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INNOVATION IN THE CONSTRUCTION OF EDUCATIONAL SYSTEMS BALANCING THE SUPPLY-DEMAND OF PHD CANDIDATES. AN INITIAL RESEARCH SURVEY

INNOWACJA W KONSTRUKCJI SYSTEMÓW EDUKACYJNYCH BILANSUJĄCYCH RYNEK EDUKACYJNY DOKTORANTÓW. WSTĘPNE STUDIUM BADAŃ

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Summary: Nowadays, the requirements and expectations of universities are increasing along with globalization. The functions of Research and Development and the doctorate programmes which aim to support education and train the academic staff, came to the fore with globalization. The doctorate programmes in European countries cannot be updated fast enough and quotas for these programs are insufficient in some regions – faster balancing seems to be the must. The Decision Support System (DSS) can be a solution to the problem. In this study, the candidates' demand of the universities, the public-private organizations and R&D centres are included to a model. As a result DSS will help us identify the need for candidates and develop PhD planning strategies by analysing the current situation of the university policies through the innovative model balancing the supply-demand for PhD candidates – including formulae of doctorate implementation (recently introduced in Poland).

Keywords: educational model, decision support system, supply-demand in PhD.

Streszczenie. W dzisiejszych czasach wymagania i oczekiwania uniwersytetów rosną wraz z globalizacją. Funkcje badań i rozwoju oraz programy doktoranckie, których celem jest wspieranie edukacji i szkolenia kadr akademickiej, zyskały na popularności wraz z globalizacją. Programy doktoranckie w krajach europejskich nie są aktualizowane wystarczająco szybko, a środki na te programy są niewystarczające w niektórych regionach – wydaje się, że konieczne jest szybsze ich równoważenie. System wspomagania decyzji (DSS) może być rozwiązaniem problemu. W niniejszym badaniu uwzględniono zapotrzebowanie kandydatów na uniwersytety, organizacje publiczno-prywatne i centra badawczo-rozwojowe. W rezultacie DSS może pomóc zidentyfikować zapotrzebowanie na kandydatów i opracować strategie programowania doktoratów, analizując bieżącą sytuację polityk uniwersyteckich poprzez innowacyjny model równoważący popyt i podaż na doktorantów – w tym formułę doktoratu wdrożeniowego (niedawno wprowadzonego w Polsce).

Słowa kluczowe: model edukacyjny, ekspertowe systemy podejmowania decyzji, podaż–popyt doktorantów.

1. Introduction

Today, higher education is becoming more important due to the increase in qualified manpower and therefore the employability of people (Serbest et al. 2005). As a result, the demand for higher education is steadily increasing. The absence of quotas by universities to meet this need will bring a huge gap between supply and demand until 2025 (Tanrıkulu, 2011). There are a number of proposals to reduce this gap. These proposals have been taken into consideration by comparing countries in terms of income, employment, population and capital. When the interaction between education and the economy is assessed, we can see that the level of welfare of a country is measured by the level of education and that the countries of higher welfare are supported by the knowledge that is the source of education (Rudder, 1999). This is no longer supported by institutions but by higher education, which makes it the main source of qualified manpower. This situation has increased the expectations of universities and made it necessary to go through expansion to meet the demand, as the unemployment rate of those who have higher education is lower than the unemployment rate of secondary education graduates. In other words, higher education brings an inverse proportion between unemployment and employability. Expansion in tertiary education plays an important role so that developing countries can take the position of the developed countries. These countries have to apply a number of models in terms of younger population and participation in higher education. The implementation of the models applied in the past will not be enough for these countries and some costs will occur; countries need to give a greater role to private universities in order to be able to meet this with public resources. Therefore, the government should make some important decisions for the modelling of profit-oriented private higher education institutions and foundations together [Daniel, Kanvar, and Uvatic-Trumbic, 2006).

