ANALYZING THE INFLUENCE OF IE FACTORS ON RECRUITMENT AND SELECTION PERFORMANCE USING KALMAN FILTER

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"...the things of this world cannot be made known without mathematics"
Roger Bacon

Abstract. *The human factor is known as being one of the key factors through which the organization may obtain success [1]. Only attracticng, recruiting and maintaining those right candidates, with proper skills, knowledge and competencies, an organization may obtain performance in a global competiting environmet, dynamic and in continuos change [2]. Performance of a recruitment and selection process depends on the internal and external (IE) factors, which are analyzed in our article. We implemented the Kalman filter on a new area, that of HR recruitment and selection, because is well known that this model has been used in engineering, or in finance. This will help us to find new solutions, to develop new strategies, to improve forecast accuracy, to improve communication in recruitment and selection processes, to know its limits and to overcome its inefficiecies and also, to establish in what measure each factor, internal or external, will influence our analyzed processes.*
Keywords: *recruitment, selection, IE factors, Kalman filter, performance.*

1. RECRUITMENT AND SELECTION IMPORTANCE FOR ORGANIZATION

Recruitment regroups all activities aimed to analyze individuals, their skills that fit best for the requirements of the vacancy [3]. Recruiting is a set of actions taken by the organization to attract candidates with the necessary skills for immediate employment or a future vacancy [4]. The recruitment process consists of several stages from the preparation of recruitment, when are identified the needs for recruitment till the acceptance and integration of the new employee into the organization [5]. Recruitment is the most popular dimension of human resource management [6]. Recruitment is not a trivial activity, but one of management that occurs either in emergency situations- winning new customers, creating new jobs, retirements, departures or in planned situations- making a recruitment strategies to be consistent with the organization strategy [7]. A study by the CIPD in 2007, shows that the main objectives of the HR function are recruitment and selection [8].

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Selection is the process of discovery of candidate qualifications and its characteristics in order to determine their suitability for the vacancy [9]. Selection means "to pick and chose out" [10]. Selection of candidates is that decision which candidates are subjected to one of two possible situations - accepted or rejected. A good selection process will bring those people trained and a better classification of people already employed, and also will bring better compatibility of individuals with different characteristics of the vacancy [11]. If an employee does not have the right qualities for the job, the organization will not get performance [12]. Effective recruitment and selection practices will make the difference between success or failure of an organization, such as the skills, knowledge and competencies make the difference to achieve organizational performance [13]. On the selection of those necessary human resources, the organization functioning will depend to achieve goals [14]. HRM should have a value-oriented personnel policy and that policy must begin with a rigorous selection [15].

2. THE INFLUENCE OF IE FACTORS ON RECRUITMENT AND SELECTION PROCESSES

The importance of recruitment and selection depends on the influence the internal and external factors have on these processes: the cost, which varies according vacancy, employment stability, qualification of human resources, union presence, technological change and consumer demands [16], and the orientation, size, structure and strategy of the organization and political factors, social, economic, cultural or legal.

2.1. THE INTERNAL FACTORS AND THEIR INFLUENCE ON RECRUITMENT AND SELECTION PROCESS

Orientation and size of the organization
The volume of recruits is establishe on the size of the organization and its sector of activity, often beign an indicator of the development of organizational strategies. The start of recruitment process requires knowing the organization orientation, and these guidelines must be precise to achieve its objectives [17].

Organizational culture
Due to relevant values promoted, the culture positively influences the desire for recruitment and hiring of candidates [18]. Large organizations, with a strong culture, adopt human resource management activities more sophisticated and socially responsible, due to the costs involved and because it is under pressure of gaining legitimacy [19].

Organization structure
Describes the allocation of duties and responsibilities of individuals and departments and designate the nature and grouping of individuals in organizations [19]. Each structural shape will meet unique challenges which will impact HRM. In organizations which have departments, HR management is made by implementing recruitment, selection, training, performance evaluation and compensation processes, and those who work in teams need to

use new methods of analysis, recruitment and socialization activities. This leads to better care for HRM implications on workforce diversity

Business strategy

Recruiting is not a field by itself, but it belongs to HR planning and strategic planning of the organization [20]. Business strategy involves exploring activities, analysis and defense. Exploring organizations are looking to develop, those who analyze are looking to develop, but in a stable and predictable way, and those who are looking for defense are less concerned with recruiting candidates from outside the organization and more interested in developing current employees. This classification has implications on the HR flow from organizations [21]. The strategy applied by the organization has an important impact on HRM, particularly on the recruitment and selection of employees [19].

Life cycle of the organization

Literature focuses on changing management priorities whcih are charaterizing the organization in different stages of development, such as: start, growth, maturity, and decline or re-development [22] and who influence the existing HRM.
* *Phase 1* - start. The employer conducts its employees alone, because in this pfase are few ;
* *Phase 2* - growth. This increase implies a larger number of employees and the organization must recruit, select and hire and have files for each employee;
* *Phase 3* - maturity . During this period, the profits increase, and thus is a significant need for diversification of operations. Recruitment and selection can be made by the organization and the specialized agencies, thus creating new jobs ;
* *Phase 4* - decline or re-development. In the decline phase, the most important activity of human resources will become training the current employees and those that will be employed. In the re-development phase, if the organization will revitalise, the human resources department will create new jobs for specialists in the field of human resources management. The number of employees increases, having diversified qualifications, will develop negotiations with unions, will appear new tasks and complex legislation. Executive managers and HR managers need to see the recruitment and selection as the most important aspects of HRM, while in mature firms greater care is given to maintaining employees [19].

Recruitment and selection team

An effective recruiter never act alone [23]. For recruitment to be as effective recruitment team should be well trained and experienced in recruitment. Due to the array of features that have to meet a candidate recruitment team must consist of at least one psychologist, a sociologist, economists, lawyers and a specialist to analyze the qualities, skills, knowledge and behavior of the candidate [24]. Choosing a candidate implicitly performing the organization's performance . Team effectiveness of recruitment and selection is to choose those people in the right place for interviewing and choosing the right person based on ethical principles of non-discrimination , sustainable development , equity and well-established integration programs, thereby achieving, individual efficiency and implicitly organizational [25].

