Semantic integration of web data for international investment decision support

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Abstract. Given the current economic situation and the financial crisis in many European countries, Small and Medium Enterprises (SMEs) have found internationalisation and exportation of their products as the main way out of this crisis. In this paper, we provide a decision support system that semantically aggregates information from many heterogeneous web resources and provides guidance to SMEs for their potential investments. The main contributions of this paper are the introduction of SME internationalisation indicators that can be considered for such decisions, as well as the novel decision support system for SME internationalisation based on inference over semantically integrated data from heterogeneous web resources. The system is evaluated by SME experts in realistic scenarios in the section of dairy products.

Keywords: Decision support, Indicators, Heterogeneous web resources, SME internationalisation, Semantic integration

1 Introduction

Given the current economic situation and the financial crisis in many European countries, SMEs have found internationalisation and exportation of their products as the main way out of this crisis. To this end, SMEs need to find relevant information that will facilitate this process such as: i) spending habits of consumers in potential markets, ii) economic fundamentals of the countries (micro and macro indicators), iii) geographic and entry barriers (legislation, certifications, etc.), iv) consumer behaviour, v) domestic and foreign competition, vi) distributors of its product to export in the selected markets, vii) contact information of potential customers. In order to find this information, SMEs have to access foreign trade offices in each country (e.g. Chambers of Commerce), dedicated databases (e.g. Market access database, Eurostat, etc.), as well as the web by using general purpose search engines (e.g. Google). In these resources, the companies expect to find the competence, potential clients and all the information that is required to take a decision for exporting products to the right country. However, this method is time consuming and complicated, because information is distributed and heterogeneous and there is no existing platform that provides access to all the necessary information. The additional problem faced by many SMEs is the language barrier, since this information is usually provided only in the language of the host country. To deal with this problem, we need technologies that provide unified access to multilingual and multicultural economic material across borders in order to guide the international investments of SMEs.

In this paper we present a decision support system that semantically aggregates information from many heterogeneous web resources and provides guidance to SMEs for their potential investments. The main contributions of this paper are the introduction of SME internationalisation indicators that can be considered for such decisions, as well as the novel decision support framework for SME internationalisation based on inference over semantically integrated data from heterogeneous web resources. The SME internationalisation indicators are chosen between different data sources. They provide information about four main domains - Economy, Social, Politics and Product. These domains represent the most important aspects of the current situation in a given country. Each individual indicator is picked with the help of people working in SME organisations and is ranked according to their view on its importance. To the best of our knowledge, this is the first attempt to develop a decision support system for SME internationalisation.

The rest of this paper is organised as follows: Section 2 provides some theoretical background, as well as an overview of the related work. Section 3 describes the SME internationalisation indicators that are utilised by the decision support framework presented in this paper. The different components of the proposed framework are described in detail in Section 4. In Section 5, the experimental results from the application of the framework to data collected from several resources are presented and discussed. Finally, some concluding remarks are provided in Section 6.

2 Related Work

Decision support systems (DSSs) can be broadly defined as computer-based applications that support people and organisations in their decision-making processes. Research on this very important scientific field has spanned 50 years and many different kinds of systems have been presented. According to [1], DSSs can be divided into the following main categories:

- Model-driven DSSs: These include computerised systems that employ accounting and financial models, representational models, and/or optimisation models to assist in decision-making [2]. One representative system in this category is ILOG JRules [3]. Using model-driven DSSs can lead to substantial benefits, such as the reduction in decision process cycle time.
- Data-driven DSSs: These systems aim at accessing and processing large amounts of data. Simple file systems accessed by query and retrieval tools

provide the most elementary level of functionality in this category [4]. A nice example of data-driven DSSs is the Geographical Information System (GIS), which can be used to visually represent geographically dependent data using maps. Among other things, data-driven DSSs can provide improved data accessibility and fact-based decision making.

- Document-driven DSSs: Multimedia document collections serve as the backbone of the decision-making process in document-driven DSSs. Document analysis and information retrieval (IR) systems are simple examples from this category [5]. Improved information flow and flexible document retrieval are some of the advantages of using document-driven DSSs.
- Communication-driven DSSs: These systems aim at supporting groups of people working on a given task, by focusing on the interaction and collaboration aspects of decision-making. At its basic form, a system of this type can be a simple threaded e-mail and in its complex form, it can be an interactive video or a web communication application.
- Knowledge-driven DSSs: They actually recommend or suggest actions to the users, rather than just retrieve information relevant to a certain decision, i.e., these systems try to perform some part of the actual decision-making for the user through special-purpose problem-solving capabilities [5]. The use of knowledge-driven DSSs can result in more consistent decisions and can reduce the time needed to solve problems [6]. It should be noted that the framework proposed in this paper belongs to the knowledge-driven DSS category.