In European countries the importance of higher education increases gradually. However this structure does not meet the demand because of the rapidly increasing population. At the same time, along with the increase in demand, the number of teaching staff has increased, but not enough to process the number of students

(Küçükcan, 2009). On the other hand, in order to educate the teaching staff, an education study program has been arranged, however this meant that the students who gained their doctorate abroad do not return and the teacher at the desired level has not been trained (Durmuş, 2011).

As of 2010, the number of students per faculty is 46.3 while the number of students per teaching staff is 18.4 (Tanrıkulu, 2011). This situation occurred not only because of the small number of faculty members, but also because of the imbalance between the departments, the students and the academic members. Hence this is not enough to increase the quota of students, there are attempts to reduce the excess demand by placing students at new universities at the same time.

This situation suggests that the gap between the faculty members and the students will negatively affect the quality of education. If good planning can be carried out, this imbalance will be eliminated. The aim of this study is to balance the supply-demand ratio between PhD graduates and workplaces in Poland (including also a selected country i.e. Turkey). To solve this problem, we have constructed a model to help the system analysis and design which is integrated to Decision Support Systems (DSS).

2. State of the art and research method

Besides the economy and technology, the importance of education has also begun to increase in developed countries. In order to reach the position of an advanced country, a number of expansions should be applied in higher education (Tanrıkulu, 2011). Therefore the number of universities has reached 200 in our country (Turkey) with the opening of new universities, so it is necessary to determine a new doctorate programme in these areas and the number of doctoral candidates needed.

In recent years, while Turkey's private sector has been improving, the demand for qualified personnel in R&D is also increasing. Universities offer PhD programmes in a set of fixed specialities. Sometimes these do not meet the labour market's need for people with PhD degrees. This gap has caused the current revision of the offered PhD programmes. In the private sector, especially such as information technology, computer technology, nano-technology, health and engineering, there is also the need to employ PhD graduates, on the other hand, some people cannot find a job after completing their PhD programme.

Based on W. Bowen and J. A. Sosa (1989), by using data on the age trend of age for the faculty and the prediction of departure rates like retirement, death and 'quits' by age to project the replacement demand for the faculty each year. Their predictions of the supply side of the academic labour market which are typical of those used in other studies, are based on a number of simplifying assumptions (Ehrenberg, 1992; Bowen, and Sosa 1989).

The student, department, program and faculty assessments are important categories in analysing and discovering the strengths and weaknesses of students and programs (Cizek, 1998).

