

# **Decision making models for managing performance using Influence Diagrams: A solution for single vs multi strategy organizations**

**Mohammad Hassan Abolbashari, Atefe Zakeri and Elizabeth Chang**

School of Business  
University of New South Wales  
Canberra, Australia

[m.abolbashari@student.unsw.edu.au](mailto:m.abolbashari@student.unsw.edu.au), [a.zakeri@student.unsw.edu.au](mailto:a.zakeri@student.unsw.edu.au), [e.chang@unsw.edu.au](mailto:e.chang@unsw.edu.au)

## **Abstract**

To maintain a competitive edge in the market, it is important for a company to track and manage its performance. Performance management is the next vital step after measuring and monitoring performance. Maintaining an acceptable level of performance is a result of performance management. A company can achieve this goal by focusing and improving on those Key performance Indicators (KPIs) which are of utmost importance to the company; In other words, focusing on the KPIs which are mostly aligned with the company's long term strategies. Accordingly, this paper proposes a model to aim the decision making process in identifying such KPIs. The model is developed as an Influence Diagram (ID). Two IDs are proposed. One for a company based on a single strategy and the other for the use of companies seeking to fulfil multi-strategies within their operations. The IDs proposed in this paper will aim decision makers to choose the right strategy or a portfolio of strategies for their company which returns the maximum expected utility (MEU). The framework is based on capturing the Key Performance Indicators and selecting the KPI or a portfolio of KPIs which returns the MEU to the company.

## **Keywords**

Performance management, Influence Diagrams, Decision support, Maximum expected utility

## **1. Introduction**

The necessity to perform performance measurement through a combined, integrated network (i.e. a Bayesian Network) and not to consider each KPI in silos has been discussed by (Abolbashari *et al.*, 2018). In performance measurement, whilst dealing with the KPIs, if they're observed and measured individually, the output will be different to the case where the KPIs are combined and modelled through in a network, capable of capturing the causal relationships among the KPIs. This integrated model can then be used for performance measurement. In fact, the relationship between the KPIs are in a way that if they're approached through a naive way, characteristics are not explicitly derived, nor is their complex relationship captured, in comparison to the situation where we combine them in a network.

Performance measurement is the task of measuring KPIs. KPIs are specific to each company and differ from a company to another. Once the relevant KPIs are identified, they are measured and used to specify the company's overall performance (Chakraborty *et al.*, 2016). Performance measurement aims to measure something which has happened in the past. However, it is important too to manage performance, which is the successor of performance measurement. Performance management is vital to maintain an acceptable level of performance in day to day operations and to make sure the current tasks are done in such a way (i.e. the best way) so that the company secures a competitive edge in the market. This fact is important not only for a company who wishes to excel, but also for a company who wishes to maintain an acceptable level performance. In today's vibrant business environment where some businesses excel and some fall behind, it is still an achievement to remain in the competitive market by managing the current operations within a company. Consequently, it is not essential only for an emerging company to manage its current performance to improve, but also a company wishing to remain in the market and not be driven

out by competitors should also manage its performance to maintain an acceptable<sup>1</sup> level of performance. Performance measurement is about the history of performance, where performance management is an ongoing and dynamic task which has to be done for either improving the company's position or maintaining its current standing. When we aim to improve the level of performance in a company, we should investigate which KPI(s) need to be focused and improved on so that the overall improvement is achieved. This fact is the subject which this paper aims to address.

But why performance management is still important for a company wishing to just remain in the market (as it has been) and not necessarily seeking to excel? The answer is that the business environment is dynamic and objectives which companies need to focus on keep changing. For example, in the early 2000's, a cell phone capable of making calls and sending text messages was satisfying enough for people to buy. Hence, a cell phone production company needed to only focus on the KPIs that would guarantee such features for their product. However, in the recent years, the technology of cell phones improved quickly and those companies who failed to fulfill the new KPIs were simply driven out of the market.

In Figure 1, performance measurement happens at  $t$  and provides us with the level of performance, which itself is the result of performance in the past. On the other hand, Performance Management is an ongoing task and takes place as we move forward. It facilitates to improve the level of performance ( $a$ ) or to just maintain the current level of performance ( $b$ ). Trend  $c$  is the situation where performance hasn't been managed. Hence, the level of performance decreases.

