

Portfolio Management for Construction Company during Covid-19 Using AHP Technique

Sareh Rajabi, Salwa Bheiry

Abstract—In general, Covid-19 created many financial and non-financial damages to the economy and community. Level and severity of covid-19 as pandemic case varies over the region and due to different types of the projects. Covid-19 virus emerged as one of the most imperative risk management factors world-wide recently. Therefore, as part of portfolio management assessment, it is essential to evaluate severity of such risk on the project and program in portfolio management level to avoid any risky portfolio. Covid-19 appeared very effectively in South America, part of Europe and Middle East. Such pandemic infection affected the whole universe, due to lock down, interruption in supply chain management, health and safety requirements, transportations and commercial impacts. Therefore, this research proposes Analytical Hierarchy Process (AHP) to analyze and assess such pandemic case like Covid-19 and its impacts on the construction projects. The AHP technique uses four sub-criteria: Health and safety, commercial risk, completion risk and contractual risk to evaluate the project and program. The result will provide the decision makers with information which project has higher or lower risk in case of Covid-19 and pandemic scenario. Therefore, the decision makers can have most feasible solution based on effective weighted criteria for project selection within their portfolio to match with the organization's strategies.

Keywords—Portfolio management, risk management, COVID-19, analytical hierarchy process technique.

I. INTRODUCTION

A. Portfolio Management

CONSTRUCTION projects entail diverse construction companies, also small as well as medium-sized firms are frequently engrossed in diverse construction projects that constitute an intricate multi-project group. Furthermore, traditional management approaches are project-centric, where project management team leads the project from initiation to completion, such projects are quite independent. Granting that distinct companies organize their projects into diverse groups under definite set of rules and classify projects into portfolios; besides, such projects are autonomously managed and there exists a scarcity for swapping of resources, technology, personnel and knowledge. These acts impede companies from drawing complete advantage from project portfolio management (PPM). For a small-size company, the issues are eased through mutual collaboration between the project managers as well as cooperation and expertise from the experienced senior leaders of the company. With the

expansion and growth of the company, an enhancement in the number of operational projects rises. Consequently, disproportionate coordination may be observed by overcharging the leaders due to inappropriate focus on the occupation. This results in significant losses owing to negligence towards project synergies. Augmenting competition enforces construction companies to formulate novel strategies to integrate, optimize and manage the projects. PPM is regarded as a budding strategy for business management that intends to pinpoint on selection of the project on the basis of priorities, incorporation, management as well as control concerning multi-project prevailing in contemporary organizations. In order to accomplish strategic advantages, PPM employs appropriate methods for the project selection and evaluation together with the optimization and balance of portfolio, allocation of resources as well as communication with the stakeholders [1], [2].

For the past five decades, PPM is ascertained as a fundamental approach regarding research associated with project management and product development along with practices concerning company management. Plentiful research has been carried out to formulate tools and techniques required for selection of project, evaluation of portfolio, prioritization as well as management of resources. However, abundant research is carried out concerning global PPM standards together with the development of practical toolkits [3].

Recently, an eagerness was displayed by the practitioners and researchers to recognize the factors influencing project portfolio achievement as well as to determine the dynamics that enhance the likelihood of attainment. According to [4], innovation expedites and sustainably increases portfolio success in long term product development. Moreover, the inspiration from internal stakeholders, senior and experienced managers, middle managers as well as project managers is designated as the vital driving force behind the success of project portfolios. Several studies corroborate the concept that the reinforcement of single project management as well as PPM is concomitant with the success of project portfolio. Nevertheless, creativity could be constrained while innovation activities may get interrupted due to excessive formalization. Additionally, [5] hypothesizes management eminence as a multi-dimensional construct encompassing quality information, quality allocation and quality cooperation thereby paving the way for success of project portfolio much ahead of the point where established success benchmarks become quantifiable. In order to assist the formulation of robust PPM capabilities, which is ascertained to evolve constantly as well as remain relevant in dynamic environments, a capability

Sareh Rajabi is PhD Student in School of Engineering & Management, American University of Sharjah, UAE (Corresponding author, phone: 971-50-8744166; e-mail: sarahrajabi@gmail.com).

Salwa Bheiry is Associate Professor of Civil Engineering, American University of Sharjah, UAE.

maturity model was proposed by [6]. Petro and Gardiner [7] established a link between the steering committee (senior managers) and influential project managers with the efficacy of portfolio management as well as with the business efficiency. However, steering committee and their role in PPM is highly significant and is imperative in applying governance as mentioned [8]. Nevertheless, a few construction companies gained success in efficiently establishing and professionalizing PPM systems. However, several companies toil with the basic administration of multiple interdependent project portfolios; moreover, conflicts related with multiple projects can potentially annihilate employees. According to [9], lack of awareness about practice and context could be the possible explanation for the conflict. A few studies observe PPM as a rational judgment process [1]-[7]. Nevertheless, the day-to-day practice of PPM could sound less rational and evident compared to the initially anticipated. A few researchers [3]-[9] suggest that diverse PPM frameworks, derivatives and process variants be existent, which can be greatly and disparately utilized under the situation when companies clinch PPM principles. Additionally, companies devoid of established PPM system witness intricacies in composing the desired methods into broad PPM application. Consequently, research on PPM in context with the construction industry is still limited. Several studies aim on project selection [7]-[10], prioritization and optimization contained by portfolio; precisely on the fundamental of *"how to do the right work"*. Besides selection of an effective project, the outcome of the construction project is persuaded by the intensity of project governance. Special guidance may be desired by many construction companies witnessing issues concerning *"how to do the work right"* [10].

Construction companies, concerning execution of investment as well as taking construction projects are required to regard success of the project only if the course of the project promises real return on investment (ROI), incurring the costs of resources engaged in the construction. This also attributes to the portrayal of respectable image of the construction company, which eventually enhances their market worth and status. Moreover, adaptive management is desired by the companies constructing their brands on the basis of successful project execution. Such management desires integration of workforce, processes as well as technologies in such a manner that company gets empowered to meet the current requirements of the projects [11].

