MODELLING OF SUSTAINABLE SYSTEMS

Jiří Křupka[a], **Jan Mandys**[b], **Jana Svobodová, Marie Augustinová**

[a]University of Pardubice, Faculty of Economics and Administration, Institute of System Engineering and Informatics, [b]University of Pardubice, Faculty of Economics and Administration, Institute of Public Administration and Law

Abstract: This paper focuses on the issue of utilization of system approach in sustainability systems modelling. Into systems that deal with sustainability are included systems that research into regional quality of life. The proposed quality of life models work with real data for regions and districts in the Czech Republic. The models use decision trees and factor analysis methods.

Keywords: Sustainability, System Approach, Quality of Life, Modelling, Decision Tree, Multidimensional Statistics Methods.

JEL Classification: *C44,C63, L38.*

1. Introduction

"Sustainability" (Olej, 2009) issues are currently very attractive and trendy. They cover a wide range of areas: e.g. sustainable architecture, sustainable building, sustainable business, sustainable development, sustainable engineering, sustainable environment, sustainable materials and similar. These issues thus have found their way also into regional management issues debates (Křupka, 2010b).

The solving of sustainability, as well as solving basic science issues of the current period (Capra, 2004), must be approached in an interdisciplinary way. The issue of sustainability, on the regional level, for the environment, economic and social areas is the content of the following projects: Indicators for valuation and modelling interactions between the environment, the economy and social correlations (No. SP/4i2/60/07, the grant is awarded by the Ministry of Environment of the Czech Republic (CR), project resolver is Obršálová I., the project runs from 2007 to 2011) and The Model for Stimulating Regional Growth Management (No. 402/08/0849, grant is awarded by the Grant Agency of the CR, project resolver is Křupka J., the project runs from 2008 to 2010). Partial findings and conclusions of the above-mentioned science projects are published also in monographies (Olej, 2009; Olej, 2011). Modelling of Selected Areas of Sustainable Development by Artificial Intelligence and Soft Computing (Olej, 2009), and Environmental Modelling for Sustainable Regional Development: System Approaches and Advanced Methods (Olej, 2011).

System theories adequately illustrate existing society and the existing world. Science theories, as organized knowledge systems, reflect and illustrate relations between processes and elements that are organized in a systematic way (Mucha, 2008). The more a society is advanced, from the point of view of the general evolutionist theories, the more it is differentiated and complex. The nature of its development is determined by system rationality and its specific requirements. Theoretic approaches

fade over with the consequences of the real assertion of more and more sophisticated organized life forms in the processes of rationalization and modernization which, by using the acquired knowledge from science and technology, set up the system character of life in the current society. An advanced society, highly differentiated and complex, enforces not only real changes in the relationship structure, but it also significantly attacks concepts and ideas that once played a significant role in the society development and deeply influences life orientation of the modern age people (Mucha, 2008). This concerns in the first place metaphysical questions, ideas about the purpose of human existence and of the world itself. The strongest demonstration of "human world" building, in which science and technology should had played a major role, was the realization of humanity ideals in its various alternatives.

Humanity and sustainability are reflected also in the Quality of Life (QL) modelling. A problem of modelling of QL can be specified like this type of system (Jirava, 2010; Křupka, 2010; Mederly, 2004). We have to use system engineering, system approach (Blanchard, 1998; Blanchard, 2004) for a solution of comprehensive, complicated, and complex systems. System engineering according to Z. Dráb can be defined as: „… aggregation of means, processes and methods for solving (that means research into, designing, creation and operation) complex technical and mixed (technical-social) systems (including the issues of their management)" (Vítek, 2003: 6). System approach is then understood to be a purposeful way of thinking or of solving problems while the researched into phenomenona and processes are viewed in a complex way taking into consideration their internal and external relations (Rosický, 1995; Křupka, 2010a).

2. Problem formulation

We can talk about QL in both the static and the dynamic meanings, the static meaning provides reports on peoples' life as of a set time, while the dynamic meaning compares and evaluates the QL in a longer period of time (Křivohlavý, 2004). Generally it is possible to say that the QL is influenced by the physical and mental health of an individual, by the level of independence, by social attitude towards the environment and by other factors (Balegová, 2002; Halečka, 2002; Blažej, 2005; Svobodová, 2007). It may be defined as an individual's life satisfaction with the life the individual person lives compared to an ideal life. The evaluation of the QL depends in this case on the value system of each individual (Akranavičiūtė, 2007; Vaďurová, 2005). If we needed to make a complicated inquiry with each individual about the individual aspects of his/her life, such approach would be very time consuming and it would not be possible to execute research into the QL on an unlimited number of respondents. For this reason we are looking for methods that would allow us to draw data from publicly available databases and reach relevant results. There a universal delimitation of the QL does not exist. The QL depends also on external factors (Akranavičiūtė, 2007), good living conditions or other conditions define a high QL, but if such conditions vary, the satisfaction with the QL then also varies.