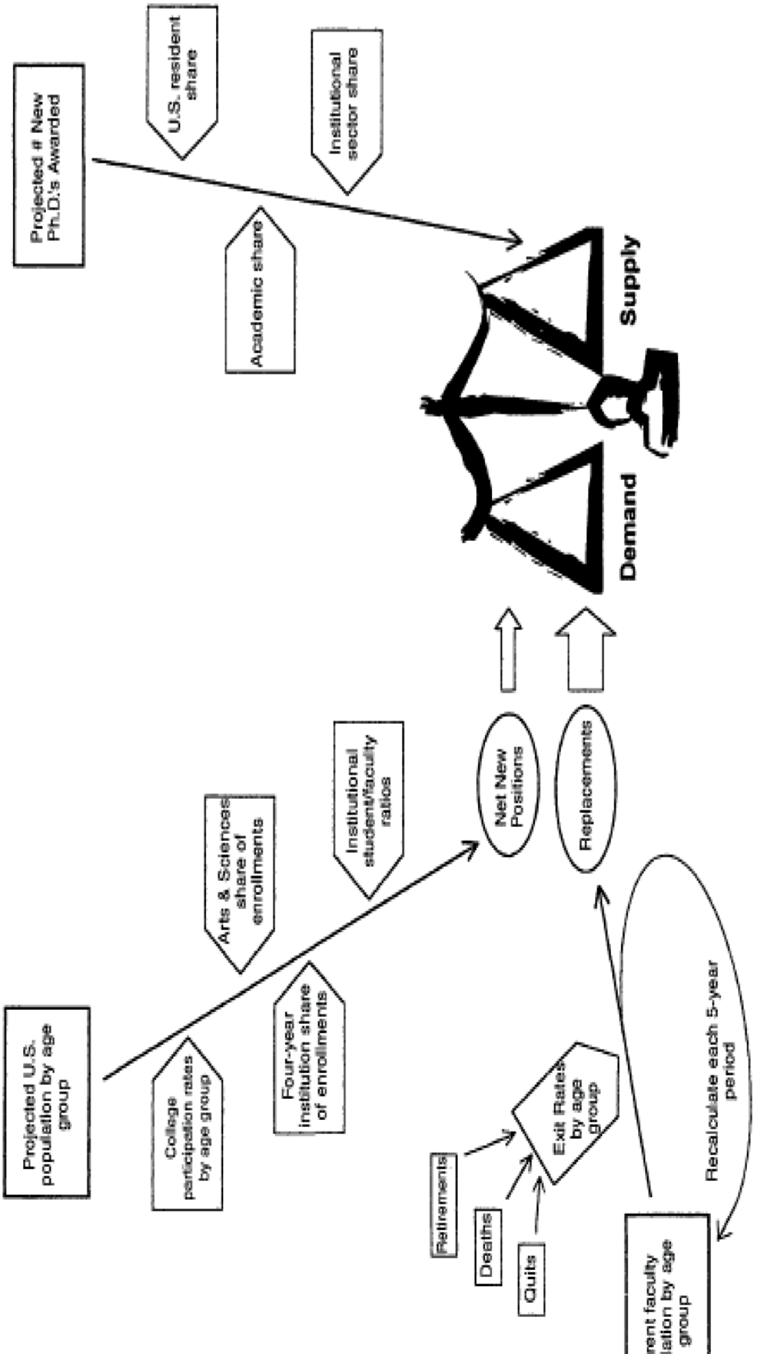

Fig. 1. Bowen and Sosa's model

Source: (Bowen, Sosa, 1989).

3. Overview of an Expert Decision Support System

A Decision Support System (DSS) is an interactive computer based system that helps decision-makers use data and models to solve structured, unstructured or semi-structured problems (Gore, 1983). According to Simon (1960) a DSS consists of three steps, intelligence, design and choice. In the intelligence phase, the problem is identified, and the information concerning the problem is collected, and the design phase develops several possible solutions for the problem. Finally, the choice phase chooses the solution (Simon, 1977).