The organizations concomitantly accomplish a few construction and investment projects, usually disseminated within a particular domain. This involves structures pertaining permanent location, distinctive management of construction spot for the duration of erection and is eventually liquidated with the wrapping up of construction job. An ongoing translocation is necessitated for the production resources from the cores of construction company into corresponding construction sites and also from one site of construction to another. The settings of diverse projects influence the progression of logistics processes; consequently, it results in complexities in stable employment of the individuals with

desired qualifications. However, this is the basis of personal risk, accordingly, thus generates challenges for PPM of the construction companies, which results in the interruptions and thereby enhances the construction cost [12].

It is noteworthy to understand that the investment and construction projects are regarded as the intricate processes. The process of construction constitutes numerous working processes associated with one another organizationally as well as technologically. The chief objective is to generate a construction element or a ready structure, i.e. prefabricated constituent.

Formulation and establishment of the project portfolio is carried out on the assumed strategies, i.e. a set of projects are consented for execution requiring specific necessities such as quality, price, deadline and scope. Nevertheless, interruption in accomplishing the objectives of these special projects engenders a jeopardy associated with these specific projects. This results in threats concerning configuration of portfolio, number of projects as well as their allocation in terms of space and time, as these resources are indispensable and must for the project execution [13].

Management of project concerning project portfolio insinuates the spreading and allocation of the enterprise activities for the accomplishment of projects as a function of time. Moreover, the choice of project portfolio encompassing the completion schedules of respective undertakings must comprise the utilization of resources of the company. In order to compute, use of special equipment is desired in diverse projects depending on the schedule of project execution. For instance, construction company engaged in investment and construction projects utilize machineries required for construction such as cranes, diggers etc. [14].

A successive supply of production resources is desired for the execution of construction processes. However, this demands an amalgamation of organizational approach to production logistics (encompassing current logistics service of production processes) as well as supply logistics (encompassing supply of materials like raw material, semi-finished products and prefabricated elements) and collection of wastes [10]-[14].

In the progression and development of project portfolio, it is essential to consider production resources encompassing own as well as foreign resources along with the quantitative relations required for the project execution. The production factors encompass equipment, and resources such as human, material as well as equipment and financial resources. However, components of jeopardy concerning production factors are regarded as the likelihood of their attainment [1]-[3].

B. Risk Management

Risk management at the portfolio level should be maintained and need to consider events bearing potential influence on the overall results of the portfolio. For instance, greater risk to the portfolio persists for the project if it is heavily (say 80%) dependent on vendor XYZ and therefore needs to be treated as such [15].

In order to rescue troubled projects, management reserves can be added up at the portfolio level, which could be more effective compared to addition of multiple reserves to a single project. Multiple reserves make the projects less attractive to potential clients as well as to the organization.

An evaluation is necessitated to evaluate reserves, contingencies and risk response in terms of efficacy, cost and advantages. Considering the fact that too much cushioning will impair the competitive advantage, therefore, it is not recommended to spend more for the risk response compared to risk exposure [16].

From the portfolio risk management, considering the analysts distinguished project risk management is about the role played by the Project Management Office (PMO). The PMO is accountable for the constant monitoring of the environmental factors of the enterprise, which might influence the projects as well as the portfolios of the organization. Besides, PMO is also liable for the formation of business continuity plan for portfolios as well as for the projects [17]. Moreover, PMO is also desired to evaluate opportunities as well as threats while working in synchronization with other paradigms such as corporate risk management, thereby aids in the development of a sound fallback plan. A bold and quick action of the PMOs was displayed by a few organizations even in the phase of COVID-19 crisis. Moreover, to minimize the detrimental impact many PMOs reassessed all their portfolios and projects as per the required modifications in the organizational strategy [18].

Various business meetings, seminars and workshops with PMOs highlighted that some of the organizations were highly innovative in their methodologies and approaches, which others were quite conservative. However, it is concluded that the PMO is positioned in a unique way to handle issues that are far beyond the capabilities of project managers. For instance, COVID-19 emerged as an unexpected, exceptional and unforeseen challenge, which some of the PMOs could handle efficiently [19].

The risk management can be categorized into internal factors as well as external factors. In order to understand and evaluate the external factors, the company is required to assess the region as well as exposure of the country to the threat. Simulations divulge that it is bound to influence every individual, either directly or indirectly, infecting a great part of the population. This impacts the economy on the global scale. However, a few countries were well set to cope with the condition, thus, they will be able to pull through speedier and earlier [20].

A few of the key external factors for consideration-

- Adequacy of health infrastructure.
- Strength of the economy of region or the country.
- Reliance of country on export or import.
- Currency exchange rates of the nation.
- Supply chain and other factors.

SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis as well as PESTEL (Political, Economic, Social, Technological, Environmental, Legal) analysis can also be applied by the analyst. After a comprehensive understanding

of the external environment, an evaluation of the organization is carried out by the analyst [21].

A few of the key organizational factors for consideration by the analyst are:

- Type of industry and the manner it is impacted by the crisis caused due to COVID-19.
- Substantial and secure risk practices formulated by the organization, if any.
- An effective business continuity plan in situation, if any.
- Concern for agility, flexibility, profit/loss, organizational health etc.

Conclusively, an analyst needs to emphasize on the individual projects and portfolios. There is a possibility that a large number of projects need to be terminated/cancelled/paused owing to the fact that organization needs to plan out their endurance and existence as their priority.

A few of the key aspects required by an analyst to evaluate their own projects are [22]:

- The location of project, especially in high-risk regions.
- Number of individuals working in person/involved in the project or the co-location of the project (as in construction work).
- The capability of team, if they can work distantly and still provide analogous results.
- Careful reassessment of the stakeholders, vendors etc. as they could be severely cramped by the crisis.