The QL (Křupka, 2009a) is influenced by: material state of affairs (goods, services, home, economic level, by conditions for work and recreation, average income, purchasing power, and so); by the quality of the environment (the level of the utilization of natural resources, sustainable development, water quality, weather, soil, and other); by the individual's quality of health (the health of the society); by the quality of education, by moral and psychological climate (inside the family, organizations, culture, states), individual feeling of safety (physical, legal, societal) and by the possibility for self-expression.

According to (Křivohlavý; 2009) QL is defined as satisfaction of a concrete individual with achieving goals defining the orientation of his/her life. This orientation is further influenced by each individual's value orientation (as a hierarchy of values in the spiritual meaning).

QL can be expressed by means of its areas and components as is showed in Fig. 1 (Akranavičiūtė, 2007).
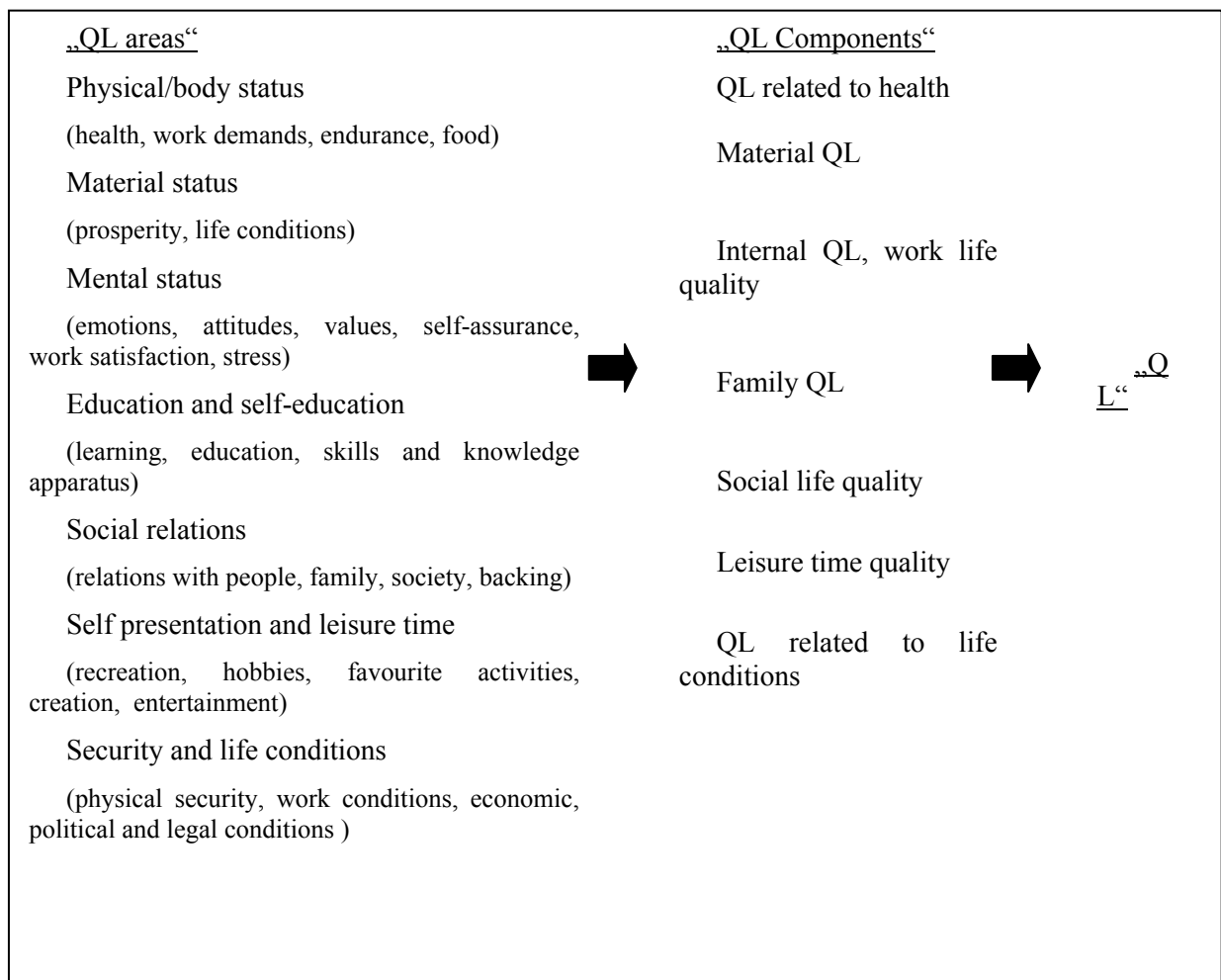