An effective recruiter never acts alone [23]. In order for recruitment to be more effective, the recruitment team should be well trained and experienced. Due to the array of features that have to meet a candidate, recruitment team must consist of at least of one psychologist, a sociologist, economists, lawyers and a specialist to analyze the qualities, skills, knowledge and behavior of the candidate [24]. Choosing a performing candidate implicitly will guide to the performance of organization. Recruitment and selection team effectiveness consist of choosing those people in the right place for interviewing and

according to the ethical principles of non-discrimination, sustainable development, equity, thereby achieving individual and organizational efficiency [25].

Jobs' stability

The employees will change jobs throughout their life, but they must want a lifelong learning. This mobility will cost much the employer, therefore it is necessary to develop effective programs to motivate and retain talented employees. Many candidates choosing a job making a comparison between present job and their desired job [26]. By applying attractive rewards systems, potential candidates will choose an organization base don the offered benefits: salary, benefits package, reputation, learning and development opportunities, which affect the ability to attract candidates for a vacancy [4]. When a potential candidate take into consideration a hiring offer, these benefits not only affects that person's decision to submit, but the decision to remain an employee for a longer period of time in the organization.

Union presence

Economic boom from 1960-1970 caused the emergence of trade unions. The old labor contracts included only information on pay and leave, now it includes clauses on technological change and retirement [4]. In the U.S., employees who belong to unions receive to other employees up to 33 % more in salary and these unions are credited as having the role to improve working conditions and safety [27]. Unions give life to its members, establish policies and procedures to improve working conditions and increase the level of pay, job security and health insurance and pension benefits [28]. Unions have seen a decline in recent years due to external forces, such as international competition and the shift from manufacturing to a service economy. HRM researchers need to understand, recognize and incorporate these realities in their work if they want organizations to achieve success in a global context [19].

Ethics, non-discrimination and equal opportunities

Recruitment represents the organization windowthrough that people watch and observe its activities, such as social responsibility, ethical behavior, sustainable development, non-discrimination and diversity [17]. Every day managers and organizations are forced to make decisions that have moral implications. As a manager, it is important to understand the ethical obligations to meet the expectations of the organization and be taken as a model of its employees. This means to act fairly and honestly in relation to employees (recruiting and hiring). Organization must propose itself in achieving recruitment policy to meet the following characteristics [29] to announce all the jobs internally, to respond to all applications for employment, to inform all the employees the essential data about the conditions of employment, to efficiently process all applications for employment received from the candidates, starting from their basic skills and to give due consideration to each person interviewed equitably .

Diversity

In recent years this activity has been increasingly promoted and supported in terms of ethics, ensuring a diverse workforce and in terms of management needs. Thus, we analyze three main factors [30]: an organization to provide an environment compatible with diversity by promoting the organization and its culture, maintain a balanced gender, ethnicity, religion or color, be attention to where and how the recruitment is conducted and what effects it will have on diversity candidates. Applicant should perceive the organization as a positive place where you can work [31], so some steps are required in applying the principles of diversity [32]: the image of diversity, diversity in recruitment team integration, applicating new

methods of recruitment, such as anonymous resumee, inserting in the recruitment notice of images and texts that support the use of diversity; statements of organization in which it shall equal employment or use by organizations of recruitment ads and special materials [33].

Sustainable development

Recruitment and selection based on knowledge, skills and abilities, human resource development and motivation make organization to have the ability to develop sustainably and respond rapidly to a constantly changing environment. Employees who engage in sustainable activities and adopt principles of sustainable development will become sustainable human resources. If the organization and its valuable employees are aligned (with ethical working conditions, healthy and safe) will increase staff morale and their engagement. Employees involved in such programs will recommend the organization will be loyal and motivated. The human factor is known as a key factor for achieving international success of the organization [34]. Practitioners recognize the value of the role of HR in achieving organizational objectives [35]. Under the principle of "healthy people in healthy organizations and a healthy environment", HR plays an important role in the implementation of sustainable development activities .

Level of qualifications

Before to employees were required to be only strong and healthy and now are required to understand a business plan, to provide maximum efficiency, to provide feedback, to manipulate a machine or a computer, to be able to work in a team, to participate in decision-making through participatory management, etc. Exclusion based on judicial history on ethnic background or political records [18], or subjective preference of a candidate over another, should not affect recruiting, but the competencies must be the only criterion that can favor a candidate and increase the profits for an organization. Talent war must be silent because it announces a huge number of people, but should reach only those persons which have those rare skills necessary to carry out certain activities . So "it is not easy to attract talents" [36]. Talent is that positive notion that human resources specialist is always needed.

Knowledge

More and more specialists recognize that the success of a company is determined by a range of knowledge, knowledge which refers to products / services, promotion, distribution or processes which differ from competitors providing added value to customers. Competitive advantage obtained through human resources should be a goal of all modern companies. Unfortunately, their role is not recognized in all the organizations.

A set of rules (VRIN Architecture) should be respected in order to achieve competitive advantage through employees [37]: resources must be valuable- people are a source of competitive advantage when they are involved with the efficient and effective achievement of objectives, rare – it means that knowledge, skills and abilities must be unique, difficult to imitate- it means that these resources are not among employees of other competitors, and irreplaceable- it means that HR to hold those unique knowledge that other people do not have, and good results can be achieved when talent is combined and developed through work.

Competencies and skills

Competencies can be natural (like personality), acquired (like education, skills, and experience) and adapted (like career results, the candidate's ability to use natural, and acquired skills) [38]. By competence it is understood those responsibilities designed and maintained by employees assigned as a result of negotiations and agreements between them and the managers [39]. Management skills are piloting an organization that make production and development skills a major vector of performance and value creation in the organization.