C. Covid-19 and Risk Management

A new variant of coronavirus designated as novel coronavirus (COVID-19) potentially cause ailments in humans and animals. In case of humans, numerous variants of coronaviruses are known to cause respiratory infections extending from common cold to other severe health predicaments. The first incidence was identified in a cluster, with pneumonia like symptoms in Wuhan City of Hubei Province of China. However, the source of the novel coronavirus (COVID-19) could not be characterized; most of the cases were epidemiologically associated with the seafood and animal market of Wuhan (China), from where the spread is thought to have originated amongst the shoppers being there. Studies are going on to decipher and determine the definite source of the disease. The symptoms encompass mild to severe respiratory problems with high temperature, dry cough, shortness of breath followed by difficulty in breathing. Patients may experience muscle pain, body ache, headache, sore throat, nasal congestion, running nose, diarrhea, nausea and loss of sense for smell [23].

Evidently, the strains of novel coronavirus (COVID-19) spread due to contact with the infected individual (person-to-person), contaminated droplet expelled by the infected/sick individual either through coughing or sneezing. The infection is also transmitted via touching an infected person or an infected surface and then touching the eyes, mouth or nose.

One of the finest ways to prevent infection is by avoiding exposure to the corona virus. The most recommended actions required for prevention include [24]:

- Stay at home

- Thorough and regular hand wash with soap and water for at least 20 seconds or using alcohol-based hand rub for sanitization.
- Avoiding contacting nose, eyes and mouth with unclean hands.
- Social distancing, at least 2-meter distance should be maintained with others especially with those who are sneezing or coughing.
- Practicing good respiratory hygiene. This involves covering mouth and nose with a flexed elbow or a tissue while sneezing or coughing. One must make sure that the tissue is disposed of immediately in a closed bin.
- Ensuring appropriate method of using personal protective equipments (PPE) such as gloves and masks.
- Maintaining good health, good nutrition, exercise as well as adequate sleep.
- Monitoring self on a regular basis for symptoms of coronavirus or fever. In case, if health predicament occurs, seek immediate medical attention.

The crisis of COVID-19 has expanded all across the world, influencing portfolios and projects enormously and at different levels. It is highly unfortunate that people are kept misinformed and lot of commotion and noise is going on, people are panicking all over the world while the organizations are countering without any methodical and rational thinking.

A thoughtful project risk management prospects encompasses followings: Envisioning that researchers endured pandemics ahead of time, theoretically, this could be regarded as a risk; however, construction companies did not incorporate such jeopardy or have registered in their projects as it is highly improbable. The risk and threat arose due to the current situation caused by pandemic are totally unknown even to the researchers, owing to lack of the identification of such perilous situation. In a similar manner, analysts believe the fact that it is arduous to precisely and truthfully evaluate the impact caused by COVID-19, no individual can possibly assess prior to pandemic phase. The uncertainty still prevails regarding the direction and atrociousness the impact of COVID-19 holds [25].

D. Statement of Problem

All the stated issues and matters above, urge the contractors to reflect the impact of such pandemic cases like Covid-19 as risk management in their portfolio selection study. Therefore, taking into account the impacts of such pandemic scenario in the investment plan of the contractor is mandatory. The decision makers should examine how the pandemic scenario can affect the cashflow, future of the organization, and completion of the project. The analyst should consider the level of risk and its severity on the project with respect to various criteria. Therefore, the research problem and gap based on discoveries in literature review can be tallied as:

- Lack of risk management in portfolio management
- Shortage of research and study on pandemic scenario
- Impact of pandemic cases such as covid-19 on business plan and strategy of the construction company
- Need of new method to examine the probability of pandemic case in portfolio management
- Gap of research on the effects of pandemic cases in portfolio management

E. Aim and Objectives

This research aims to demonstrate a theoretical framework to investigate the impact of the pandemic scenario in the construction field. This framework examines the effects of pandemic situation in decision making process of board members and management. Therefore, the outcomes of this research can be used in decision making and risk analysis of the portfolio management for the construction companies. The objectives of this research study to accomplish its aims and goals are as follows:

- Develop a framework to forecast the probability of pandemic scenario on the project and program
- Investigate the pandemic situation in the construction company and project selection processes
- Determine the project/program risk based on the pandemic cases
- Explore the areas to study the overall impacts of pandemic scenario projects

F. Research Questions

The below questions are designed to respond in theoretical framework to analyze the impacts of pandemic situation for the construction company while processing their portfolio decision processes:

- What are the areas that might affect under pandemic scenario?
- What are the questions to be asked while the project/program selection is in the process?
- How to demonstrate the risk severity of each project based on pandemic scenario?
- What technique to be used to verify the project/program risks?
- What are the reasonable criteria to be considered in portfolio management while evaluating the pandemic as risk on construction projects?

To attain the research aims, the following research tasks are needed to be accomplished:

I. A literature review to:

- ❖ Demonstrate a thoughtful process of portfolio management
- ❖ Realize the benefits of estimating the risks such as pandemic scenario on portfolio process
- ❖ Expand the history and development of risk management
- ❖ Develop an understating for applications of risk management in the portfolio processes
- ❖ Evaluate the impact of pandemic scenario on the construction projects

II. A qualitative study to elaborate on:

- ❖ To design the effective questionnaire about impact of the risk management in the portfolio processes in water tradeoff projects
- ❖ To propose a framework to examine the impacts of

Covid-19 on the projects

III. A quantitative study to elaborate on:

- ❖ To quantify the severity of the risk (Covid-19) in the portfolio management and selection processes
- ❖ To represent quantified risk based on the survey for each project/program

IV. Data Analysis: To investigate the effectiveness of Covid-19 which is considered as risk in the portfolio management and its impacts in decision making process

G. Content of Research

This research includes four sections. A brief of each section is explained below as a schematic direction to this study:

- Section I – Introduction: This section explains the introduction to the topic, the research questions, and the objectives of the research. Also, it indicates the benefits of framework toward the concept of portfolio management
- Chapter II – Literature Review: This section assesses the previous works and papers, related to risk management and portfolio management, especially in the countries that the economy is based on the construction.
- Chapter III – Research Methodology: The research methodology contains the framework, questionnaire, design of the survey, data collection and data analysis which are explained in this section.
- Chapter IV – Summary & Conclusion: A conclusion of the achievements will be demonstrated in this section for each research questions and goals to represent the research deliverables.