A detailed literature review with respect to the research conducted on the use of semantic web technologies in the DSS context can be found in [5]. A large number of semantic web-related studies have focused on the medical and healthcare domains. For instance, [7] explore the use of Web Ontology Language (OWL) reasoning services, in order to execute clinical practice guidelines (CPG) in clinical decision support systems (CDSSs). In [8], a generic architecture for the semantic enhancement of CDSSs, which also considers the reutilisation of knowledge embedded in a CDSS, is proposed. Another prominent research domain is e-commerce. In this context, [9] introduce a Semantic Web Constraint Language (SWCL) based on OWL and utilise it, in order to implement a shopping agent in the Semantic Web environment. Furthermore, [10] design and develop a shopbot that can help customers compare products located in e-stores, using different languages. In order to achieve this, they propose a semi-automatic method for constructing multilingual ontologies, as well as a semantic searching mechanism based on concept similarity. In another approach [11], the authors present a system that provides high quality environmental information for personalised decision support based on reasoning.

In addition to the aforementioned works, there have been some DSS-related studies that deal specifically with financial management and investment decision-making. More specifically, [12] employ the Object Oriented Bayesian Knowledge Base (OOBKB) design to develop a real-time DSS that supports managing of investment portfolios. In another work, [13] presents a hybrid intelligent system that consists of a DSS based on portfolio management rules, as well as a fuzzy inference system. Finally, a detailed analysis of tools implemented in DSS to support individuals in their financial management and investment decisions is provided in [14].

This paper, inspired by the ontology-based decision support systems, such as [9] and [11], presents a knowledge-driven DSS for SME internationalisation based on semantic integration of heterogeneous internet data.

3 SME Internationalisation Indicators

In most cases, the main issue for SMEs that want to internationalise is to assess the different countries that could be potentially interesting for exporting their products. The selection of the correct country for the international investment depends on a number of indicators, which allow a comparison and therefore help the decision-making process. In order to build the decision support tool, we need to combine the indicators in a sophisticated manner. To do that, we have to initially conduct a screening and establish a categorisation of the indicators so that we can prioritise and weight them according to their relevance. The grouping considered captures a framework of macroenvironmental criteria, which is considered in the strategic management of SMEs when assessing opportunities or threats. The study for the definition of indicators has taken place in the context of the MULTISENSOR project[1] with the support of the SME internationalisation department of PIMEC[2].

To analyse, select and organise the indicators and its grouping, we considered the PEST analysis together with other indicators more focused on the product. SMEs export managers with a vast experience on internationalisation assessment participated in the elaboration of the methodology of the decision support. As we are dealing with targeting foreign markets, the decision support tool needs to consider external factors. In this sense, the PEST analysis refers to the combination of Political, Economic, Social and Technological factors which can affect the business. Within this framework, contrasted indicators from reliable sources – e.g. Eurostat[3], World Bank[4] - were selected so that the final result is robust.

For a more complete and personalised feature, SME export managers agreed that there was a need for another group of indicators, directly related to the small company that is looking for a market to export. For this purpose, we included UN COMTRADE data, which measures trade for every product and set of products. Thus, the decision support tool incorporates the selected product data, so that the outcome is not only the result of general factors but also, and decisively, of the concrete product commercialisation.

Altogether, we obtain a combination between product specific and personalised data with country factors. Indeed, every indicator and group of indicators have a different importance when making a decision. Hence, the decision support tool integrates a differentiated weight for every indicator and category according to SME export managers' criteria. More specifically, we grouped the indicators into 4 categories:

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[1] http://www.multisensorproject.eu/
[2] http://www.pimec.org/
[3] http://eurostat.linked-statistics.org
[4] http://worldbank.270a.info/