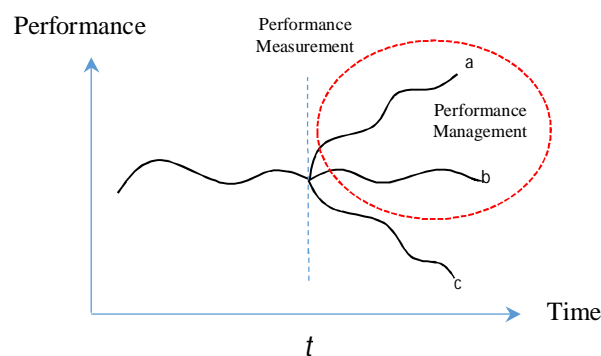


Figure 1. Performance Measurement vs Performance Management

Previously, (Abolbashari et al., 2018) proposed a methodology on how to improve the current performance of a buyer by making a better use of the same level of available resources. Their methodology was applied to a Bayesian Network designed for performance measurement and was based on an optimum re-allocation of the company's resources among the KPIs. This fair allocation improved the dominant KPIs of the company, resulting in an overall higher level of performance. The current paper introduces another approach for performance management, aiming to maintain or to improve the current level of performance in a company. Two IDs are proposed. One can be applied when aiming to select one KPI for a single strategy company. The other is applicable when aiming to select a portfolio of KPIs in order to address multi strategies within the company. The remainder of the paper is as follows. In section 2, Influence Diagrams in general and the proposed framework implemented in this paper are explained. In section 3, two Influence Diagrams are built and utilized for performance management. Moreover in section 3, the functionality of the proposed IDs are demonstrated through an illustrative example. Finally, section 4 concludes the paper and discusses future work.

<sup>1</sup> The notion "Acceptable" is subjective and depends on the company's objective. For a humanitarian institution, for example, the objective is to deliver services at the least finished price. Such these institutions are non for profit and monetary KPIs are less important. Hence, an acceptable level of performance for these companies is not necessarily to create profit, but to just cover operational costs. Whereas in another company, the acceptable level of performance might be defined as to make a certain amount of profit.

## 2. Methodology

### 2.1 Influence Diagrams

The modelling technique used in this paper is an Influence Diagram (ID). IDs are graphical modelling techniques which can be used for formulating decision analysis problems (Tatman and Shachter, 1990). They are an effective modelling technique in many areas. They are mostly adopted in problem domains which include a probabilistic relationship among variables. However, they are also useful in fuzzy domains such as performance evaluation where many linguistic and qualitative variables need to be modelled and treated quantitatively for the purpose of decision analysis. IDs are an extension of Bayesian Networks (BNs). The difference between IDs and BNs is that in addition to chance (or probability) nodes, they also include decision (or action) and utility nodes. Same as a BN, each ID has two parts. One is the graphical demonstration of the Influence Diagram and the other is the associated data and information with each node and link, demonstrating the quality of the probabilistic relationship among nodes. The nodes are connected to each other via information links. The links between chance nodes demonstrate conditional probability dependence among them. To achieve their goals, decision makers need to choose the decision that returns the maximum expected utility. IDs can be used as an effective tool to achieve this goal. By modelling the decision making scenario with IDs, the decision maker would be able to select the decision which returns the maximum expected utility.

### 2.2 Proposed Framework

The proposed framework is depicted in Figure 2. This framework includes 5 steps within three main phases. In the first phase, the conceptual aspects of the modelling process are identified. In this phase, the Key Performance Indicators of the company are determined by domain experts, based on the company's strategy(s). In the perceptual phase, the structure of the model is built and the working of it is developed. In the first step, the physic of the model is developed which includes the nodes and the connection links among them. In the second step, the heart of the influence diagram is added to the model which includes the probabilistic relationships between the nodes. This stage enables the working of the model since actual data is implemented to the model. Finally, in the practical phase, the model is used for decision analysis. The decision which returns the maximum expected utility is then selected.