II. LITERATURE REVIEW

Portfolio Management is one the most important tools and skills for organization's strategies and goals nowadays due to its critical role in the future of the organization. On other hand, one of the most effective elements in portfolio management is the risk, which is investigated under the umbrella of risk management. As a part of the risk management, pandemic case and scenario plays important roles due to its level of severity. Therefore, due to the latest global crisis, Covid-19 case is considered as risk management scenario under this study to demonstrate client's concentration and selection process in the portfolio management.

Portfolio Management

The first basic portfolio for security analysis was developed by Markowitz [26]. Early work of Markowitz was an effort to meticulously employ probability theory for the selection of portfolio. Such an aim relied on the objective of incorporating the degree to which definite securities did or did not travel instantaneously. The chief role of the author was to provide the concept of an effective, proficient and optimal portfolio, capable of providing supreme predictable return from the intensity of jeopardy. Many researches concentrated on the security analysis, without any attention to apply the research on other categories of investment. However, for the last 35 years, research on portfolio management emphasized strongly on the methods to implement basic theories in diverse fields.

Vergara and Boyer [9] presented the introductory research on application of portfolio theory in the field of construction. Their paper investigated the conceptual understanding of the theory and displayed a probabilistic model for the evaluation of the portfolio. Further, the paper defined the basic mathematical concepts, but it falls short in exhibiting practical glitches witnessed in implementing theoretical concepts in the construction field. In a similar manner, Farid [27] demonstrated the method to link portfolio theory with the Capital Asset Pricing Model. Despite the fact that Farid built the Fair and Reasonable Markup Pricing Model on the assumptions of portfolio theory, the model could not straightforwardly pact with the portfolio theory.

Another study carried out by Kangari and Boyer [28] applied the portfolio theory to the construction projects which were grounded on net present value of cash flow. The practical intricacies witnessed by the model are not the part of this study, as the sole purpose of the present study is to concentrate on major issues concerning practical relevance of the theory in the field of construction. The current paper will make an effort to sort out these intricacies.

Risk Management

Diverse approaches are prerequisite for the selection of international projects. Factually, such approaches focus chiefly on jeopardy at the level of individual project instead of jeopardy at the corporate level. Yet, by simply summing up the peril generated at the individual projects is notably distinctive compared to the total peril generated at the perspectives of the enterprise. This may result in the tribulation of the company and it may fail to choose optimal combinations of gain and hazard for the corporation [15]-[17].

On the basis of such restrictions, portfolio management is recommended [1]-[14]. The fundamental concept of portfolio management encompasses reduction of overall perils linked with project portfolio by means of divergence. Considering that each project entails certain jeopardy and return, however, coalescing investments where the hazards are not closely interrelated, variance diminution can result in reduction of peril intensity. Thus, this section deliberates the principle of portfolio theory and its application concerning construction industry.

According to [29] and [30], down-side risk metrics are always appropriate in order to measure risk concerning asymmetric distribution of returns. They therefore recommended a novel paradigm for risk management and for portfolio construction, conceivably by means of computational advances; this made essential by enhancing the use of derivatives in portfolios. They designated such novel paradigm as postmodern portfolio theory.

In addition to the downside risk metrics, [26] recommended semi-variance, regarded as an equivalent to the variance with below-average gains or returns. Subsequently, [31] and [32] formulated lower partial moments (LPM); the series could be defined through four moments namely- mean, standard deviation (SD), kurtosis and asymmetry. Since LPM is grounded on single side distribution, it stands for moments in

a similar manner as semi variance is for variance.

Although LPM and semi-variance emphasize on returns lower than the set target or the average respectively, there are other downside risk metrics designated as value at risk (VaR) and expected shortfall (ES) or conditional value at risk (CVaR) which is concerned with the negative returns or the tail jeopardy. Dowd [33] defined VaR as the utmost or maximum possible financial loss in a given duration and confidence interval such that no certainty of any extreme adverse event is observed. According to [34], CVaR is denoted as the expected loss condition when an extreme unfavorable incident occurs.

Corona (Covid-19)

In 1960, corona virus was primarily characterized as a causative agent of common cold. A study performed in Canada reported flu-like symptoms in more than 500 patients [23]. On performing the virological analysis using polymerase chain reaction (PCR), 3.6% of the cases were found to be positive for HCoV-NL63 strain. Up until 2002, corona virus was regarded as a non-fatal, simple virus, but, in 2002-2003 an outbreak in Guangdong province of China eliminated the incongruity. The virus spread to other nations including Vietnam, Thailand, Taiwan, Singapore, Hong Kong and the United States of America and was responsible for causing severe acute respiratory syndrome (SARS), accountable for higher mortality rate in more than 1000 patients [23]. Following the outbreak, infectious disease experts and the microbiologists laid concern on understanding the disease, its pathogenesis and other details. Later, it was revealed that the infection resulted due to new variant of the corona virus. The severity of viral infection was assessed with the total of 8096 reported cases, causing 774 casualties. Consequently, in 2004 [24], a state of emergency was declared by the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO). Another report [24] from Hong Kong disclosed that the 50 cases were presented with symptoms of SARS and of these, more than 60% were found to be positive for corona virus. Thus, the corona virus displayed a capability of rapid evolution to become more virulent as well as extremely lethal to human beings. The progressive evolution of corona virus continued and in 2012, another outbreak due to corona virus occurred in Saudi Arabia. The virus spread in other nations of Middle East and also across the world. The consequences of this eruption were devastating and resulted in several deaths, stemming the recommenced of interest in the studies encompassing novel form of coronavirus [23]-[25].