- **Product**: This is the key category in our system, as it is directly connected with the product the SME is producing or offering. Here, we include UN COMTRADE data, which gives precise information of the export/import flows between countries worldwide, segmented by product in the Harmonised System code. We take into account trade between the targeted country and the rest of the world, as well as trade with the country of origin of the SME running the decision support tool. Furthermore, we incorporate a variable that measures the trade flows per capita. Lastly, distance between countries is included; a value that is given different weight depending on the product, as the type of good conditions the importance of a fast delivery. In all, the Product category captures the balance of trade of the specific products and brings very relevant information to compare the economic and consumption specificities of the countries in relation to SMEs' commercialisation.
- **Economy**: This category combines macroeconomic data that gives an input of the countries' recent economic performance – e.g. GDP growth, GDP per capita - together with general balance of payments data. Also, the Easiness Doing Business ranking from the World Bank plays a major role, as it describes how difficult it is to do business in every country, including variables such as how complex it is to start a business, to what extent contracts are enforced and how easy it is to trade across borders. Hence, we obtain a sum of the health of the countries' economies, its overall trade flows and its business and legal culture.
- **Politics**: Membership of economic areas and trade agreements constitute the basis of this category. In this sense, the main variables are being or not a member of the European Union, the European Economic Area or the European Free Trade Association, which affect commercial trade decisively. Additionally, legal certainty aspects are also included with indexes that reflect political stability, levels of corruption and government effectiveness.
- **Social**: This category has the lowest weight and embraces societal aspects that describe the market dimension and consumption possibilities of the countries with selected indicators such as their total population, their level of education or their unemployment rate. Furthermore, we include an economic perception index that gives us the sentiment that consumers have towards their economy, which can affect their preferences when it comes to consumption.

In Table 1, we present the most important SME internationalisation indicators categorised and weighted.

4 Decision Support Framework

The proposed decision support framework consists of the following main components (Fig. 1): Indicator information mining from the web, semantic integration of this data in a semantic repository (database) and the decision support mechanism. Guidance is provided through a user friendly interface.

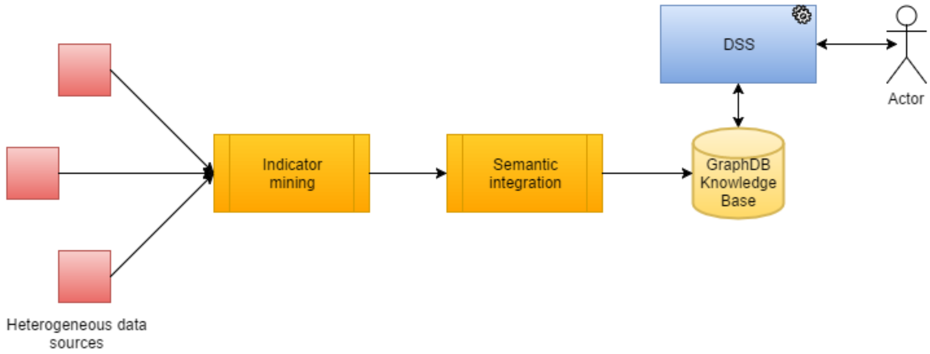

Fig. 1. Data flow (architecture) of the decision support system

4.1 Web Retrieval and Mining of Indicator Data

In order to extract information on the SME internationalisation indicators we use dedicated APIs from specific websites, such as Eurostat and WorldBank and UN COMTRADE (see Section 5.1 for details). Then we convert this information to RDF and load it in Ontotext GraphDB[5], a semantic repository that can store and query semantic data. We selected the W3C CUBE ontology [15], which is the most appropriate way of representing statistical data in RDF format. We also use elements from SDMX [16], which provides terms for some common dimensions such as population, GDP, etc.

Some sources are already available in the required format [17], e.g. data from Eurostat and World Bank. For other sources, e.g. UN COMTRADE[6], we had to use a specific API. We used the free API that has the following limits: 100 requests per hour per IP address, and maximum of 50k records per request (each record represents one trade flow between two partners for one product group). This provides plenty of data (potentially up to 120 million records per day), but we had to make sure that none of our requests exceeded the limit of 50k. We did this through judicious selection of dimensions and downloading strategies (e.g. how many Year series and Product codes to retrieve at a time). To collect this data, we developed a program that queries the COMTRADE API repeatedly by varying the parameters, downloads the data and converts it to the required format.

In addition, we used the Google distance API to extract information regarding city distances in various transportation modes (e.g. air vs surface). We used the Google distance API, which is free for 2.5k requests. In order to stream-line the process, we prefetched the distances between the capitals of all source and destination countries, and converted them to RDF using a custom program.

With respect to other indicators such as Government type, Political instability, Corruption percent index, Human development index, etc., we downloaded them manually from various web sites and converted them using a mix of automatic and manual

[5] http://ontotext.com/products/graphdb/
[6] http://comtrade.un.org/

approaches. They are provided in different tabular formats, such as web pages, csv, tsv, etc.

