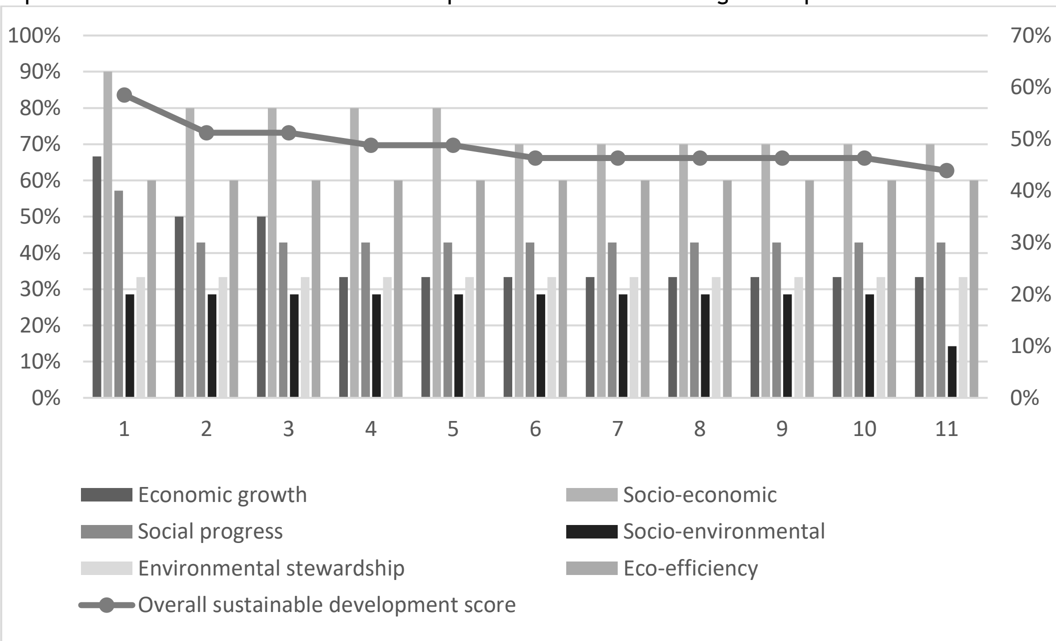


Figure 2: Drivers for sustainable development by part

Step 5: Value-added analysis: The value-added analysis has two components: the SROI and the cost-effectiveness and efficiency ratios.

The SROI identifies the stakeholders, inputs, outputs, and outcomes to calculate the impact and to determine whether the benefits of manufacturing the parts locally outweigh the initial capital investment. For all the parts, the SROI is greater than the value of one. This implies that the local suppliers create both economic and social value by manufacturing each of the parts. The SROI thus shows that manufacturing by local suppliers reduces the tension between learning and accountability by placing the perspectives of the stakeholders at the core of the valuation process.

For the second part of the value-added analysis, the cost-effectiveness and efficiency ratios are calculated to determine the economic value of manufacturing parts locally as opposed to outsourcing them from international manufacturers. The non-local manufacturing costs are quoted by the China Synergy Group, based on the estimated mould sizes of the various parts. The failure rate of the imported parts is assumed to be similar to those of the primary supplier – i.e., five per cent.

The cost-effectiveness and efficiency ratios are negative for parts one to five. These parts have the largest and most complex moulds, and can be sourced at lower cost from international manufacturers. For parts six to eleven, the cost-effectiveness and efficiency ratios are positive. This implies that the economic value of manufacturing parts locally is higher than that of non-local imports. This can be credited to the high labour cost, production cost, and setup costs of the machines to manufacture the mould, regardless of the size of the mould. Figure 5.7 shows the outcome of the value-added analysis for the BIMS project.

Table 9: Outcomes of value-added analysis

	SROI	Efficiency ratio	Cost-effectiveness ratio
1	0.0027	0.2962	0.2962
2	0.0008	0.4823	0.4823
3	0.0008	0.6590	0.6590
4	0.0003	0.7249	0.7249
5	0.0007	0.6598	0.6598
6	0.0010	1.9929	1.9929
7	0.0001	1.7584	1.7584
8	0.0002	1.7584	1.7584
9	0.0002	1.7584	1.7584
10	0.0003	1.7584	1.7584
11	0.0007	1.9929	1.9929

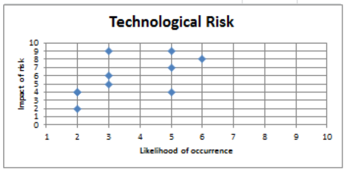
Step 6: Risk assessment: For the risk assessment, each part is given a likelihood of occurrence and impact, with occurrence scores for the technological, societal, and environmental risk factors. The likelihood can be defined as the probability of a risk occurring, and is scored on a scale from '1' (every day) to '10' (very seldom). The impact can be defined as the direct consequence when the risk materialises, and is scored on a scale from '0' (least/minor) to '10' (most/major). The risk factors with their corresponding scores are shown in Table 10. For each part, all the risks are plotted on an impact versus likelihood scale.