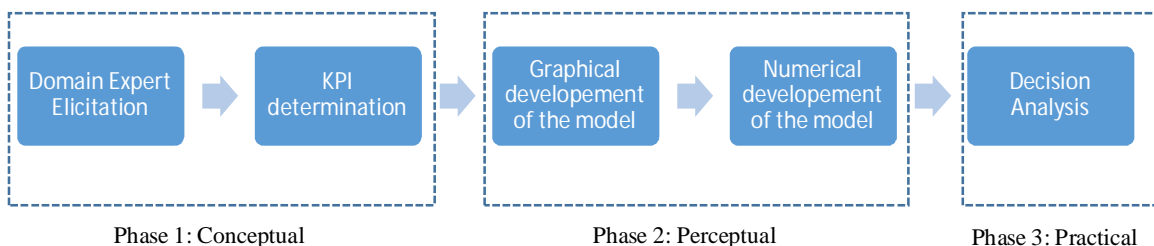


Figure 2. The proposed framework

## 3. The proposed model and its applications

### 3.1 Single strategy

In today's competitive market, it is not possible for companies to be perfect in every aspect. In fact, it is reasonable and even the best strategy for a company to focus on a single strategy. This strategy then becomes the core competency or say, the competitive advantage of that company. For example, a company might be famous for fast delivery but does not necessarily provide high quality products whereas another company offers higher quality products but is slower for delivery options. Accordingly, each company has its own market share based on the special feature it provides to its customers. That is because a group of customers are interested in fast delivery while quality is not that important for them whereas the other group of customers are willing to wait longer for higher quality products.

Before a company is established, it is important for the founders to specify the company's strategy. As mentioned before, it's impossible for companies willing to be perfect in every aspect and hence should focus on a single strategy as their core competency. Once this single strategy is specified, they should then focus on it and aim to excel in that area.

In this section, an influence diagram will be introduced to assist companies choose their single strategy that they should focus on. This decision might be straightforward and not require a tool (i.e. an Influence Diagram) to make the right decision. However, when the domain of the problem as well as the number of alternatives increase, the agent will require a tool to assist him/her for making the best decision.

It should be noted that the strategy selection process is not limited to the initiation of the company. In fact, it is an ongoing task in some cases (such as the cell phone industry mentioned before) and companies need to revisit their strategies from time to time. There could be a debate that it is not reasonable for companies to alter their strategies from time to time, as this task could be very costly. However, in some industries, the market is extremely dynamic in terms of customer needs and those who fail to adopt with the new changes abruptly, will be eventually driven out the market. A clear example here is the cell phone industry. In the last decade, by the introduction of smart phones, those who failed to offer smart features on their cell phones, lost their share of the market and were finally pushed out. Accordingly, revisiting the company's strategies from time to time is necessary to secure a competitive edge in the market.

The evaluation of a company's core competency is done through Key Performance Indicators (KPIs). In other words, there is a one-to-one alignment between each strategy and a KPI. It is through the measurement and evaluation of KPIs that a company explores its performance, in regard to the strategy it should focus on. Alternate strategies could also be defined as KPIs. Hence, the research objective here is what KPI the company should focus on, among a series of alternatives.

The proposed ID in this case is demonstrated in Figure 3. In this figure,  $K_i$  stands for  $KPI_i$ .  $ROR^2$  is the borrowed terminology from economics and indicates the efficiency of investment on a certain KPI.

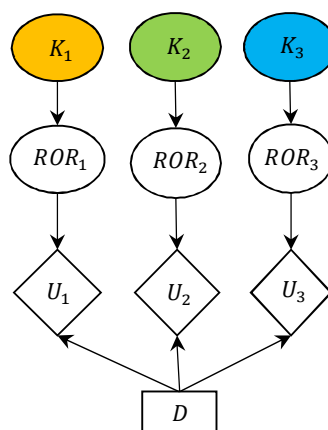


Figure 3. Influence Diagram for managing procurement performance

ROR depends on the state of a KPI. A KPI in an average state usually has a higher ROR than a KPI in a low or high state. When a KPI has a very low state, it generally requires more resources to be improved. If the KPI is in a moderate state, it is already initiated and settled and hence, can be improved with less amount of resources. Finally, if a KPI is already in a good state, it is very hard to seek further improvements. An overview of this managerial concept which is derived from experience is explained in Table 1 and Figure 4. This figure shows that initial and final improvements require more resources when compared to the situation where performance in a KPI is at a moderate level. Therefore the problem is not straightforward and we are dealing with a situation where the resources required for the transaction from one state to another, say  $s_1$  to  $s_2$ , is different from  $s_2$  to  $s_3$  and should be treated differently.