4.2 Semantic Data Integration

Data integration from disparate data sources is often required for online analytical processing (OLAP) and DSS analysis. In recent years, semantic data integration [18] has emerged as the most promising integration approach, because of the simple and uniform data model that it uses (RDF). RDF is a graph data mode, in which data is broken into atomic facts called triples. URLs are used to identify every block of data and every property (relation or attribute). This allows data sharing on a global scale.

Reusing property names and values defined by others (in our case, SDMX and Eurostat) is one of the benefits of the semantic web. It both reduces the time required to create data models and the chance of data reuse by others. After converting the data to RDF and loading it to Ontotext GraphDB, we calculate some derived data using SPARQL UPDATE [19]. Then, for each pair of observations IMP/EXP with matching dimensions, we calculate two derived observations: TOT (total trade) and BAL (trade balance). We record them in URLs that mirror the original URLs, where the Indicator part is replaced appropriately.

Since we deal with many indicators in different areas, each indicator has its own value range and direction of growth (for some indicators increase is desirable, for others decrease is desirable). To perform meaningful calculations over this heterogeneous data, we need to normalise data to the range between 0 and 1. For this purpose, we are using the following formula for the normalization of rates, which adjusts values measured on different scales to a notionally common one:

$$z_i = x_i - min(x)/(max(x) - min(x)) \qquad (1)$$

where $x=(x_1,...,x_n)$ and z_i is the i^{th} normalised data.

4.3 Query-Based Decision Support

After indicator data is converted to RDF and loaded into the knowledge base, it can be used for decision support. The user selects his country of origin and the desired commodity code (product group). We use the following mechanisms:

- Weighted sum of indicators (see Table 1 for the weights, which are empirically selected).
- Simple inference rules, e.g. “If the commodity code indicates a perishable product then use air cargo distance; if it’s a heavy product then use surface cargo distance; else compare both”.
- Simple decision tree elements.

We implement these mechanisms using parameterised SPARQL templates to retrieve the appropriate data from the cube. This backend processing allows us to implement the following features:

- Rank target countries (and select the most appropriate one)

- Compare two countries across all indicators, e.g. we can compare Germany and Austria across GDP, GDP per capita, corruption level, human development index, population purchasing power, etc.
- Display various charts to illustrate the time dimension (we use the Google Charts API).

Using these functionalities, a manager or entrepreneur can obtain solid information to support the decision making process. It should be noted that at the moment the system has some limitations. It can't be customised, which means that there is no way the user can change the weights of the indicators or disable some of them.

5 Experiments

In this Section, we present the experimental results from the application of our decision support framework to data collected from several heterogeneous web resources.

5.1 Dataset Description

The following data were retrieved and integrated for this experiment: i) Eurostat dataset, including statistical indicators for Europe; ii) World Bank dataset, which includes World Bank Indicators; iii) UN COMTRADE, which offers comprehensive data on cross-country trade volumes for various types of goods, collected since 1962.

Other indicators obtained from specific sources such as: i) Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism. (Worldwide Governance Indicators - The World Bank Group); ii) Corruption perception index (Transparency International). In the table below you can see the main selected indicators, divided by categories. Each indicator is assigned an individual weight (w1). The indicator categories are also assigned with weight w2.

Table 1. SME internationalisation indicators and weights

Group	Indicator	w1	w2
Economy	GDP growth	6	6
	GDP per capita PPP	5	
	Exports in % of GDP	3	
	Imports in % of GDP	3	
	Inward FDI stocks in % of GDP	3	
	Export Import ratio	3	
	Harmonised Index of Consumer Prices (Inflation)	3	
	Easiness of Doing Business	10	
	Average days to Export	6	
	Average days to Import	6	
Social	Total population	8	
	% Tertiary education	3	
	Unemployment rate	5	

	Economic Sentiment Indicator	3	3
	Human Development Index	3	
	% Internet at Home	3	
Politics	EU Member	10	5
	EEA Member	10	
	EFTA Member	10*	
	Political Stability Index	3	
	Corruption Perception Index	3	
	Government Effectiveness Index	3	
Product	Export (partner: World)	5	10
	Import (partner: World)	10	
	Export (partner: country of origin)	5	
	Import (partner: country of origin)	8	
	Product balance (Export - Import / Partner: World)	8	
	Product balance (Export - Import / Partner: country of origin)	6	
	Imports per capita (Import divided by Population / Partner: World)	8	
	Imports per capita (Import divided by Population / Partner: Country of origin)	6	
	Distance	10	