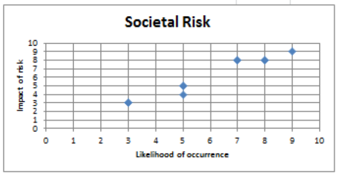
Table 10: Outcomes of risk assessment

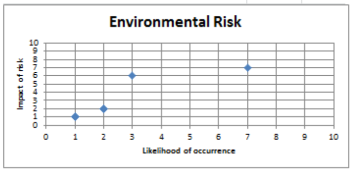
Technological risk	Likelihood	Impact
Computer crime/hacking/viruses/malicious codes	5	4
Technology failure/system failure	6	8
Lack of innovation	5	9
Insufficient electricity supply	3	9
Infrastructure and network failure	2	4
Data fraud and/or theft	3	6
New technology non-availability	2	2
Data explosion or data-related vulnerability	2	4
User errors	5	7
Service provider errors	3	5

Societal risk	Likelihood	Impact
Damage to reputation/brand	7	8
Failure to attract or retain top talent	3	3
Failure to innovate/meet customer needs	5	5
Increasing competition	8	8
Economic slowdown/slow recovery	8	8
Regulatory/legislative changes	5	5
Corruption	9	9
Skill shortage	5	4
Health epidemic	3	3
Strike action	7	8

Environmental risk	Likelihood	Impact
Water crisis	7	7
Earthquakes	1	1
Climate change	1	1
Natural catastrophes	1	1
Flooding	1	1
Fire	3	6
Decrease of local demand due to poverty	2	2
Food crisis	2	2
Failure of climate change mitigation and adaption	2	2
Biodiversity loss and ecosystem collapse	2	2







5.2.3 *Phase 3: Model validation*

Step 7 – Summary and conclusion: The integrated results of the localisation decision-making framework are presented in a colour-coded summary. A recommendation is made about which parts should be developed and manufactured by local suppliers, and which parts are economically and socially more feasible to source from international manufacturers.

Table 11: Outcomes of summary and conclusion of analysis

	Localisation policies	Sustainability	Value-added analysis			Attractiveness of investment (High/Low)
			SROI	Efficiency	Cost-effectiveness ratio	
1	√	√	√	x	x	High
2	√	√	√	x	x	High
3	√	√	√	x	x	High
4	√	√	√	x	x	High
5	√	√	√	x	x	High
6	√	x	√	√	√	High

7	√	x	√	√	√	High
8	√	x	√	√	√	High
9	√	x	√	√	√	High
10	√	x	√	√	√	High
11	√	x	√	√	√	High

The above summary table reflects that the integrated results of the BIMS project are predominantly positive. The recommendation is made that the manufacturing of parts six to eleven should be invested in by local suppliers. From the TBL matrix, it is clear that parts six to eleven are not fully classified as sustainable. These are the smaller and less expensive moulds. For parts one to five it is recommended that further investigation be conducted to determine whether the larger, more complex moulds could be manufactured by local suppliers at a lower cost. If not, the moulds should be sourced from international manufacturers. However, it is important to consider the advantages and disadvantages of using international manufacturers when making the decision.

6 CONCLUSION

Localisation decisions are made on a daily basis all around the world by participants such as corporate companies, start-ups, and governments. Local content and supplier development is critical to supporting the long-term economic growth and social progress of a country. The localisation decision-making framework provides a structured approach to selecting localisation investment opportunities. It is a generic tool that can be applied to any context and any industry to facilitate the easy and effective development of localisation strategies. The tool will provide increased organisational control of localisation decisions that ultimately support local suppliers as best possible.

The primary aim of the project was to develop a practical framework to support localisation decision-making. The localisation DSS framework will assist the user to make investment selections about which parts of a project should be developed by local suppliers, and which parts should be sourced from international suppliers. The framework does not only guide localisation investment selection, but also facilitates the development of localisation strategies.

In terms of primary objectives: a relevant and easy-to-use localisation decision support system framework was formulated. In terms of secondary objectives: the developed DSS framework is generic in nature, and can be used to make localisation decisions in any context and any industry. Validation of the tool was completed through expert interviews, a survey, and a case study (Table 12).

By using the localisation DSS framework, local opportunities can be identified and leveraged with greater ease. Opportunities that would have previously been overlooked are now realised through the application of the tool. Investing in local content development enriches the local community through increased job creation, increased wealth from exports, and enhanced economic growth. The proposed DSS framework is intended to raise awareness among important role-players of the importance of taking a structured approach to localisation decision-making.

Table 12: Outcomes of validation activities of the DSS framework

Type of validation	Method of validation	Results of validation
Tool validation	Validation with a **tooling expert** at Stellenbosch University by conducting **interviews** at multiple points in time during the development of the tool.	As a result of the continuously validation process with a tooling expert, the developed framework includes all the factors relevant when making localisation decisions. Therefore the framework, as a whole, is relevant and can be used in industry to support localisation decision-making.
Tool validation	At a workshop session during the Global Conference of Sustainable Manufacturing 2016, the research project was presented, and surveys were handed out to tooling experts.	The survey results reflect that the localisation DSS framework does account for the most important factors of local decision-making. With future improvements to the project, the tradable demand criteria could be removed from the framework.
Context validation	Through an **interview**, a final-year masters student at Stellenbosch University provided insight into the concept of local supplier development.	The DSS framework for localisation investment selection incorporates the higher-level needs of the lending and contract phases of local supplier development. The DSS framework is applied in the supply and demand phase - the second phase of local supplier development.

Application validation	The DSS framework was applied to the **BIMS case study**. The project manager provided the information required by answering a **questionnaire**, derived from the **data collection guideline**.	The recommendation is made that the manufacturing of parts six to eleven of the biometric identity management system (BIMS) be invested in by local suppliers. For parts one to five, it is recommended that further investigation be conducted to determine whether the larger, more complex moulds could be manufactured by local supplies for less.

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