<sup>2</sup> Rate of Return

Table 1. The variation of required resources against the variation of performance for each transaction

Transaction	Global rule
$s_1(x_1, y_1)$ to $s_2(x_2, y_2)$	$\frac{\Delta y}{\Delta x} > 1$
$s_2(x_2, y_2)$ to $s_3(x_3, y_3)$	$0 < \frac{\Delta y}{\Delta x} \leq 1$
$s_3(x_3, y_3)$ to $s_4(x_4, y_4)$	$\frac{\Delta y}{\Delta x} > 1$

According to Table 1, the transaction from state 1 to 2 and from state 3 to 4 requires more resources than the transaction from state 2 to 3. That is because the ROR for a KPI in a poor or good state is lower than a KPI in a moderate state. In other words, it requires more effort to establish a KPI when compared to a KPI that is already settled. Similarly, it is hard to further improve a KPI which is already in a good state.

**Global rule:** If the level of performance for a KPI is closer to the moderate level, then investing on that KPI will return a higher utility when compared to a KPI in a poor or good state.

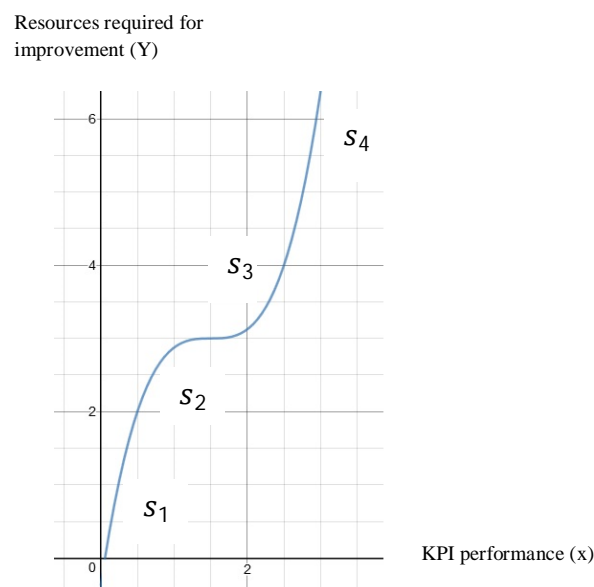


Figure 4. The amount of resources required for improving a KPI depends on the performance level of that KPI

At this stage, the framework mentioned in section 2.2 can now be implemented and followed. To demonstrate the functionality of the model, we tackle the utmost important field of procurement and show how an Influence Diagram can be designed and utilized for performance management in procurement. We have decided to apply our model specifically to the field of procurement since many studies in the literature have highlighted the significance of this process in any organization (Aissaoui, Haouari and Hassini, 2007; Wang, 2010; Abdollahi, Arvan and Razmi, 2015; Nair, Jayaram and Das, 2015; Ubada, Alsua and Carrasco, 2015). Moreover, it has also been mentioned in the literature that the current practices and strategies regarding procurement performance measurement and management are incompetent and require further research (Waldron, 2008; Balter, 2011; Lepse, 2013).

The first phase is to approach domain experts within the organization and seek the appropriate KPIs that need to be considered in the model. Once shortlisted, these KPIs are used to build the Influence Diagram. After eliciting the experts' opinions, we assume the three following KPIs: Procurement Cycle Time, Special Procurement<sup>3</sup> and Procurement Cost. In the second phase, the graphical development of the model is conducted and the proposed

<sup>3</sup> Special Procurement refers to the organization's capability in acquiring items which are abruptly required. To do so, the organization should be capable of handling procurements outside its usual routines.

Influence Diagram is illustrated in Figure 4. In this figure,  $D$  is the decision on which KPI to select and  $U$  determines the utility associated with each decision alternative.

For the numerical development of the model, each KPI in the organization is monitored and an approximation of this measurement is considered as the probability distribution of that KPI. The probability distributions for the three KPIs in this example are shown in Table 2.

Table 2. Probability distributions among the states of each KPI

KPI	State	Probability
Procurement Cycle Time	Short	0.2
	Average	0.3
	Long	0.5
Special Procurement	Incapable	0.3
	Emerging	0.4
	Capable	0.3
Procurement Cost	Low	0.6
	Moderate	0.2
	High	0.2

The ROR for each KPI is then determined based on the global rule mentioned before. Since each ROR has a predecessor node, the state of each ROR depends on the state of its predecessor. Hence, the probability distribution for each ROR is a conditional probability distribution and is specified as in Table 3. This table demonstrates the conditional probability values for the first ROR (ROR of Procurement Cycle Time). However, the same values are considered for the two other RORs.