5.2 Experimental Setup

In order to evaluate the proposed system, we have conducted experiments at PIMEC in Barcelona [20]. The evaluation involved a focus group of five (5) export managers, as well as one-on-one interviews with three (3) SME export responsible and one (1) export manager. This focus group was used to test the individual functionalities of the system. First we provided an initial explanation of the status of the system and described the functionalities that were available for testing. The participants were asked to evaluate a table of indicators where the user could compare two countries and visualise their differences. Specifically, the task was the following: each user was supposed to be the CEO of an SME selling dairy products (e.g. cheese and yogurt), who wanted to decide which country is the most convenient for exporting products. In Fig. 2, we illustrate the user interface of the decision support system, in which different indicators for Slovenia and Czech Republic are compared[7].

[7] A demo of the DSS is available at: http://grinder1.multisensorproject.eu/uc3/

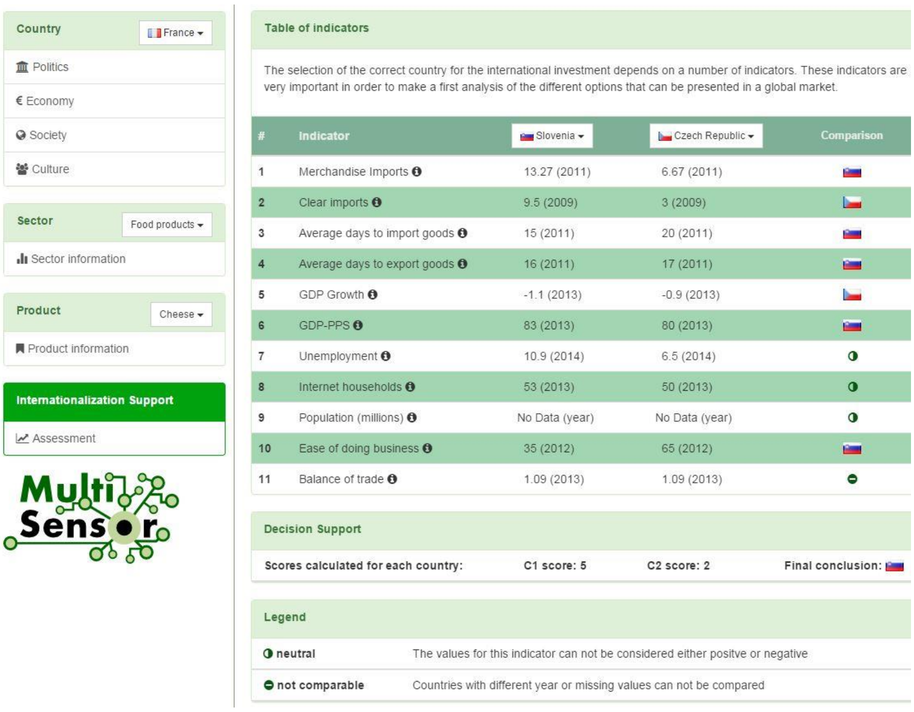

Fig. 2. Decision support interface

5.3 Results

In general, the results of the performed evaluation can be considered satisfactory. Regarding the task, where the users were asked to evaluate the table of indicators and the decision support functionality (Fig. 3), the table was valued positively by all users as a way to compare the situation in two countries more easily. In addition, all users valued its relevance positively. Larger number of indicators and more concrete ones were mentioned as a way to better capture the advantages or disadvantages of exporting to one country or another.

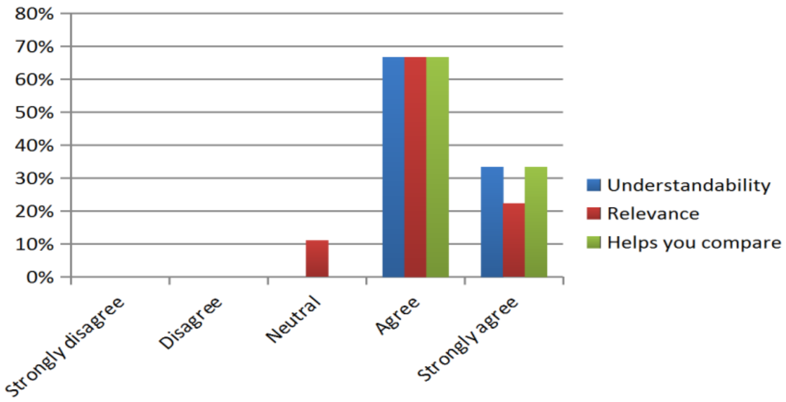

Fig. 3. Evaluation of indicators table and decision support functionality

After evaluating concrete aspects of the different tasks, the evaluators were required to value the overall efficiency of the decision support platform. The results are visualised in Fig. 4 and as we can see, the opinions were highly positive. All the participants felt that the system was easy to use and, also, that it allowed them to save time compared to alternative ways of looking for similar information.