The characteristic features of the corona virus depicted that it is an enveloped RNA virus. A single-stranded RNA acts as a genetic material. The morphological feature of the virus is spherical or pleomorphic and manifest club-shaped glycoprotein projections. The corona virus has various subtypes, entitled as alpha, beta, gamma, delta corona virus. Each of these subtypes bears many serotypes. For instance, OC43-like and 229E-like are known to have an effect on humans [24], while other types may influence animals. The transmission of corona viruses is via airborne zoonotic

droplets, while the virus replication appeared in ciliated epithelium, the mature viral particles causes cellular damage and bust out the infected cells to release several newly formed mature viruses leading to inflammatory reaction at the location of infection [35]. Besides humans, corona viruses are also prevalent in other mammals such as bats, whales, pigs, cats, dogs, mice and also in birds [36], [37].

On an average, the incubation period of MERS-CoV ranges from 5.2 to 12 days. The virus affects mostly the adults, but, numerous pediatric cases are also turned up in Saudi Arabia. The typical clinical picture presented by MERS-CoV encompasses flu-like symptoms accompanied by fever and cough in as many as 87% cases [23]. Further, chills, rhinorrhea, rigor, myalgia and fatigue are some other symptoms of corona virus infection. Moreover, more severe symptoms include shortness of breath in as many as 48% cases, which eventually results in respiratory failure and a requirement for intubation and ventilation. Besides respiratory symptoms, gastrointestinal symptoms are also reported encompassing vomiting, nausea, diarrhea and abdominal pain; such symptoms are expressed in 35% of the patients [23]. Certain cases of acute renal failure requiring hemodialysis are also reported to be associated with the corona virus infection. In general, physical examination of the patients' present condition of fever while the pulmonary findings display rhonchi and crepitation. Further, laboratory investigation discloses lymphopenia, disseminated intravascular coagulation (DIC), thrombocytopenia and multi-organ failure which eventually results in mortality. Considering the severity of the disease, CDC recommends collection of multiple specimens from different sites at different times, for instance, samples need to be collected from nasopharyngeal and oropharyngeal swabs, blood, sputum, rectal swabs, stools and lower respiratory tract, which often is positive in case of viral infection [38].

Characteristically, processing of the samples is carried out using real-time reverse transcription (rRT)-PCR to examine and evaluate the following sequences- open reading frame 1b (ORF 1b), upstream of E-protein gene (upE) and open reading frame (ORF 1a), which is regarded as the most sensitive sequence for recognition of the explicit virus. In MERS-CoV genome, N genes and RNA dependent RNA polymerase (RdRp) are also designated as the target sites. In order to confirm the diagnosis, at least one of the following benchmarks needs to be fulfilled- (1) PCR result needs to be positive for at least two distinct explicit target present in MERS-CoV genome or (2) At least one positive PCR result for explicit target on MERS-CoV genome as well as an extra distinct PCR product authorizing a recognized sequence of MERS-CoV [39].

The algorithm or procedure for the diagnosis of coronavirus is as follows: (A) upE-specific rRT-PCR- in case of positive sample, confirmation is done with ORF 1a rRT-PCR analysis. (B) upE-specific rRT-PCR- in case of positive sample, confirmation is carried out with sequencing of one of the two target sites (RdRp or N assay). In PCR analysis, if the sample is found to be positive, the case is said to be confirmed. The

samples could be false negative if the issues occur during collection of samples such as early/late collection or issues concerned with shipping and handling [36], [37].

Corona virus is identified as a zoonotic virus; conversely, the MERS-CoV is designated as a novel virus, although the zoonotic transmission is not yet established. Several international studies carried out from 2012 to 2014 in diverse regions of the world encompassing South Africa, Ghana, Mexico and other European nations such as Ukraine, Romania, Germany and the Netherlands have examined and evaluated if bats could act as the carrier of MERS-CoV. However, the studies have chiefly tested bats for 329-bp fragment of RdRp in the oral, blood and fecal samples [40].

5.3-24.9% of cases were reported to be MERS-CoV positive. However, >70% of the positive results were identified in the fecal samples bearing excessive viral load. Therefore, the possibility of transmission via bats could not be denied. In Saudi Arabia, patients suffering from corona virus might have come in proximity with the bats. The diverse species of bats prevalent in Saudi Arabia which were tested encompass *Rhinopoma microphyllum*, *Rhinopoma hardwickii*, *P. kuhlii*, *Taphozous perforates*, *Eidolon helvum*, *Eptesicus bottae* and *Rosettus aegyptiacus*. Besides the fact that a positive connection persists between bats and corona virus infection, no such relationship was found between MERS-CoV and bats, indicating that the transmission of MERS-CoV is not through bats [41].

III. RESEARCH METHODOLOGY

Projects will observe a halt on a temporary basis owing to the closure of non-essential activities and workers are forced to stay at home to prevent the spread of corona virus. A shortage in the supply chain is also observed by the construction owners and this is one kind of a possible delay that could be expected in a construction project. The current report highlights the perspective of analysts for their clients to overcome such challenges and the ways to ensure health and safety measures for their employees. Therefore, in order to analyze such scenario, the risk of Covid-19 on the projects has been investigated and studied based on the following four areas: health and safety, completion risk, commercial risk and contractual risk.