Management skills involves sorting internal resources, which is competitive advantage for the organization [40]. Measurement and evaluation of a candidate's skills are activities heavier than we imagine, so analyzing the knowledge and skills held by them [41]. Competencies are defined as an individual's recognized capabilities in mobilizing its own resources to achieve actions and pending the results expected [42]. More precisely, we can define recruitment as a set of actions taken by the organization to attract candidates with the necessary skills for immediate or future employment of a vacancy [4].

Policy and human resource management practices

Without knowing the strategies and policies of the organization, without an analysis of the organizational long-term planning, situational awareness absences, retirements, recruitment methods become inaccurate and imprecise and human resource management in an organization could not have a proper planning of vacancies or movement of human resources [4]. One of the first measures to be taken when planning recruitment is to establish policies and procedures. Recruitment policy is the code of conduct of the organization in this field [29].

2.2. THE EXTERNAL FACTORS AND THEIR INFLUENCE ON RECRUITMENT AND SELECTION PROCESS

Internationalization

Increasing the international interdependence and globalization of markets has led, for the last two decades, to an internationalization of business organizations. Internationalization is not only expanding national management activities abroad, it also means an increase in complexity and modernization of HRM. They are motivated by the multitude of functions and activities that have gained international character, loads generated by heterogeneous economies of the countries, the increased risk due to the personal nature and causes of financial failure on commitments abroad, etc. [43]. HRM needs to address a number of operational issues as: reducing costs and increasing quality recruitment and selection of competent candidates hiring, training, mentoring, adaptation and integration of the new employee into the organization and reintegration of foreign labor.

Globalization

Due to developments in technology, demographic changes and globalization, the world of work is changing. Given that competition is increasingly fierce , the labor market evolving, HR must quickly adapt to a world in the process of globalization in order to deal with any challenges. Thus, by adopting modern techniques with internet access, labor becomes every day more and more demanding in terms of employee-employer relationship. The impact of globalization and ICT recruitment and selection processes have resulted obtain flexibility and responsiveness of employees. Thus the labor market using new methods of recruitment and selection to increase efficiency and improve working conditions, reduce stress, time and expense of recruiting and selection and widening geographical areas of recruitment and selection. Globalization is a phenomenon of the modern era. Mutations in HRM occur in response to changes occurring in the external environment of the organization. Currently labor market is highly influenced by complex phenomena such as labor migration from Eastern Europe, the European internal market development and competition conjectural, developments in technology, demographic changes, globalization, the impact of ICT on HR

employment, appearance of new professions, the world division of labor and the emergence of multinational firms .

Labor market conditions

Some economic dimensions, including unemployment, labor diversity and structure of the labor market are considered important macroeconomic variables. The entire recruitment process is expensive since the search candidates and training of those carrying out recruitment and the cost varies depending on the number of vacancies ; with an unemployment level below the average of 10 % in Europe , the new generations , the withdrawal generations retire, compete to become increasingly acute among organizations. Such organizations hire those who have some potential and are willing to develop their skills [44]. Organisations may use different institutions and different categories of candidates to attract them: universities – the relationship between organizations and universities are beneficial for both sides [20], placement agencies, can be an important source of recruitment, people with disabilities, they face various negative attitudes, but the organization must take into account for certain activities and retirees who because they possess skills which can be a source of recruitment should not be forgotten.

Technological change

In the past, work was done by people with less aid from the machines, today, robots are replacing the human resources. Computerization presence is felt in human resources through programs that assess candidates' CVs in record time and makes the recruitment process in a short time; impact of technology on the social dynamics of organizations has been long recognized but little time American researchers have determined the implications of technology on human resource management [19]. Snel and Dean [45] showed that human resource management is directly influenced by the presence of advanced technology, quality management and just-in-time control. A study made in 512 manufacturing firms has shown that companies which are using traditional technologies, to those that are using advanced technology were less involved in selective hiring, training, development, evaluation and fair payment [46]. The combination of the complexity of existing technology in an organization and human resource management is an indicator of climate conducive to technical equipment.

Legal and political factors

In recent decades, the state has adopted many laws on labor relations, so employees are better protected; during the two processes of recruitment and selection candidates should not be discriminated, so the candidates will be chosen on skills and knowledge criterion. Because American companies have been operating across borders, they were faced with legal problems of the host countries [19]. European countries are obliged by law to allocate some money for training and development.

Social and economic situation

Some candidates submit their resumes for positions for which they are qualified or less qualified, so those ho recruit must be careful when recruiting candidates " overqualified " A number of factors have led to the trend shift from full-time employment to atypical conditions, such work from home, fixed-term contracts or part-time alongside their outsourcing and contracting with external collaborators. Outsourcing of recruitment and selection can be one of the chosen services firm, to better focus on activities that know better to perform. This is supported by well-known authors in the field of management, Tom Peters , who urges companies to focus on what I can do better . But regardless of the available

workforce , an organization must pay particular attention to the recruitment and selection processes , even if they are outsourced to be sure that the human resources of the organization is satisfied with the most efficient manner possible [47].

Attractive area location

The organization the more close to inhabited areas (especially urban) , the candidates are more interested in enrolling in a post vacant currently no organizations; but for example, tourist areas can attract candidates.

Education and culture

Researchers have shown that the practices of recruitment, selection and retention of employees are closely linked to culture [48]. When a company wants to expand its business in another country must consider the criteria on which the selection is performed , otherwise you will have difficulty in recruitment and selection of staff. A study in the 18 Western companies operating in Russia has shown that personality and experience are the main criteria for selection. Consequently, criteria such as certificates and diplomas mattered less in comparison with honesty, ambition, team spirit, willingness and ability to learn. In the international context, multinational companies establish "criteria equivalent". Recruitment and selection due to differences in educational systems and cultural specificities of each country. Not understanding the differences between the education systems of different countries may generate obstacles to recruitment and selection of employees using the system equivalence [43].