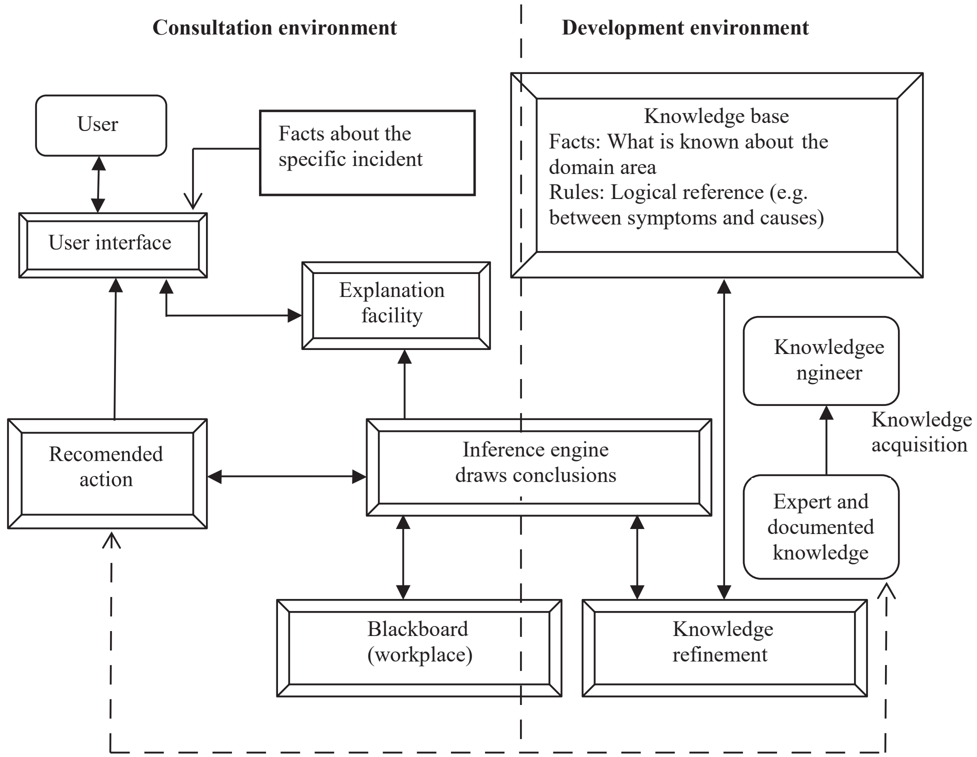

Fig. 2. An expert system concept

Source: (Turban, 2001).

DSS can basically be data-driven or model-driven. The data-driven DSS emphasizes the access and manipulation of the time series of internal company data and external data (Jessani, 2003). In our study we worked on a model-driven DSS, which uses user data and parameters provided by users, access to and manipulation of a statistical, financial and optimizing a situation (Gachet, 2004).

On the other hand, R. G. Ehrenberg showed the supply side of academic labour and presented data on a number of component stocks and flows that relate to the supply of new doctorates, “the flow of new doctorates” (Figure 3 shows the flow of American doctorate students (Ehrenberg, 1992).

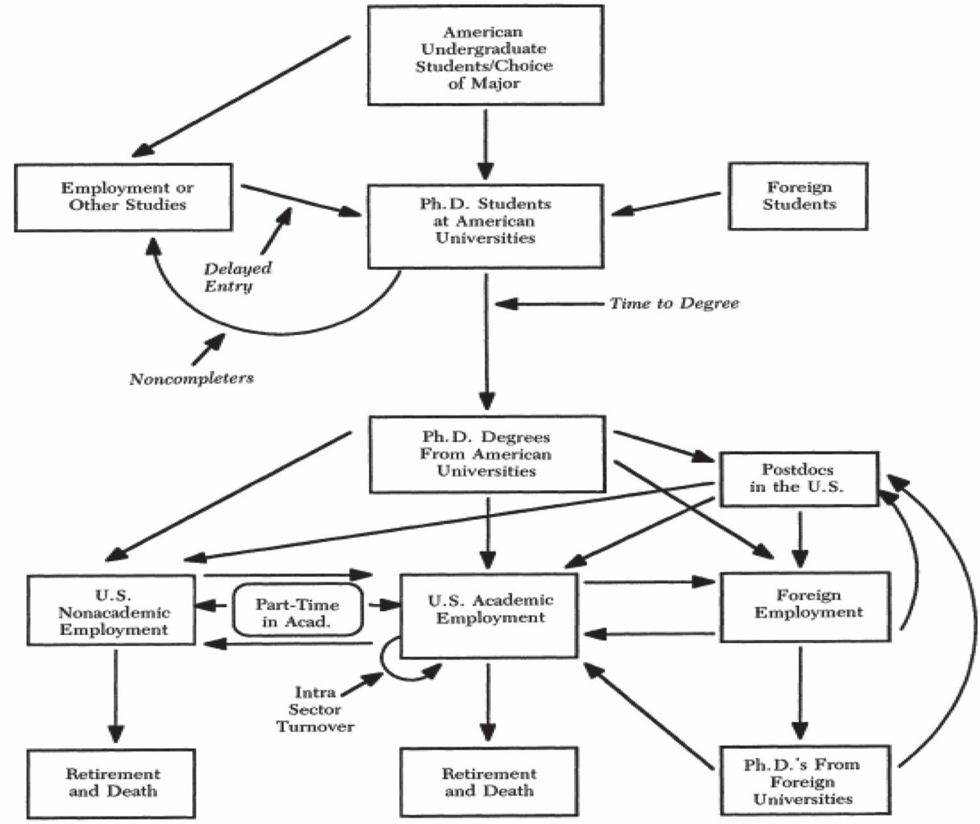

Fig. 3. Academic labour supply

Source: (Ehrenberg, 1992).