„QL areas"

Physical/body status

(health, work demands, endurance, food)

Material status

(prosperity, life conditions)

Mental status

(emotions, attitudes, values, self-assurance, work satisfaction, stress)

Education and self-education

(learning, education, skills and knowledge apparatus)

Social relations

(relations with people, family, society, backing)

Self presentation and leisure time

(recreation, hobbies, favourite activities, creation, entertainment)

Security and life conditions

(physical security, work conditions, economic, political and legal conditions)

„QL Components"

QL related to health

Material QL

Internal QL, work life quality

Family QL

Social life quality

Leisure time quality

QL related to life conditions

„QL"

Fig. 1: Model of QL

The term QL is discussed in many fields of science and each field of science approaches the term mainly from the view of its own science terminology. The value system of each individual has a major role in the definition of the individual's QL.

"Values represent a system of acquired dispositions of an individual to act towards or to strive to move towards a goal in accord with the desires determining the conditions of the existence." (Cakirpaloglu, 2004: 385). According to (Šebek, 1973) values represent an individual's life purpose, they are a means for the adaptation to society and they are a means for conflict resolution inside a personality's system (that is in particular a conflict born in decision making). Values influence behaviour; they integrate a personality in the context of important life goals and prevent chaotic behaviour. At the same time they are also one of the sources of conflicts.

Schwarz's value system can be taken as the generally accepted value model. This model describes ten types of values. Schwarz has derived these value types by analyzing individual social needs. He considers these values to be essential for the functioning and the survival of all systems (Kavalíř, 2005). The model is based on the assumption that each individual is influenced by the following basic needs (Hnilica, 2005):

- The necessity to fulfil his/her biological needs
- Participation in social interactions (coordinated interactions)
- To meet institutionalized requirements that are related to group survival possibilities.

Schwarz's model can be interpreted as a structure (Fig. 2) that consists of four areas (Hnilica, 2005):

- Transcendence: it includes the values of universalism and benevolence
- Conservatism: it includes the values of conformity and related traditions and the value safety
- Orientation on self of an individual: it includes power, success and partially the value of hedonism, however, this value is included also in the following area
- Openness to change: it includes the already partially mentioned value of hedonism, but also the value of stimulation and self-determination.

It is essential to realize, in particular, the importance of cultural and social factors for the preservation of values that we recognize. The culture norms of a given society system give us clear guidance to what rules we must obey. It shows us the values and norms accepted by the majority society and it applies to all members of the given society (Cakirpaloglu, 2004).

Health represents a component of the overall QL that is generally valued and accepted in all societies. In (Vašina, 1999) the author, on a general level, defines health as an abstract representing intact body and well functioning and good condition of all body organs and the entire body. Health is thus a normal function and illness means abnormal function, or suppressed function or an atypical function. Further, the author brings attention to the meaning of the definition of health as it is represented by the World Health Organization. The organization understands health to be the state of absolute body, mind and social well-being. Health understood in this way is not anymore the solely biological-medical problem, but is overlaps to social sciences.