Emergence of multinational firms

Because American organizations have expanded their operations beyond their borders, they were faced with legal problems of the host countries [19]. For example, in European countries, organizations are required to establish certain amount of money for training and development. For corporations , where employees are expatriates, immigration can influence decisions in human resources [49] and can meet the social and political realities. For example , in some countries, civil and religious laws can co-exist and define the legal context for human resource management. The experience gained by them in recent decades confirms that the greatest benefits were obtained from organizations that have successfully integrated the latest achievements in science and technology within their organization and also promote high standards for staff training [50]. Today multinational corporations is a massive presence in the global economy, they internaţionalizând and production services. Global corporations are positive forces for development and economic prosperity [51]. Multinational companies have brought human resources policies and therefore new methods of recruitment and selection . In the multinational companies, recruitment and selection of a strategic gain as promoting parent company strategy and values of the host country is provided by managers and employees involved in its subsidiaries.

The emergence of strategic alliances

Competitive advantage increasingly depends not only more internal capabilities of a company, but also the types of alliances and the scope of its relations with other companies [52]. Collaborative work between companies has a profound effect on managerial practices implicitly on best practice recruitment and selection. Alliances can be formed in order to increase market access, reducing costs , increasing productivity and sales, profit and improve the image [53]. Alliances are now perceived as a means to add value to the firm, focusing on strategy, knowledge and opportunity to involve competitors. Alliances appear in various legal and organizational forms, some contract, some based on a joint venture [54].

Competition

When some experience is required for a job , there are various competitors , which can be in the same area or the same area. Even small companies can benefit from employees at large companies that own skills obtained from training programs followed [20]. Multinational companies may face labor market globally, with a very intense competition.

Image and brand of the organization

The results of this practice have an economic impact on the organization, the social impact on the organization and its image and psychological impact on candidates : loss of confidence and trust in the organization [10]. Recruitment activity not only supply resources but also one marketing. So when trying to recruit employees, the organization does nothing to compete with other organizations to obtain suitable candidates. If you are treated fairly and effectively, candidates communicate on a positive image, even if their application is unsuccessful hiring. If the organization has a negative recruitment efforts may be limited [2]. To become an employer reference, organizations must improve their ability to attract and retain employees and candidates [55]. Recruiting the organizational brand combines elements such as recruitment and marketing to present a true and positive organization among those to be recruited. This combination of human resources and marketing allows the organization to excel in attracting talent and customers [56]. Organizations need to attract employees in the same way that attracts customers. To be a real "magnet" among candidates , the organization needs to know how to draw, and once established relationship between them , we must recruit and retain them [57]. Brand talent is a marketing tool that provides the required number of employees. Organizations must involve employees in the development and improvement of organizational brand [58]. Especially in organizations that provide services, employees are customer brand image [59]. When the organization is a leader, has certain influence on the people they employ , what positions and how they are organized to operate [60]. In the current increasingly people react more to their organization's name and reputation and rumors or information provided by the knowledge [61]. In a recent study of 703 people , 61 % said that the most recent job was occupied by knowledge [62]. The brand must not only smart and attractive advertising developed by the company's marketing department , but must ensure that what looks on the outside, it is inside [63].

The strategic role of the HR department

In large firms and multinational alignment is achieved by recruitment and selection processes in vision and objectives of the organization , while the small and medium there is no HR department to conduct recruitment and selection processes and manager of the company is directly involved in choosing employees through an intuitive management. Department of HR has a strategic role in the organization by: staffing forecasting , order planning , human resource planning by analyzing the organization's objectives [29], methods used in the determination of human resources, estimating human resource needs based on productivity labor tasks for job analysis and job designation, specification writing staff (by determining behaviors, knowledge and skills of candidates in hiring vacancy), the content of recruitment, using marketing methods to attract a sufficient number of potential employees that the vacancy, using internal and external sources to meet the requirements of vacancies, use of recruitment methods and techniques as varied, using new recruitment techniques to attract a large number of candidates, using new methods and techniques for selection conducting interviews with a specialized team consisting of economists, sociologists and psychologists (without distinction) to better understand the behavior and thinking of each candidate [63].

Market dynamics

Substantially affect human resource management. Today the European internal market is becoming stronger by removing many barriers between countries. Also, when taking into consideration: increased traffic of goods, communications policy, media policy , consumer policy, literacy policy, free choice of employment and residence stability, we can say that we are witnessing the essential events will give rise to significant changes. They go to standardize on one hand and on the other hand favors the growth of market dynamics. Changes in markets, leading inevitably to a new application personnel both quality and quantity time with them on getting staff to change, and the increased demands on staff development.

- Outsourcing - Outsourcing recruitment process gaining more ground in the organization and is explained by [64];
- Routine process outsourcing using all functions of the organization - the organization may outsource only certain phases of the process , and those considered strategic, keeping them to control the process;
- The importance given to the process in time and money - may be more cost effective if outsourced;
- The level of professionalism of some external providers - recruitment agencies , thus reducing the risk of outsourcing .

In recruiting aims [65]:
- The quality of internal customers - adequacy individual post by indicators such as the percentage of employees at the end of the probationary period, the assessment activity after one year , the degree of leaving the job early ,
- Quality external clients - use indicators such as the number of spontaneous applications. Most organizations focus increasingly more on their core activities and related activities (recruitment, selection) are delegated to specialized organizations or in certain countries where costs are lower [44].

3. ABOUT KALMAN FILTER AND ITS STEPS OF IMPLEMENTATION

The Kalman filter is an estimator for is called the linear-quadratic problem, which is the problem of estimating the instantaneous [66]. Kalman filter is a recursive algorithm for optimal processing of information about the system studied. It incorporates all the information that is provided by the system by processing the measurements available, given their degree of precision, in order to estimate the current value of the variable of interest [67]. Producing accurate economic forecasts using data-based quantitative models is difficult. The model must be based on past data [68].

Kalman algorithm is based on three elements:
(1) knowledge of the system and mechanism dynamics measurements;
(2) a statistical description of the system noises, measurement errors and uncertainty in dynamic models [69];
(3) any available information about the initial conditions of the variable of interest.