In light of Bowen and Sosa’s model (presented in Figure 1) and Ehrenberg’s model, we improved the academic labour supply/demand balances for routing PhD graduates to universities, research centres, and public and private sectors. This will help the Decision Support system that is to be created.

4. Description of the model

4.1. General characteristics of the model

According to the above assumptions, all the essential categories (institutions, demands, supplies and other determinants) should be included in the elaborated model. Figure 4 is a schematic representation of the design of a decision support system, in which basically three separate sections are projected. The left side of the model shows the doctoral demands including the private sector, the public sector and the academics. The data in the middle part of the model will suggest a doctoral programme that should be opened/closed in a region, and also determine whether the department can be opened at that university by looking at the infrastructure and quota of the university. First, the system will show the job positions in that area. At the same time, one can use the "need for doctoral staff" data in the demand part and inform decision-makers about it. On the right side of the model, there is a section showing unemployed people with PhD (supply). This model brings them together to balance the demand/supply ratio. The information from sectors and universities that are looking for a PhD position is also added to the database and a common data pool is formed. This pool will be presented to the decision-makers as an output from the decision support system by adding statistical distributions.

The left side of the model is determined by the following components:

Academic: In this component, the possible academic positions such as engineer, post-doctoral, researcher, research assistant, tenure track and others, including region and department information will be added to the data base.

Public/Private sectors and the R&D centres: The public/private sectors and the R&D centres' demand will be added to the database with the information of region, department and job description.

Replacements: This component may be the most effective regarding job positions, as it depends on death, leaving and retirement.

Most of the supply side of this model is created by universities. All the data from universities including region, department, institute, work experience, experimental and theoretical experience, age, sex etc. will be added to the database; retirements and leaving from the private and public sectors increase the supply side.

In addition to these data, the status of universities such as minimum and maximum quotas, lectures, sources, experimental and theoretical infrastructure region by region will be added to data pool. This information will supply a statistical background, which must be updated year by year.

After creating the data pool, it is time for the DSS. This model will produce the optimized result for its users. As a basic example, a production company of electronics like a microchip manufacturing needs a cleanroom experienced R&D worker. This demand will be placed on the left side of model, then the model searches for the best profile on the right side with experience of cleanroom technologies. If there is no