The multidimensional notion of health is clearly demonstrated in (Křivohlavý, 2009). It is stated there that physicians understand the meaning of health to be the absence of any illness or injury. Sociologists see the notion of health as the ability to function well in all social roles. Idealists describe a healthy individual as an individual that feels well physically, mentally, spiritually and socially. Humanists consider an individual to be healthy when the individual bears positively the burden of all daily life requirements and tasks to be fulfilled by the individual.
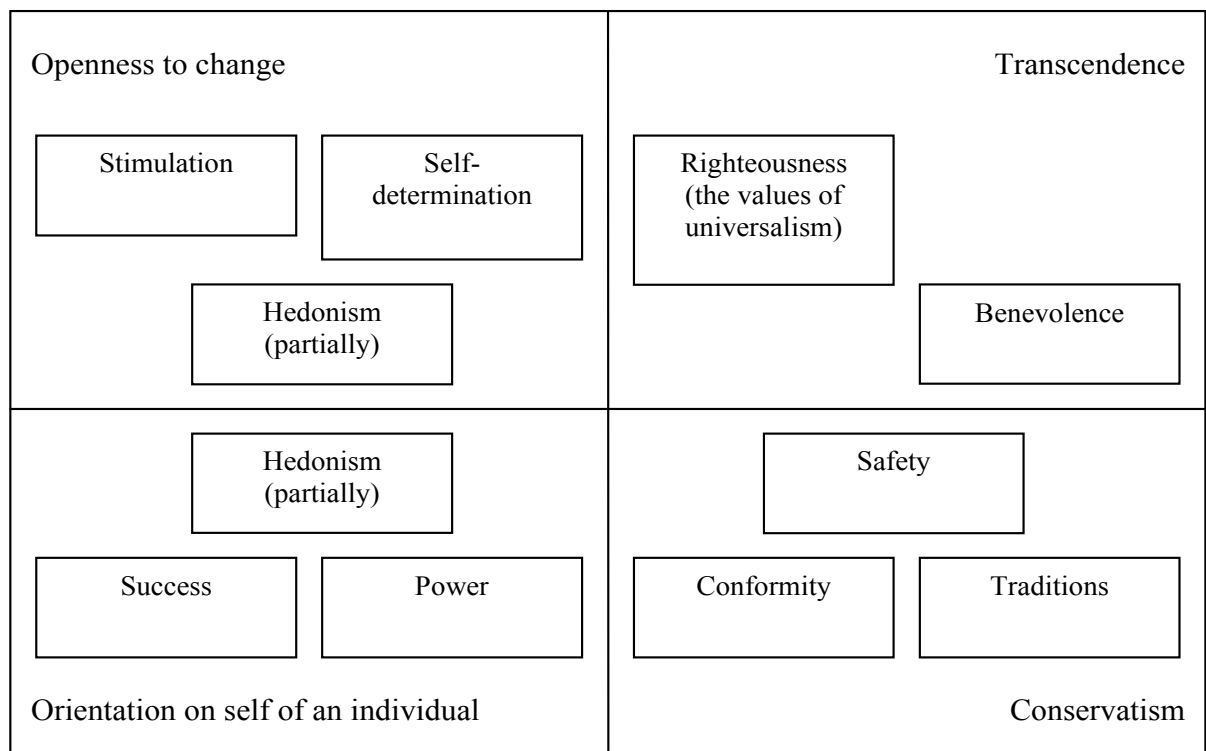
Openness to change		Transcendence
Stimulation	Self-determination	Righteousness (the values of universalism)
	Hedonism (partially)	Benevolence
	Hedonism (partially)	Safety
Success	Power	Conformity / Traditions
Orientation on self of an individual		Conservatism

Fig. 2: Organization of values

Source: Redraw on the basis of (Hnilica, 2005: 375)

Health theories can be divided, according to whether health is understood as the goal (ultimate status) or whether health is a means to reach goals (Křivohlavý, 2009), to: health as a source of physical and mental health, health as a metaphysical power, salutogenesis – individual source of health, health as the ability to adopt, health as the ability of well functioning, health as a good and health as an ideal. This approach to researching into health is demonstrated in Fig. 3.
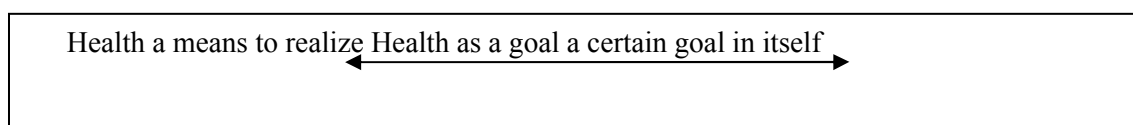
Health a means to realize Health as a goal a certain goal in itself

Fig. 3: Health theories dimensions

Source: (Křivohlavý, 2009: 33)

Concrete view of how people understand health can be found in (Vašina, 1999). They are empiric study results. The study included two basic questions that were given to the respondents:

- Do you think you know someone who is in perfect health? Who is that person? What is his/her age? What can you say about his/her health?

- Sometime a person is more healthy than other time. What does it mean to be healthier?