Whether a descrete dynamic system, modeled by an Itô stochastic equation:

$$x_{k+1} = \Phi(t_{k+1}, t_k) x_k + \Gamma(t_k) w_{k+1}, \; k \in N,$$ (1)

where through x_k we denoted the system estate at the moment t_k, $x_k \in R^n$, Φ being a square matrix, non-singular, of order n, matrix of passing of system estates, $\Gamma \in M_{n,r}(R)$ and $\{w_k\}_{k \in N}$ is a white vectorial Gaussian sequence $w_k \in N^r(0, Q_k)$. We suppose that x_0, the initial condition, is a random variable with a given independent repartition and independent from the sequence $\{w_k\}_{k \in N}$. We also consider the stochastic equation, which models the observation process, which take place over the estate system:

$$y_k = H(t_k) x_k + v_k, \; k \in N, \; H \in M_{m,n}, \; v_k \in N^m(0, R_k), \; R_k > 0.$$ (2)

We suppose that the sequences $\{w_k\}_{k \in N}$ și $\{v_k\}_{k \in N}$ are independent.

Kalman algorithm , as defined above, is a set of equations that provides an efficient means of computing and recursively estimate the state of a dynamic system, supporting all known information about the system. Filter equations consist of two groups: the time evolution equations of the system and the equations for updating data, information obtained by statistical measures. The time evolution equations provide the projection, on the time and the estimate of the current state error covariance matrix to obtain estimates for the next step, while the update equations of the feedback data carries out, by incorporating the following estimate, new information about the system state in order to improve them. Thus, while evolution equations are called prediction equations and updating the information with the new measures are called correction equation [70]. At least in the case of discrete Kalman filter algorithm resembles the algorithm predictor - corrector.
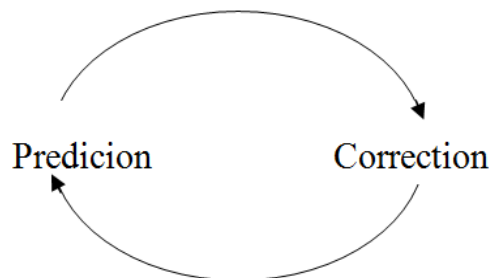
Fig. 1. The mode of action of the Kalman filter.

The two types of equations are summarized below.

Proposition 1. [71]:
1. Equations of evolution in time of the discrete Kalman filter are:

$$\hat{x}_{k+1}^k = \Phi(t_{k+1}, t_k) \hat{x}_k^k,$$ (3)

$$P_{k+1}^k = \Phi(t_{k+1}, t_k) P_k^k \Phi^T(t_{k+1}, t_k) + \Gamma(t_k) Q_{k+1} \Gamma^T(t_k);$$ (4)

2. Time evolution equations, estimates the states of the dynamic system design and the covariance matrix from time to time are the matrices defined above, and which appear in the stochastic differential equation system (4.1'), while the covariance matrix, defining the nature of the disturbing process.

3. Actually matrices and changes in each iteration, but it can be assumed constant.

4. Equations for updating information through new statistical measurements, the Kalman filter are:

$$K_k \equiv P_k^{k-1} H^T(t_k) \left[H(t_k) P_k^{k-1} H^T(t_k) + R_k \right]^{-1}, \tag{5}$$

$$\hat{x}_k^k = \hat{x}_k^{k-1} + K(t_k)\left(y_k - H(t_k)\hat{x}_k^{k-1} \right), \tag{6}$$

$$P_k^k = \left[I_n - K(t_k)H(t_k) \right] P_k^{k-1} \left[I_n - K(t_k)H(t_k) \right]^T + K(t_k) R_k K^T(t_k). \tag{7}$$

5. First requirement, if the measurement update is to compute the value of the expression Kalman. The next step is to update the measurement process, obtaining the vector, and then to generate an estimate of the system by incorporating new measurements, as shown in (6). The final step is to obtain an estimate of the covariance matrix of the estimation errors (7).

6. After each set of update equations and measurement time, by performing repeated algorithm a new estimate, used later in the design and prediction of the next step. Recursive nature is a quality offering Kalman filter application - makes practical implementation more feasible condition, estimate all past measurements. The figure below gives a complete look to the operation of the filter, combining equations diagram in Fig.1 above.

7. First requirement for measurement update is to compute the value of the expression Kalman. The next step is to update the measurement process, obtaining the vector, and then to generate an estimate of the system by incorporating new measurements, as shown in (6). The final step is to obtain an estimate of the covariance matrix of the estimation errors (7).

8. Time after each set of equations and measurement update algorithm is repeated by performing a new estimate, used later in the design and prediction of the next step. Recursive nature is a quality offering Kalman filter application - makes practical implementation more feasible condition, estimate all past measurements. The figure below gives a complete look to the operation of the filter, combining equations diagram in Fig. 1 above.
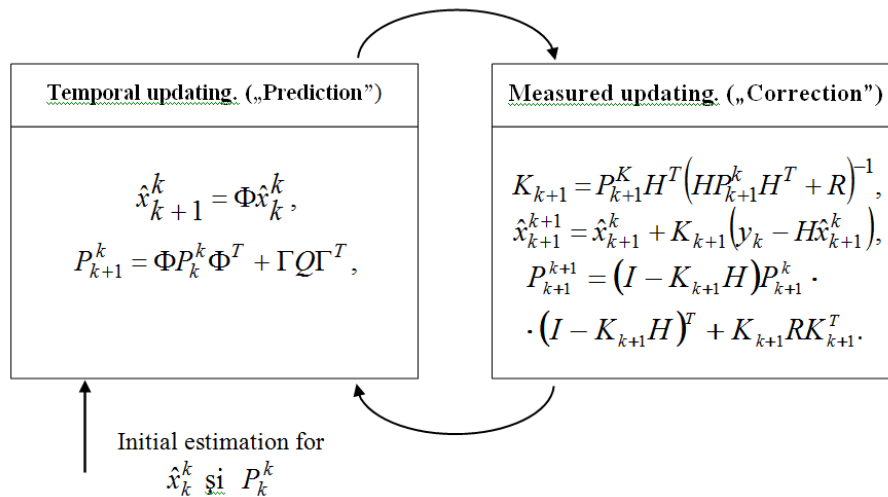
$$\hat{x}^k_{k+1} = \Phi \hat{x}^k_k,$$