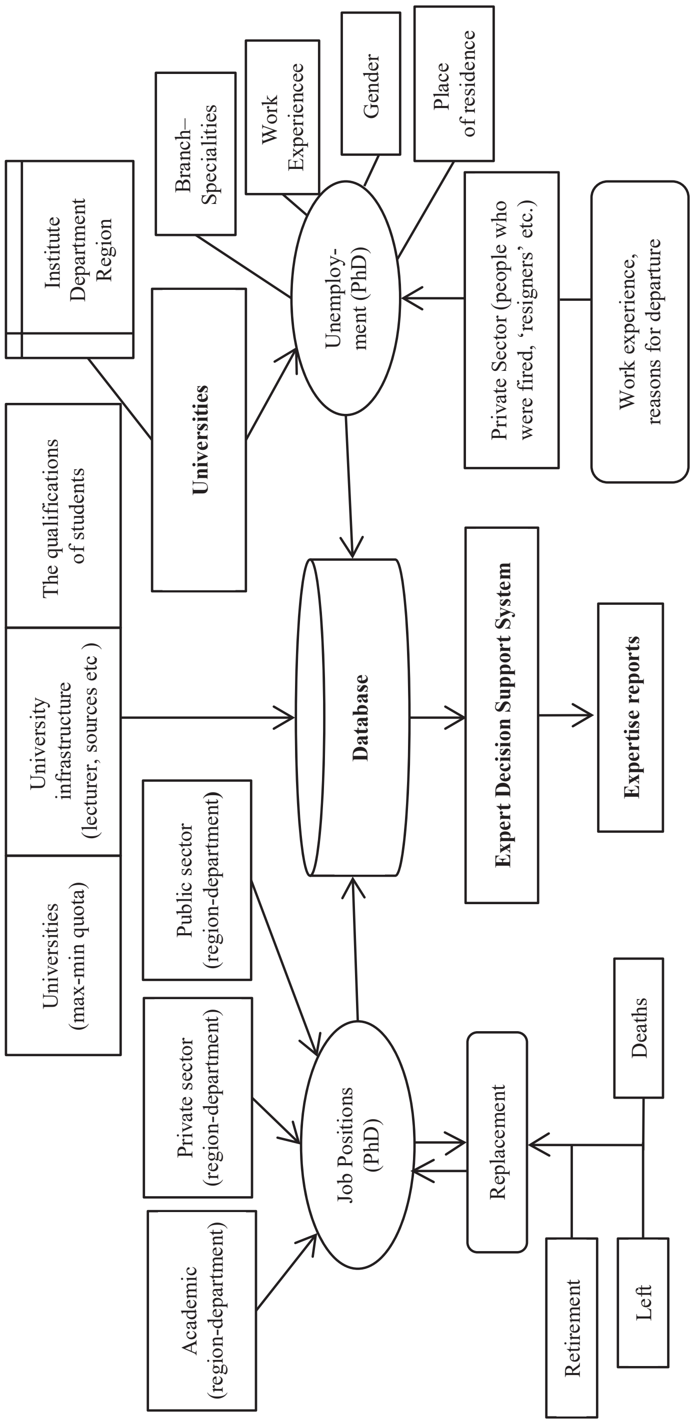

Fig. 4. Expert Decision Support System with environment

Source: own elaboration.

profile as searched, a gap appears, therefore as an output of the model, the suggestion of "new area must be opened in a suitable region" statement will be seen. This model can be a fast solution to this problem.

Statistical outputs will be included in region and department-based and updated every year. After their processing, these data will provide information to decision-makers as to where they should open a department or which departments should be closed.

Data on trends in doctorate faculty ratios and suppositions about what is probable to occur to these ratios in the Future will appear,. after this they will plan how the changes in enrolment will convert into changes in the demand for new faculty

As a basic example for the suggestion output, we prepared an algorithm which shows the flow of suggestions (Figure 5). Before the suggestion output for any region, all required data have to occur in the data pool for that region. Then, the system will check the demand and supply, department by department (such as Department A, Department B, etc.); in our model we showed only the department B situation.

The system will check "Has Department B any job position (demand)? If "no", system will give the output "No Suggestion" or "Department B does not need any supply", because there is no job position to meet the supply. hence the quota of supply side for Department B must be decreased or closed for a time period until it is required. If the answer is "yes", it means that department B has job positions, so the system will check the demand/supply ratio, is it bigger than 1? If "yes", the system will check how much bigger than 1. Is it 2 or more? This means that demand is two times or more than the supply. If the answer is "yes", the system will suggest "new program must be opened or current quotas must be increased to meet the demands". If the answer is "no", which means that the demand/supply ratio is between 1 and 2, the system will give an output such as "good ratio, no suggestion". If the demand/supply ratio is lower than 1, the system will check "how much lower than 1? Is it 0.5 or lower? If yes, which means supply is two times bigger than the demand, the system will suggest "decrease the current quota or close some program until it is required". If the answer is "no", again the demand/supply ratio is good. Thus the output will be "good ratio, no suggestion".