Based on the acquired data we can identify eight concepts of health – health as: no-illness; subjective state of illness/ health despite illness; health reserve, backup and capacity; physical condition (fitness); energy and vitality; social relations; functions; mental-social wellbeing.

3. Model design

There are various ways how to measure the QL. Generally these methods of measurement can be divided into three groups (Křivohlavý, 2001) where:

- The evaluator is a third person (the shortcoming is that this evaluation is in many cases different from the evaluation of the individual done by himself/herself, one of the methods is Karnof index – e.g. a physician expresses his/her opinion on the total health status of the patient as of a certain date)

- The individual himself/herself is the evaluator – the QL is measured as it is subjectively felt and defined by the person who is himself/herself the subject of the inquiry. Here various methods are used, e.g. the evaluation of the individual quality method program (Schedule for the Evaluation of Individual QL) – the respondent fills into a questionnaire his/her personal life goals, evaluates the fulfilment of these goals and defines their importance, another method is the health method related to the QL (Health Related QL)

- The evaluation arrived at by the combination of the above-mentioned methods is used – here the method of the short way of assessment of the QL can be utilized (Manchester's Short Assessment of QL) - with this method we evaluate not only the complete life satisfaction, but also the satisfaction with a number of pre-defined life dimensions, or the Life Satisfaction Scale method can be used.

When we concentrate on the individual person's satisfaction as one of the basic conditions determining the quality of his/her life then his/her "satisfaction" is influenced by a range of various approaches. These are an economy, health, environmental, psychological, religious, sociological and philosophic approaches. More detailed information is in (Křivohlavý, 2001; Philips, 2006; Rapley, 2003; Systém, 2009; Vliv, 2003). If we focus on (Systém, 2009; Vliv, 2003):

- Economy approach, where the economic situation of an individual (the society) has more and more influence on his/her QL. The economic situation

of a certain society can be expressed, among other indicators, by the well known gross domestic product (GDP) indicator. The higher the GDP indicator level, the better economic situation in a given country. Some critics of the expansive economy and of an unlimited economic growth however point at negative impacts of this on the future human beings life

- Health approach, where health can be defined as the state of complete physical, psychological and social well-being, not only as the absence of any disease or defect. Health is influenced by internal (impossible to influence) and external (possible to influence) influences

- Environmental approach where in most cases this approach is observed in relation with the health status of the population. Here we observe the quality of the air, potable water, noise level or the effect of foreign matter substances on the human body, e.g. from food chains and similar then it is possible to define the sets of input variables (indicators) of the mentioned approaches that influence the QL.

According to selected approaches it is possible to define sets of input variables (indicators) that influence QL.

When processing the QL indicators a number of mathematical methods can be used from one dimensional to multidimensional statistical methods, artificial and computational intelligence methods, decision trees, rough sets and the method of case based reasoning.

We can define QL system S_{QL} for design of QL model based on system approach by the following way:

$$S_{QL} = \{ A_i , M_j , I_{ki} , Ap_m , Da_n \} \tag{1}$$

where: A_i is i-th approach for description (specification) of QL, M_j is j-th method for QL modelling, I_{ki} je k-th indicator (attribute) for i-th approach, Ap_m je m-th appendix attribute and Da_n je n-th demographic attribute.

Among the approaches we can include for instance solving of the following issues:

- Quality of air in selected localities based on the chemical composition of atmospheric rainfall (Křupka, 2009)

- Region QL determinants (Křupka, 2010b; Křupka, 2010e)

- Data analysis and modelling of dependencies between selected environment attributes and health in the region (Křupka, 2010c; Křupka, 2010d).

Among the methods used we can include decision trees algorithms, neural networks, rough sets and similar.

The attributes are selected based on professional consultations and technical literature. The original, real metadata come from the Public Opinion Research Centre Institute of Sociology, Academy of Sciences of CR, from "Team initiative for regional sustainable development", from the Czech Statistical Office, from the Health Institute and similar institutions.

For the purpose of the creation of the here proposed QL models there have been used data for the period 1998 - 2007 acquired from the Regional Information Service portal, Pardubice region Czech Statistical Office, Public database of the Czech Statistical Office, Institute of the Health Information and Statistics of CR and the Czech Hydrometeorological Institute.

There were two matrices constructed - Matrix A_1 (for 29 indicators/attributes describing CR regions in the given time period) and matrix A_2 (for 42 indicators/attributes characterizing CR districts in the given time period).