$$P^k_{k+1} = \Phi P^k_k \Phi^T + \Gamma Q \Gamma^T,$$

$$K_{k+1} = P^K_{k+1} H^T \left(H P^k_{k+1} H^T + R \right)^{-1},$$

$$\hat{x}^{k+1}_{k+1} = \hat{x}^k_{k+1} + K_{k+1} \left(y_k - H \hat{x}^k_{k+1} \right),$$

$$P^{k+1}_{k+1} = \left(I - K_{k+1} H \right) P^k_{k+1} \cdot$$

$$\cdot \left(I - K_{k+1} H \right)^T + K_{k+1} R K^T_{k+1}.$$

Temporal updating. („Prediction")

Measured updating. („Correction")

Initial estimation for $\hat{x}^k_k$ și P^k_k

Fig. 2. A complete picture of the behavior of the Kalman filter, combining the diagram of Fig. 1.

Propozition 2: Filter parameters and regulation

When implementing the filter, the noise covariance matrix R affecting the measurements is usually measured prior to the time at which the filter operates. The measurement covariance matrix R is, in general, possible because, in practice, the measurement system may be performed at any time (and under the effect of the filter in some cases), so that, in general, need to know the noise variance measurement [72].

1. Determination covariance matrix, Q, of the system disturbance is generally more difficult, especially when we are not able to directly observe a system whose evolution estimate. Sometimes a relatively simple model can produce acceptable results if one "injects" enough uncertainty in the selection of system dynamics matrix Q. Certainly, in this case, we might hope that the measurements made on the system are safe.

2. The other situations when we have a reasonable basis for the choice of parameters in time, superior performance can be improved by setting the filter parameters of the filter, R, and Q. adjustment occurs frequently with another Kalman filter, separately, an process that resembles an identification system.

3. When Q and R are constant, both estimates of the error covariance matrix P^k_{k+1}, P^{k+1}_{k+1} and Kalman's harmonizing factor will stabilize quickly and remain constant. Where appropriate, these parameters can be pre-calculated every time the filter independently or for example by determining the stationare value P^k_k.

4. RESEARCH METHODOLOGY

The importance of Kalman filtering in engineering is well know [73], but it is also one of the most popular in finance, stock prices, and many other areas where it can be employed [74]. This article is describing how the Kalman filter can be used to estimate dynamic interaction of IE factors on HR recruitment and selection processes. Factors influencing the recruitment and selection must be reduced to munimum negative influence and positive impact should be streamlined to the maximum to achieve performance [33]. The factors influencing the recruitment and selection processes are divided into groups of internal factors and external factors group.

Internal factors- 15 factors divided into 5 categories with 3 factors each

f1 - organizational structure, orientation and size of the organization, organizational culture

f2 - human resource policies and practices, team recruitment and selection, employment stability

f3 - business strategy, life cycle of the organization, trade union presence

f4 - ethics and non-discrimination, diversity, sustainable development

f5 - level of skills, knowledge, and abilities

External factors- 15 factors divided into 5 categories with 3 factors each

f6 - internationalization, globalization, the emergence of multinational firms

f7 - labor market conditions, the strategic role of HR department, outsourcing

f8 - technological changes, political and legal factors, education and culture

f9 - attractiveness of the area, and brand image of the organization, the emergence of strategic alliances

f10 - competition, market dynamics, socio-economic situation

Determine the influence of each factor on factor analyzed, with the values between 0 and 6, where 0 – minimum influence and 6 - maximum influence. It establishes and mutual influence of each factor in its own group, and in the second group, eliminating their influence on factor analyzed as follows:

- Internal factors of the organization, according to the environmental analysis of marketing theory, influence each other but are also influenced by external factors of the organization;

- External factors, according to the same theory, not influenced by factors in the internal environment of the organization, but only influence each other.

$$f1=4f2+1f3+3f4+6f5+4f6+6f7+6f8+3f9+3f10,$$

$$f2=6f1+1f3+4f4+6f5+3f6+4f7+6f8+2f9+2f10,$$

$$f3=6f1+4f2+4f4+6f5+1f6+4f7+4f8+0f9+1f10,$$

$$f4=6f1+6f2+2f3+4f5+1f6+2f7+2f8+2f9+0f10,$$

$$f5=6f1+4f2+4f3+4f4+4f6+4f7+4f8+3f9+4f10,$$

$$f6=6f7+6f8+4f9+4f10,$$

$$f7=6f6+4f8+2f9+6f10,$$

$$f8=4f6+3f8+2f9+3f10,$$

$$f9=5f6+5f7+5f8+5f10,$$

$$f10=4f6+4f7+6f8+4f9.$$

Thus, we propose to analyze the evolution of a dynamic system, using Kalman filter. The system is governed by the 10 factors remember which influence each other through a linear matrix described by the following equation:

$$
\begin{pmatrix} f_1 \\ f_2 \\ f_3 \\ f_4 \\ f_5 \\ f_6 \\ f_7 \\ f_8 \\ f_9 \\ f_{10} \end{pmatrix} =
\begin{pmatrix}
0 & 4 & 1 & 3 & 6 & 4 & 6 & 6 & 3 & 3 \\
6 & 0 & 1 & 4 & 6 & 3 & 4 & 6 & 2 & 2 \\
6 & 4 & 0 & 4 & 6 & 1 & 4 & 4 & 0 & 1 \\
6 & 6 & 2 & 0 & 4 & 1 & 2 & 2 & 2 & 0 \\
6 & 4 & 4 & 4 & 0 & 4 & 4 & 4 & 3 & 4 \\
0 & 0 & 0 & 0 & 0 & 0 & 6 & 6 & 4 & 4 \\
0 & 0 & 0 & 0 & 0 & 6 & 0 & 4 & 2 & 6 \\
0 & 0 & 0 & 0 & 0 & 4 & 3 & 0 & 2 & 3 \\
0 & 0 & 0 & 0 & 0 & 5 & 5 & 5 & 0 & 5 \\
0 & 0 & 0 & 0 & 0 & 4 & 4 & 6 & 4 & 0
\end{pmatrix}
\cdot
\begin{pmatrix} f_1 \\ f_2 \\ f_3 \\ f_4 \\ f_5 \\ f_6 \\ f_7 \\ f_8 \\ f_9 \\ f_{10} \end{pmatrix} ,
$$