This flow is the demand side view. One can also run the algorithm as the supply side, again after the data pool is created department by department, the system will check, "has department B any supply?", and if "yes", the system will follow the demand/supply ratio part. If there is no supply, the system will check the demand for department B, "is there any job position for department B". If "yes", the system will suggest "new program must be opened", and if no, it means no demand, so the output will be "no suggestion".

The suggestion outputs can also be composed as algorithms, depending on the regions, universities departments, etc., to check which university is the best fit for a new program, or if the quotas can be increased for the current universities. Every additional algorithm will enhance the accuracy of suggestions and these will help its

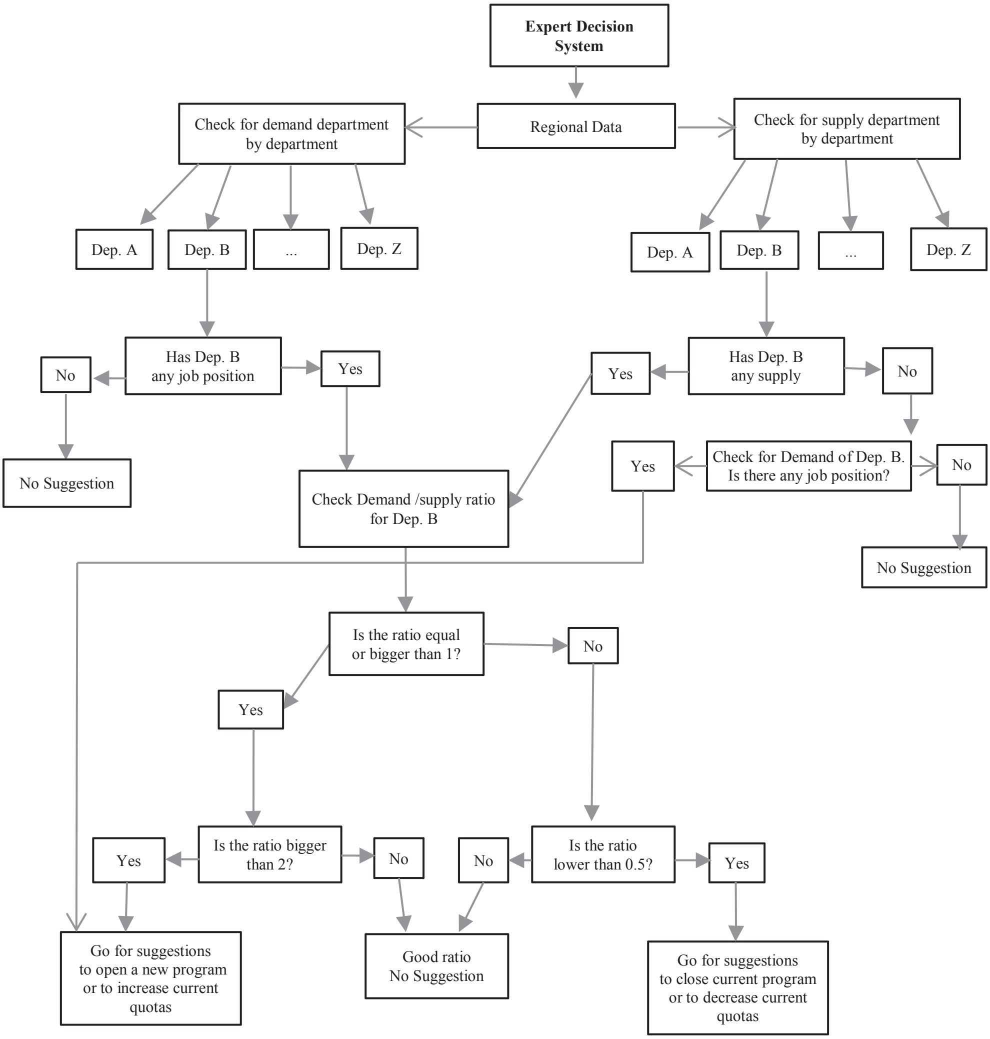

Fig. 5. The decision tree representing the knowledge base of an Expert Decision Support System

Source: own elaboration.

users to make the best decisions in their regions; this system can show the power of the region, department by department. Thus it can also suggest a new work area or new technologies for the country.