A. Health and Safety Risk

Amid the phase of COVID-19 the risk is same for every individual and construction owner, contractors as well as suppliers are identical to the general population. Therefore, owners are desired to take into account the physical well-being and safety of each team-member of the project, their stakeholders and other participants, which are directly or indirectly a part of the construction projects. Owners must judiciously follow the guidelines as well as recommendations set by the government and healthcare professionals. Inadequate follow-ups may turn out to be disastrous; experience reveals that the confirmed COVID-19 cases mount exponentially due to negligent behavior of the inhabitants and safety and health controls remain disregarded.

Enforcement of health and safety procedures is desired by construction owners on site of construction. These measures encompass sanitary protocols, social distancing, proper hygiene, use of PPE. Toolbox talks as special COVID-19 requirements, reporting health issues concerning COVID-19 in a prompt manner especially about the construction workers. Moreover, contractors and subcontractors are desired to keep safeguards in place in order to ensure protection of workers from COVID-19 even at other places away from construction sites. 14 days of quarantine must be followed after the potential exposure. A few of the budding practices on construction sites encompass encouragement of sick workers to stay at home, staggering shifts as well as lunch time, curtailing gatherings and large meetings, cleaning of lunch areas and common offices on a regular basis. For large projects, on-site medical facilities must be expanded such as measuring temperature of workers as well as assessing symptoms of COVID-19 in any of the workers ahead of the onset of work. Moreover, according to OSHA [23], employers are desired to formulate an Infectious Disease Preparedness and Response Plan, which involves checking out the possible ways which may act as sources of exposure to COVID-19 by the workers. Other risk factors encompass non-occupational risk factors especially at home and community centers. Besides, workers may themselves have their individual risk factors as immunity of every individual may not be the same, the employers must ensure appropriate control measures essential to tackle the risks.

B. Completion Risk

Considering the potential of extensive prevalence of COVID-19 pandemic impacts, a delay as well as disruption in several construction projects and programs is envisaged; this is further attributed to the lockdowns as a safety measure. For instance, a shutdown of all construction work for the minimum period of two weeks was ordered in Boston on 17th March 2020, the foremost city to take such a step. In a similar manner, construction workers in the San Francisco area are supposed to abide by the shelter-in-place orders issued by the governments of the nation, state and city, this scenario was expected to continue until 7th April 2020. Noteworthy to understand that in a constricted and tough labor market, already construction firms are perceiving scuffle to get appropriate workers for the timely accomplishment of projects.

A disruption in supply-chain is also observed during the COVID-19 pandemic accompanied with the concerns of cash-flow as well as restrictions related to funding/financing. Consequently, an extension or rescheduling of critical activities is desired. Moreover, the contractors are also required to adjust their methodology to perform tasks in order to comply with the instructions and mandates laid by the government.

As a result, construction owners need to act swiftly in order to assess as well as mitigate jeopardy associated with completion of their vast capital construction programs and projects. Therefore, a detailed schedule reviews is desired for

the ongoing assignments chiefly for those which are in the stages of either completion or in the halfway point. Owners may take a decision to perform QRAs (Quantitative Risk Assessments) on their schedules, instead of fine-tuning with the determinative schedules. This aids in understanding the array of uncertainty concerning plausible dates for completion. Development of procedures in order to execute QRAs on huge construction assignments is designated to be a project-control leading practice for contractors and owners.

C. Commercial Risk

Impact of COVID-19 has influenced every fragment of life, the impact on commerce cannot be ignored; which encompasses commercial jeopardies including escalation in labour cost, price swings of resources and commodities, extended cost of performances as well as greater interest payments. For instance, owners may be asked to pay higher cost for resources like concrete, lumber, steel and drywall from the suppliers attributable to interruptions caused by the COVID-19. Labour cost also upsurges owing to the fact that contractors are strained to plump for workers from a restricted pool more because of travel constraints. Extension of project completion schedules and dates also incur a burden on owners as additional costs is required for management of internal staff as well, besides third-party construction consultants and managers are also required. Eventually this adds to an augmentation in financing costs, developer costs as well as fees of management.

An early discussion between owners, contractors and stakeholders concerning potential influence of COVID-19 containment measures can provide a preparedness for commercial jeopardies on diverse construction projects. Thus, owners should be encouraged to assign personnel as well as formulate the procedure to authenticate all the commercial sways and for these bends, stake holders and contractors may look for economic recovery. Essentially, owners need to advise their consultants, suppliers, contractors as well as other personnel associated with assignments that provisions in contracts must be noticed and need to be strictly enforced. Moreover, it should be clear that impacts of COVID-19 costs will not be taken in consideration unless the owners are informed about the contract necessities. Additionally, owners should be vigilant and attentive to review progress reports on daily, weekly as well as monthly basis, they must analyze modifications and alterations in labor force of contractors as well as enquire the contractors regarding cost and schedule bearings regarding COVID-19 concerns.

D. Contractual Risk

The accountability of delays, commercial jeopardies and disruptions are stereotypically signified out in construction contracts and applicably allocated to the party in the pre-eminent location in order to mitigate such jeopardies. Postponements that occur due to the influence of the COVID-19 could be shielded under force majeure or akin section of the contract. There could be some argument by the contractors regarding postpones amid COVID-19 that such delays were

totally unpredicted and outside the constraint of contractors and therefore, they should not be held accountable. However, such situations generated for various contracts, authorize the contractor to extend the time schedule required for accomplishment of the project and also for the recovery of enhanced performance price. Moreover, contracts facilitate contractors to negotiate bumped up material price and labor costs under the price-escalation provisions, in case if they surpass pre-defined thresholds or proportions of baseline price valuations. In case, if the impact of COVID-19 pandemic enhances the labor and material prices of the contractor beyond the threshold limits, the contractors is permitted to regulate the overall amount of contract. Under such circumstances, contractors are required to provide the owners with the object evidence of enhanced prices and also justify that such an increase is beyond the contractual limits. On the other hand, owners are urged to review their construction contracts and determine the existence of force majeure or temporary halt or the suspension of work or work stoppage, order clause that potentially provide support and relief to those contractors who are seeking extension of time/schedule. In a similar manner, project directors need to pay special attentiveness concerning contract provisions facilitating contractors to make a request for compensation regarding- act of God (natural calamity), restrictions by the government or any action taken by the government authorities, pandemics or owner-mediated and directed suspension or stoppage of work.