Matrix A_1 (Svobodová, 2010) includes health, environmental, economy, complementary and demographic data. Among the health indicators are: life expectancy (male/female); death caused by neoplasm, live birth, death birth, deceased; deceased persons due to disease of the circulatory system; deceased persons due to disease of the respiratory system, deceased person due to disease of the gastrointestinal system; deceased persons due to external factor-e.g. suicide and similar; number of hospitals, number of physicians. Environmental indicators include: acquired investments to environment protection; emissions of basic polluting substances. Economy indicators: GDP, gross earnings; net disposable household income, rate of registered unemployment. Among the complementary indicators are marriages, divorces and criminality; the demographic factors are the region; state of the inhabitants, area and the total increment in the number of inhabitants.

Matrix A_2 (Augustinová, 2010) is composed from the following indicators: total district area; population density; inhabitants´ average age; share of selected types of parcels – agriculture land share in the total district area; completed apartments, room or a set of rooms, that can serve as independent apartments, and that have got effective certificates of practical completion in the observed period; mass accommodation facilities; acquired investments for the environment protection by the investor seat by district; independent buildings and other investment measures leading to improvement of the existing state of the environment; …; swimming basins and swimming pools, swimming basins are objects next to water flows that are operated by an operator. When there is more than one swimming basins in one area then each swimming basin is taken as an individual facility; gymnasiums; stadiums included sheltered stadiums; winter stadiums including sheltered stadiums (see more detailed information in (Augustinová, 2010).

The given matrixes (A_1, A_2) represent the inputs into models M_1 and M_2. The first one utilizes decision trees for the proposal of QL qualification models (Křupka, 2009; Křupka, 20010b). Its output is five QL levels for health and economy indicators and three QL levels for "general" QL including environment and complementary indicators. The second model uses factor analysis (Blahuš, 1985; Hebák, 2007; Kubanová, 2004; Labudová, 2010; Meloun, 2002). Its output is only seven so called "latent" or derived variables on which depends the QL level in the given district. We can with "confidence" allocate a group of relevant indicators to every derived variable.

4. Conclusion

Based on the analysis of the M_1 model outputs we can say that the following regions are the regions with high QL. These regions are Plzen region, Hradec Králové region, Pardubice region, and Zlín regions ("Plzeňský, Královéhradecký, Pardubický a Zlínský"). Among the regions with above-average QL are South Bohemia region, Karlovy Vary region, Liberec region, Vysočina region and Olomouc region ("Jihočeský, Karlovarský, Liberecký, Vysočina and Olomoucký"). The average QL is in Central Bohemia region and South Moravia Region ("Středočeský, Jihomoravský"), that are on the breaking point between average and below average. The worst QL is in Ústecký region and Moravskoslezský region ("Ústecký and Moravskoslezský"). This fact can be caused by, for instance, the reduction of heavy industry, high unemployment rate and problems with bad quality of the environment.

The results of the second M_2 model showed the possibility of using one of the multidimensional statistics methods for the "reduction" of a large amount of real attributes, indicators.

The achieved results can be used as a supporting knowledge for the regional management for the reinforcement/support of the selected indicators with the objective to increase the QL in the given region.

The model input data can be used for further processing, e.g. the model M_1 data have been modified, extended and used for the specification of Quality of Health State in CR regions (Křupka, 2010c; Křupka, 2010d).

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Contact Address

Doc. Ing. Jiří Křupka, CSc.
University of Pardubice, Faculty of Economics and Administration, Institute of System Engineering and Informatics
Studentská 84, 53210 Pardubice, Czech Republic
E-mail: jiri.krupka@upce.cz
Phone number: +420 466036015, +420 466036171

Mgr. Jan Mandys
University of Pardubice, Faculty of Economics and Administration, Institute of Public Administration and Law
Studentská 84, 53210 Pardubice, Czech Republic
E-mail: jan.mandys@upce.cz
Phone number: +420 466036171
Remark: PhD. student at University of Ostrava, Faculty of Arts

Ing. Jana Svobodová
University of Pardubice, Faculty of Economics and Administration
Studentská 84, 53210 Pardubice, Czech Republic
E-mail: jana.svobodova1@student.upce.cz
Phone number: +420 466036015, +420 466036171

Ing. Marie Augustinová
University of Pardubice, Faculty of Economics and Administration
Studentská 84, 53210 Pardubice, Czech Republic
E-mail: marie.augustinova@student.upce.cz
Phone number: +420 466036015, +420 466036171