Table 3. The conditional probability table for RORPCT

Procurement Cycle Time	ROR		
	Low	Moderate	High
Short	0.7	0.2	0.1
Average	0.1	0.2	0.7
Long	0.7	0.2	0.1

Finally in the last phase of the proposed framework, based on the input data in the model, the Influence Diagram will return the expected utility value for each decision. Consequently, the decision maker is able to identify the optimum decision, which returns the most expected utility, when compared to other decisions. Figure 5 shows the numerical development of the Influence Diagram which has been performed in Netica software. Based on the probability distributions among the states of each KPI, the optimum decision for this example is to invest on improving Emergency Procurement, since this decision is expected to return a higher utility than other decisions.

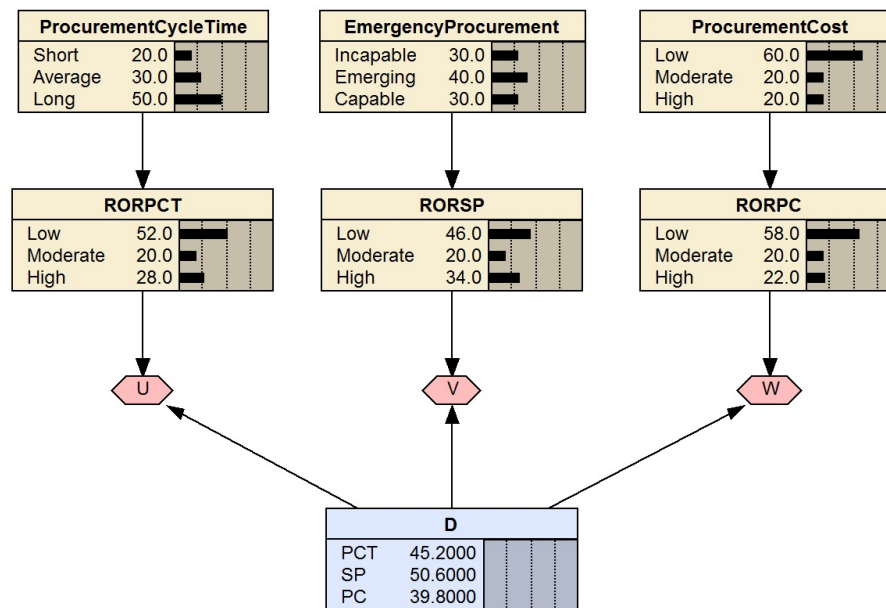


Figure 5. Numerical development of the Influence Diagram in Netica Software

The advantage of adopting such a model as a performance management system in an organization is the flexible structure of it. If the level of performance changes for any KPI, the probability distribution for that KPI can be easily updated and the model will return the new optimum decision.

### 3.2 Multi Strategy

This is the case where a company wishes to maintain a balance among more than one KPI. The company's resources are limited and hence the company cannot achieve an excellent state in every aspect (KPI). The level of competency in each KPI and among all the KPIs, is capped by the available resources. If the amount of available resources is equal to  $C$ , then  $C$  needs to be fairly allocated among the KPIs. In this paper, by fair resource allocation we mean the allocation to a KPI is proportional to its expected utility; a KPI with a higher expected utility is allocated more than a KPI with a lower expected utility. Accordingly, the results of the Influence Diagram mentioned in section 3.1 can be applied to facilitate such distribution among KPIs. To calculate the percentage of  $C$  which is allocated to each KPI, we need to calculate the normalized expected value for each KPI as follows:

$$NEV_i = \frac{EV_i}{\sum_{i=1}^n EV_i} \quad \text{Eq. 1}$$

The notations in Equation 1 are as follows:

$NEV_i$ : Normalized expected value for  $KPI_i$

$EV_i$ : Expected value for  $KPI_i$

$n$ : Number of KPIs

Consequently, the percentage of allocation to each KPI is calculated as 33% to Procurement Cycle Time, 37% to Special Procurement and 29% to Procurement Cost.