We transform the matrix system estate in a stochastic matrix

$$
\Phi =
\begin{pmatrix}
0 & 4 & 1 & 3 & 6 & 4 & 6 & 6 & 3 & 3 \\
6 & 0 & 1 & 4 & 6 & 3 & 4 & 6 & 2 & 2 \\
6 & 4 & 0 & 4 & 6 & 1 & 4 & 4 & 0 & 1 \\
6 & 6 & 2 & 0 & 4 & 1 & 2 & 2 & 2 & 0 \\
6 & 4 & 4 & 4 & 0 & 4 & 4 & 4 & 3 & 4 \\
0 & 0 & 0 & 0 & 0 & 0 & 6 & 6 & 4 & 4 \\
0 & 0 & 0 & 0 & 0 & 6 & 0 & 4 & 2 & 6 \\
0 & 0 & 0 & 0 & 0 & 4 & 3 & 0 & 2 & 3 \\
0 & 0 & 0 & 0 & 0 & 5 & 5 & 5 & 0 & 5 \\
0 & 0 & 0 & 0 & 0 & 4 & 4 & 6 & 4 & 0
\end{pmatrix}
$$

and obtain Ito stochastic differential equation with which we intend to study the evolution of the system:

$$
x_{k+1} = \Phi(t_{k+1}, t_k)x_k + \Gamma \cdot w_k , \quad k \in N , \Gamma = I_{10} , w_k \in N^{10}(0, Q_k) \tag{1'}
$$

where the estate vector is : $x_k = (f_1, f_2, f_3, f_4, f_5, f_6, f_7, f_8, f_9, f_{10})^T$.

Equations (2) are:

$$
y_k = x_k + v_k , \quad k \in N, \ H = I_{10}, \ v_k \in N^{10}(0, R_k), \ R_k > 0 \tag{2'}
$$

For the studied system the equation (3) of the filter is written as:

$$z_k = \Phi \cdot x_k \tag{3'}$$

Was redefined the estate variable $z_k = \hat{x}_{k+1}^k$, $x_k = \hat{x}_k^k$ and the estate matrix $\Phi = \Phi(t_{k+1}, t_k)$, is remaining constant in time, $\Phi \in M_{10}(R)$ and has the next form:

$$\Phi = \begin{pmatrix} 0 & 0.016 & 0.004 & 0.012 & 0.024 & 0.016 & 0.024 & 0.024 & 0.012 & 0.012 \\ 0.024 & 0 & 0.004 & 0.016 & 0.024 & 0.012 & 0.016 & 0.024 & 0.008 & 0.008 \\ 0.024 & 0.016 & 0 & 0.016 & 0.024 & 0.004 & 0.016 & 0.016 & 0 & 0.004 \\ 0.024 & 0.024 & 0.008 & 0 & 0.016 & 0.004 & 0.008 & 0.008 & 0.008 & 0 \\ 0.024 & 0.016 & 0.016 & 0.016 & 0 & 0.016 & 0.016 & 0.016 & 0.012 & 0.016 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.024 & 0.024 & 0.016 & 0.016 \\ 0 & 0 & 0 & 0 & 0 & 0.024 & 0 & 0.016 & 0.008 & 0.024 \\ 0 & 0 & 0 & 0 & 0 & 0.016 & 0.012 & 0 & 0.008 & 0.012 \\ 0 & 0 & 0 & 0 & 0 & 0.02 & 0.02 & 0.02 & 0 & 0.02 \\ 0 & 0 & 0 & 0 & 0 & 0.016 & 0.016 & 0.024 & 0.016 & 0 \end{pmatrix}$$

Equation (4) of the filter for the studied system is:

$$A_k = \Phi P_k \Phi^T + Q; \tag{4'}$$

To implement MATLAB program, we renoted the matrix $A_k = P_{k+1}^k$, $P_k = P_k^k$, and the co-variance matrix, $Q_{k+1} = Q$, is considered constant in time.

These renotations appear in this manner in the next equations of the filter:

$$K_k \equiv A_k \cdot \left[A_k + R\right]^{-1} \tag{5'}$$

$$x_k = z_k + K_k \cdot \left(y - z_k\right), \tag{6'}$$

$$P_k = \left[I_{10} - K_k\right] \cdot A_k \cdot \left[I_n - K_k\right]^T + K_k \cdot R \cdot K_k^T \tag{7'}$$

Running data using MATLAB helps us to analyze the influence of disturbing factors and dynamics, factors that impact on each other and on the processes of recruitment and selection analysis. By turnover data is also analyzed and the system states after a certain period, state denoted by n, where n = 5, 10 or 15. Factors f1 to f10 note the state vector of the system are analyzed, and analyzes the results of the interference filter them and absorb noise, making it a dynamic system into a more stable.