Noteworthy to understand that owners need to encourage early discussions between contractors and project team and there should be no communication gap so as to determine if the COVID-19 associated impacts influence their projects or not and if they are influencing then should estimate the extent of jeopardy. Owners are required to state written or oral statements concerning the delays caused by the contractors and suppliers as well as the impact of the cost under appropriate contract clauses. Moreover, detailed record-keeping is also desired to corroborate the claims.

E. Conceptual Framework

The research framework is shown in Fig. 1, which consists of six steps. The framework initiates its process through investigation in the previous studies, papers and literature review. Then, the selection criteria will be chosen based on importance and citation. In the next steps, the importance of each criterion will be weighted through a questionnaire conducted by the experts in the field. At this time, the project will be evaluated based on each criterion to find the project overall score for management decision making. Finally, management has choice of selecting one or more project/program based on the scored projects. The technique used in this research to weight the criteria and score the project is AHP, which is an influential and humble technique for project selection and portfolio management. It is regularly utilized for program/project evaluation and selection. This technique will allow capturing the organization's strategies through strategic project/program selection.

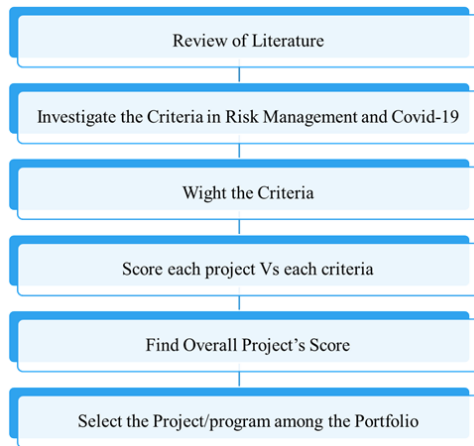


Fig. 1 Research Methodology

The first step after reviewing the literature review and papers is to design the questionnaire. The questionnaire was designed based on four sub-categories of: Health and safety risk, commercial risk, contractual risk and completion risk.

The questionnaire includes 9 questions as shown in Appendix I.

The next step is to weight and rank the selected criteria based on perception of the experts. The experts' perception is observed through the designed questionnaire. The pair-wise comparison is used to weight the criteria based on AHP technique. The experts responded for each criterion using ratio scale and utilizing only odd numbers from 1 to 9, proposed by [19] where 9 is the strongest and 1 is the weakest within scale.

Total of 72 responses were received out of 95 distributed questionnaires, which include staffs working in developers, owners of private development companies, and some consultants. This highlights 75.5% as a response rate for the conducted questionnaire. Table I shows the summary of pair-wise comparison between the criteria based on the conducted questionnaire. And Table II indicates the final output of this questionnaire as weightage of each criterion along with their ranking among others.

TABLE I
PAIR-WISE COMPARISON FOR THE SELECTED CRITERIA OF RISK MANAGEMENT

AHP - Weightage										
		Health and Safety risks			Completion Risk		Commercial Risks		Contractual risk	
		HSR1	HSR2	HSR3	CR1	CR2	COR1	COR2	CON1	CON2
Health and Safety risks	HSR1	1.00	5.00	1.00	0.33	1.00	2.00	7.00	1.00	0.33
	HSR2	0.20	1.00	0.20	0.14	0.33	1.00	1.00	0.20	0.14
	HSR3	1.00	5.00	1.00	0.33	1.00	5.00	3.00	0.33	0.20
Completion Risk	CR1	3.00	7.00	3.00	1.00	5.00	7.00	9.00	3.00	3.00
	CR2	1.00	3.00	1.00	0.20	1.00	3.00	3.00	0.33	0.20
Commercial Risks	COR1	0.50	1.00	0.20	0.14	0.33	1.00	1.00	0.20	0.20
	COR2	0.14	1.00	0.33	0.11	0.33	1.00	1.00	0.20	0.20
Contractual risk	CON1	1.00	5.00	3.00	0.33	3.00	5.00	5.00	1.00	1.00
	CON2	3.00	7.00	5.00	0.33	5.00	5.00	5.00	1.00	1.00

TABLE II
RANKING OF WEIGHTED CRITERIA FOR RISK MANAGEMENT

AHP - Weightage			
Category	Criteria	Weightage	Ranking
Health and Safety risks	HSR1	0.1037	R4
	HSR2	0.0268	R9
	HSR3	0.0895	R5
Completion Risk	CR1	0.2997	R1
	CR2	0.0707	R6
Commercial Risks	COR1	0.0309	R7
	COR2	0.0270	R8
Contractual risk	CON1	0.1484	R3
	CON2	0.2034	R2

IV. DATA ANALYSIS AND CASE STUDY

In this section, the case study is a portfolio of three identical projects for a developer: Project 1 (P1), Project 2 (P2) and Project 3 (P3). These projects will be evaluated based the selected criteria and their importance in accordance to the conducted questionnaire. The evaluation of projects is conducted through structured survey among five decision makers following the same rating system applied in previous

step. A pairwise comparison matrix will be built for each selected criterion in accordance to number of the projects or programs available in portfolio basket. As a result of this step, will be a score matrix, in which each element of this matrix indicates a value to demonstrate the score of each project with respect to each criterion.