Another technique for decision making in such cases is to consider the proposed Influence Diagram in Figure 6. This ID is a Multi-agent influence diagram (MAID) or Game-theory based influence diagram (GID) as discussed by (Koller and Milch, 2003) and (Zhou, Lü and Liu, 2013) respectively. Each decision node can be considered as an agent. In such models, the decision an agent can make depends on the decision of other agent(s). In our case, the decision about the level of performance we desire to achieve for a KPI depends on the decision we have made for

other KPIs. If the total amount of available resources is equal to  $C$ , then  $C$  can be distributed among a portfolio of KPIs to achieve a certain amount of performance in each KPI. This allocation is Pareto-efficient (Ghodsi *et al.*, 2011) meaning that more allocation to a KPI (i.e. further improvement in that KPI), will result in less allocation to another KPI. According to (Shachter, 1986) and (Kjaerulff and Madsen, 2008), an ID can include a series of sequential decisions. If a second decision node appears after another decision node, then information of the first decision node and all of its predecessors are available at the time of making the second decision. In other words, the alternatives left for a latter decision depend on a former decision which has already been made.

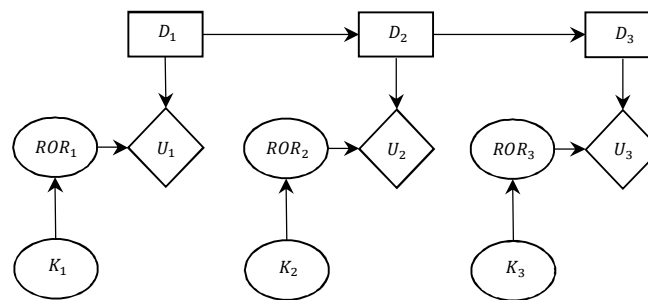


Figure 6. Influence Diagram for selecting a portfolio of strategies

#### 4. Conclusion and discussion

In this paper, a novel method is proposed to manage performance in an organization. The proposed methodology is based on capturing the most important Key Performance Indicators and building an Influence Diagram as a tool for managing performance. The Influence Diagram considers the state of each KPI and based on that, calculates the expected utility for each decision alternative. The alternatives include the decision on whether to invest on improving a KPI or not. Based on the designed Influence Diagram and the output of the model, we showed that the organization can choose the best KPI to invest on, which is also expected to return the maximum utility to the organization, when compared to the expected utility of other KPIs. Alternatively, based on the same results, the organization is able to conduct a fair resource allocation among a portfolio of KPIs. For future research, a Dynamic Bayesian Network may be proposed for managing performance in different time slots based on the Influence Diagram designed in this paper.

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## Biographies

**Mohammad Hassan Abolbashari** is a PhD student at University of New South Wales, Canberra, Australia. He is also a sessional academic at University of Canberra. He received his Bachelor's and Master's degrees in Industrial Engineering from Ferdowsi University of Mashhad and Amirkabir University of Technology respectively. His research interests include the application of Bayesian Networks in Business/Management decision making and analysis. His research has been published in journals such as Knowledge-based Systems and International Journal of Production Economics.

**Atefe Zakeri** received her Bachelor and Master degree in Industrial engineering from Ferdowsi University of Mashhad, Iran. She is currently a PhD student at the University of New South Wales, Canberra, Australia. Her research interests include Green Supply Chain Management, Data Mining, Business Intelligence and Decision making. Her research has also been published in International Journal of Production Economics.

**Elizabeth Chang** is a Professor of Logistics and Canberra Fellow at UNSW Canberra. Professor Chang leads the Defense Logistics research group at UNSW Canberra, targeting the key issues in Logistics ICT, Big Data Management, Defense Logistics and Sustainment, Predictive Analytics, Situation Awareness, IoT and Cyber Physical Systems, Trust, Security, Risk and Privacy. In a 2012 article, published in MIS Quarterly vol. 36, Professor Chang was ranked fifth in the world for researchers in Business Intelligence. She has delivered 52 Keynote/Plenary speeches largely at major IEEE Conferences. Her academic achievement includes 26 competitive research grants, including 12 Australian Research Council (ARC) Grants worth over \$15 million. She has supervised/co-supervised 41 PhD theses to completion, 21 Master theses and 16 postdocs. She has published 7 authored books, over 500 international journal papers and conference papers with an h-index of 44 (Google Scholar) and over 30,000 citations.