By running the system data were obtained the following results with the initial values

$$x_0 = (1,1,1,1,1,1,1,1,1,1), \quad y_0 \text{ aleatory}, \quad Q = 10^6 \cdot I_{10}, \quad P_0 = 10^4 \cdot I_{10}, \quad R = 10^5 \cdot I_{10}:$$

$n = 5, \; z_k$	$n = 5, \; x_k$	$n = 10, \; z_k$	$n = 10, \; x_k$	$n = 15, \; z_k$	$n = 15, \; x_k$
0.0834	1.9517	0.0956	0.9763	0.0575	0.5661
0.0781	0.7705	0.0724	1.4644	0.0536	0.2548
0.1397	1.2445	0.1351	1.1351	0.1298	0.5584
0.0677	0.9809	0.0843	0.2165	0.0339	0.0870
0.0904	0.8819	0.1006	1.3785	0.0397	1.5763
0.0550	0.1178	0.0362	0.4076	0.0224	0.5553
0.0409	1.3099	0.0464	0.1460	0.0194	0.6719
0.0290	1.7853	0.0332	0.2540	0.0131	1.5920
0.0372	0.1832	0.0346	0.2406	0.0222	0.8298
0.0573	1.1033	0.0483	0.4076	0.0165	0.7898

resulting that we obtained on the first 5 places as importance influence on recruitment and selection processes:

For n=5 Zk, we have f3, f5, f1, f2, f4. For n=5 Xk we have f1, f8, f7, f3, f10.
For n=10 Zk we have f3, f5, f1, f4, f2. For n=10 Xk we have f2, f5, f3, f1, f10 and f6.
For n=15 Zk we have f3, f1, f2, f5, f4. For n=15 Xk we have f8, f5, f9, f10, f7.

After more turnovers, we see that f3 is several times on the first place, then f5, f1, f4, and f10.

That means, that recruitment and selection are influenced more by f3 - business strategy, the life cycle of the organization, trade union presence, f5 - level skills, our knowledge, skills and abilities, f1 - organizational structure, orientation and size of the organization, organizational culture, f4 - ethics and discrimination diversity, sustainable development and f2 - human resource policies and practices, team recruitment and selection, employment stability and f10 - competition, market dynamics, socio-economic situation, f6 - internationalization, globalization, emergence of multinational firms and f7 - labor market conditions, the strategic role of the HR department, outsourcing.

For $x_0 = (1,1,0.5,0.5,1,0.7,0.8,0.8,0.6,0.5)^T$, $P_0 = 10^4 \cdot I_{10}$, $R = 10^5 \cdot I_{10}$, y_0 aleatory

$$Q = 10^6 \cdot \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{pmatrix}$$

it is obtained:

$n = 5, \ z_k$	$n = 5, \ x_k$	$n = 10, \ z_k$	$n = 10, \ x_k$	$n = 15, \ z_k$	$n = 15, \ x_k$
0.1143	0.8360	0.1264	0.6821	0.1064	0.7696
0.1086	0.8305	0.1202	0.6759	0.1013	0.7644
0.2114	0.9305	0.2339	0.7903	0.1975	0.8630
0.0816	0.8043	0.0905	0.6461	0.0768	0.7391
0.1190	0.8406	0.1318	0.6876	0.1113	0.7746
0.0618	0.7850	0.0681	0.6236	0.0569	0.7189
0.0558	0.7791	0.0615	0.6170	0.0514	0.7133
0.0374	0.7612	0.0412	0.5966	0.0345	0.6959
0.0619	0.7851	0.0682	0.6237	0.0570	0.7190
0.0557	0.7790	0.0614	0.6168	0.0513	0.7131

resulting that:

for n=5, n=10, n=15 (Zk and Xk) on the first 5 places are the following factors:

1- f3, 2- f5, 3-f1, 4- f2, 5- f4,

where f3 - business strategy, the life cycle of the organization, trade union presence, f5 - level skills, our knowledge, skills and abilities, f1 - organizational structure, orientation and size of the organization, organizational culture, f2 - policies and practices human resources, team recruitment and selection, workforce stability, f4 - ethics and non-discrimination, diversity, sustainable development.

5. CONCLUSIONS AND PROPOSALS

Implementing this model, it can be made partial observations, analysis, and finding advantages, but also some limitations, which can be reduced. Knowing them, the organizations may develop good strategies and making new decisions.

Applying this model, allows:
- the HR manager to study HR recruitment and selection in detail and their complexity,
- the managers to be informed of the potential consequences, the impact of recruitment and selection processes on organizational performance, or to establish an alternative course of action,

- explaining and understanding the past influences of IE factors on recruitment and selection processes and forecasting the future influences,
- using large volumes of data about different candidates,
- making quick adaptation to new situations,
- taking into account the effects of one-off special events,
- bringing new information and alternative perspectives to the forecasting task,
- offering statistical challenges or making rational assessments,
- improving forecast accuracy and better communication in recruitment and selection processes,
- investing little effort in exploring the model evolution or to limit its inefficiencies,
- offering information about average performance of recruitment and selection processes over a number of periods,
- supplying feedback, motivation and implicitly organizational and individual learning,
- drawing attention to HR managers to make pertinent decisions.

This model has also some limitations:
- the forecast may generate less accurate data,
- it can generate results inconsistent with economic theory,
- the risk to obtain less efficient results,
- it can be subjected to systematic biases and inefficiencies that can damage forecast accuracy,
- the costs of greater complexity and data collection,
- the poor quality due to low expertise and subjective judgement of the researchers, regarding the problem structuring, decision making and judgemental assessment,
- the minimization of forecast errors,
- it can make real predictions to suit their objectives or to achieve credibility.

Despite their limitations, quantitative models can lead to an enhanced understanding of the reasons underlying the past behavior of economies. For its application, it is not always possible or desirable to measure every variable that you want to control, and the Kalman filter provides a means for inferring the missing information from indirect and noisy measurements.

From the standpoint of those involved in estimation and control problems, this is considered the greatest achievement in estimation theory of the twentieth century. In this article we discussed the problem of initializing a Kalman filter and using stochastic equations in a new area, that of HR recruitment and selection, where there is no analysis made. We made an analysis under the pressure of internal and external factors, obtaining results of interest, which provide general solutions, necessary for decisions making and problem solving.

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