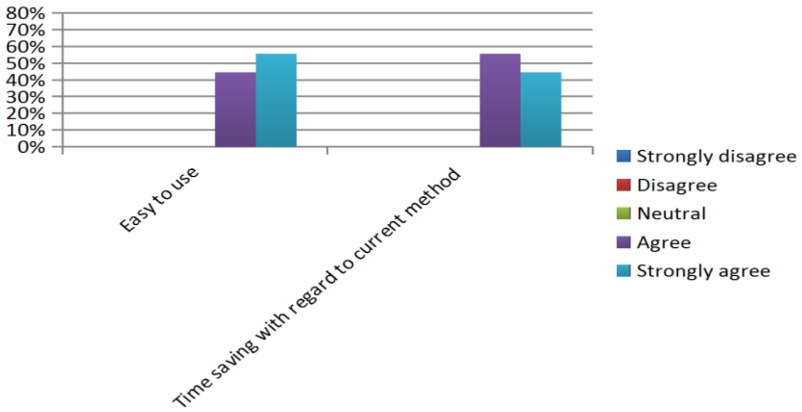

Fig. 4. Efficiency evaluation of the decision support platform

Regarding satisfaction (Fig. 5), all the participants (100%) felt in control when using the decision support system and thought that it was intuitive and easy to use. Participants appreciated the user interface and navigability of the platform. A vast majority (80%) considered its use as a satisfying experience and a way to be more productive (65%). The majority of the participants (55 %) would also recommend the system to colleagues. In general, most of the participants acknowledged that the MULTISENSOR DSS has a good potential, but could also benefit from additional focused information, as well as the integration of additional functionalities in order to deliver a more complete support in the decision-making process.

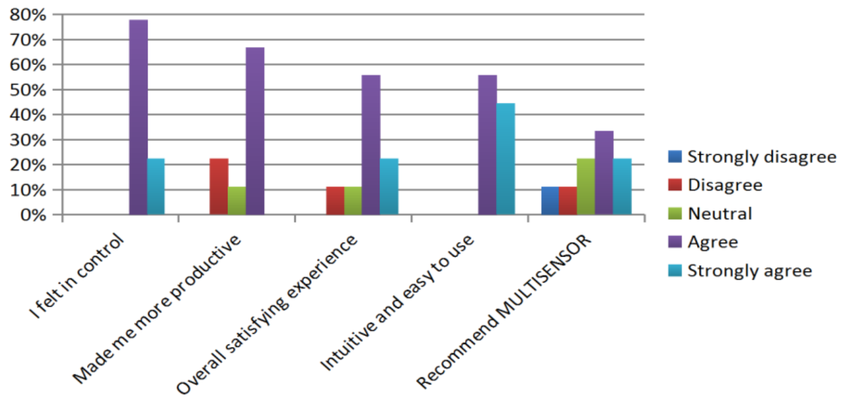

Fig. 5. Satisfaction evaluation of the decision support platform

6 Summary and Conclusions

In this work we define SME internationalisation indicators and we provide a decision support tool for SME internationalisation, which builds upon semantic integration of information from heterogeneous web resources. This application could support SMEs in order to have guidance in deciding to which country they could export. It provides a comparative view of the countries in question and shows insights based on the SME internationalisation indicators. The evaluation with professionals working on SME internationalisation shows the potential of this tool in the market.

As future work, we plan to crawl and add more indicators to the system, employ additional techniques for providing guidance, such as decision trees and fuzzy reasoning, as well as investigate how the already integrated set of indicators could inform Internet-based services or SMEs that provide online services. It should be noted that at the moment, the procedure for adding new indicators to the system is demanding (crawl new sources of information, convert the data to RDF format, modify the system to handle the new information, etc.). We should work in perspective, in order to automate the process in such a way that the addition of new indicators becomes just a matter of configuration.

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