4.2. Major tasks of the decision system

The major tasks of the decision system that will provide the supply-demand balance of PhD graduates employment were defined as follows:

- Appropriate input data has to be extracted from added data beforehand, brought into a coherent state and integrated into a single warehouse to ensure data base for querying and calculations.
- When one wants to open a new department in a region, first the system will consider the request for PhD staff in that area in that region. Then the system will develop recommendations based on whether the university has academic qualifications and structure. For example, a faculty is establishing a new PhD degree in a department in any region. The task is to check if this plan is supported by the existing teaching resources by region, and how many businesses are looking for candidates with a PhD.
- When one wants to open a department for e.g. philosophy at any university, first it is necessary to know how many people will be required by the department in the region. The query will work on the amount of job demands in that region. The decision system will check how many job positions they have in the region for persons with a PhD in philosophy (if the need in the region is not measured, unemployment will increase because of the excess supply). At the same time it is important to know the number of the current supply (PhDs). After that, it is necessary to know about the academic infrastructure for the university. If these requirements are acceptable, the decision system will suggest that the department should be opened for that area.
- If the decision-makers want to know about any department that needs to be opened in a region, they can query the demand for PhDs for job positions in the department. The results will appear according to the need and the number of PhDs, the system will suggest whether the department should be opened or not. For example, if the need for “computer science” in the “Sakarya” region is queried, the system again will check the job positions in that area and if there is no need for PhDs in the region, but the universities are ready to open this section with a strong academic infrastructure, the decision system will suggest that this department can be opened in future.
- For example, when job positions are analyzed for Chemistry Dept. in Istanbul, and there are more job positions than current PhD’s number, then the decision system will warn the decision makers and suggest that this department must be opened at a suitable university or the quota in the existing universities should be increased.
- When a university request opening a department (e.g. molecular biology) first it is important to determine the region (Katowice) in which the university is located. If there are enough job positions to open this department in the region and also if the university has the infrastructure for it, the decision system will allow for the opening of this department in the university.

5. Conclusions

The final results of the paper can be formulated as follows:

- There is a real need to generate a supply-demand balance of PhD students oriented on an implementation thesis.
- The model of the supply-demand for PhD students should include essential information about the problem and the environment.
- The prepared expert system, based on the elaborated model, should be able to support the decision-makers.

Further research will focus on the development of more advanced solutions in the defined problem, embracing other artificial intelligence methods.

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Appendix. Examples of rules representing a knowledge-based model

RULE [1]
if [department] = "philosophy" and [job position] ≥ 5 and [person with PhD] < 1 and [academic infrastructure] = "yes"
then [situation of the department] = "should be opened"
RULE [2]
if [region] = "Sakarya" and [department]= "computer science" and
[job position] ≤ 1 and [academic infrastructure]= "yes"
then [first decision about the department]= "can be opened in future"
else [first decision about the department]= "opening of the department is not appropriate"
RULE [3]
if [department]= "physics" and [job position] < 1 and [region]= "Warsaw"
then [decision about the department]= "should be closed in region"
RULE [4]
if [region]= "Katowice" and [department]= "molecular biology" and
[job position] ≥ 2 and [academic infrastructure]= "yes"
then [situation of the department] = "can be opened now"
RULE [5]
if [region] = "Istanbul" and [department]= "chemistry" and [current PhD's] < [job position]
alert [situation of the department] = "should increase the number of current quota in universities" or
[situation of the department] = "this area should be opened in a suitable university in region"