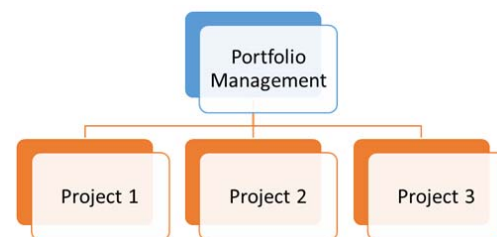


Fig. 2 Portfolio Management (Case Study)

The summary of score matrix is show in Table III, where the score of each project with respects to the selected criteria is explained. Therefore, we can compute the project overall score when the weightage of each criterion is computed and

the score of each project with respect to its criteria is available. As final step, the ranking and selection among the available options (Projects) is attained through selecting the project with higher score, means Project (P1). Here the project with higher score indicates less riskiness in completion and operation. The summary of this case study is shown in Table III, where Project 1 (P1) is less risky project and Project 3 (P3) is riskiest project.

TABLE III
SCORE TABLE FOR THE CASE STUDY
AHP - Scores

Category	Criteria	Project 1 (P1)	Project 2 (P2)	Project 3 (P3)
<i>Health and Safety risks</i>	HSR1	0.72	0.08	0.19
	HSR2	0.20	0.20	0.60
	HSR3	0.11	0.26	0.63
<i>Completion Risk</i>	CR1	0.43	0.43	0.14
	CR2	0.11	0.26	0.63
Commercial Risks	COR1	0.33	0.33	0.33
	COR2	0.63	0.11	0.26
Contractual risk	CON1	0.75	0.19	0.06
	CON2	0.11	0.63	0.26

TABLE IV
PROJECTS/PROGRAMS SCORING AND RANKING IN PORTFOLIO MANAGEMENT
Overall Project Value

Project 1 (P1)	Project 2 (P2)	Project 3 (P3)
0.386	0.354	0.260

V. SUMMARY AND CONCLUSION

In this research the impacts of Covid-19 and pandemic scenario are evaluated under four main criteria and through their parameters to score the riskiness of the project and program. The four criteria are commercial risk, contractual risk, completion risk and safety and health risk. The importance of this research is due to severe financial and non-financial impacts of pandemic scenario on the construction projects.

AHP was used in this research to evaluate level and severity of covid-19 as pandemic case which varies over the region and projects. Therefore, the portfolio management assessment was conducted based on the severity of such pandemic case on the project and program to reduce overall organization's operational and financial risks. The impacts of Covid-19 can be assessed based on look down effects, interruption in supply chain management, health and safety requirements due to health authority, transportations and commercial impacts. Finally, as a research value and outcome, the result of this analysis and methodology will provide the decision makers and board members to choose the right basket of the projects and programs with less risks for the organization. Moreover, number of criteria can be increased with another reasonable area in risk management to provide overall risk management of an individual project and program rather than impacts of pandemic case only, within the portfolio of an organization to achieve their mission and set goals.

APPENDIX I

TABLE V
QUESTIONNAIRE SAMPLE

SN	Risk Management
SN	Health and Safety risks
HSR1	Rules set by the government and healthcare professionals
HSR2	Probability of enforcement for health and safety procedures
HSR3	Safety awareness of the subcontractors and suppliers in the region
SN	Completion Risk
CR1	Expected delay on construction activities in case of pandemic appearance
CR2	Expected lockdown or business closure due to government restrictions
SN	Commercial Risks
COR1	Escalation in the labors cost
COR2	Increase in the material and subcontractor rates
SN	Contractual risk
CON1	Contract flexibility toward pandemic scenario
CON2	Contract clauses on price fluctuation

REFERENCES

- [1] "PORTFOLIO," Northwest Florida Daily News, p. F.3, 2007.
- [2] G. Bilgin, G. Eken, B. Ozyurt, I. Dikmen, M. T. Birgonul, and B. Ozorhon, "Handling project dependencies in portfolio management," *Procedia Computer Science*, vol. 121, pp. 356-363, 2017, doi: 10.1016/j.procs.2017.11.048.
- [3] P. E. Eriksson, "Exploration and exploitation in project-based organizations: Development and diffusion of knowledge at different organizational levels in construction companies," *International Journal of Project Management*, vol. 31, no. 3, p. 333, 2013.
- [4] W. Heising, "The integration of ideation and project portfolio management - A key factor for sustainable success", *Int. J. Proj. Manag.*, vol.30, pp. 582-595, 2012.
- [5] C. Beringer, D. Jonas, and A. Kock, "Behavior of internal stakeholders in project portfolio management and its impact on success", *Int. J. Proj. Manag.*, vol. 31, pp. 830-846, 2013.
- [6] C.P. Killen, and R.A. Hunt, "Robust project portfolio management: capability evolution and maturity", *Int. J. Manag. Projects Business*, vol.6, pp. 131-151, 2013.
- [7] Y. Petro, and P. Gardiner, "An investigation of the influence of organizational design on project portfolio success, effectiveness and business efficiency for project-based organizations", *Int. J. Proj. Manag.*, vol. 33, pp. 1717-1729, 2015.
- [8] N. Guo and S. W. Yu, "The Necessity of Project Portfolio Management in the Construction Industry of China Mainland," *Applied Mechanics and Materials*, vol. 357-360, p. 2238, 2013, doi: 10.4028/www.scientific.net/AMM.357-360.2238.
- [9] M. Martinsuo, "Project portfolio management in practice and in context", *Int. J. Proj. Manag.*, vol. 31, pp. 794-803, 2013.
- [10] B.-G. Jadwiga and G. Jaroslaw, "Establishing the project portfolio management in the construction company," vol. 603, no. 5, 2019, doi: 10.1088/1757-899X/603/5/052014.
- [11] R. Kangari and L. S. Riggs, "Portfolio Management in Construction," *Construction Management and Economics*, vol. 6, no. 2, p. 161, 1988.
- [12] O. Kokshagina, P. Le Masson, B. Weil, and P. Coge, "Portfolio Management in Double Unknown Situations: Technological Platforms and the Role of Cross-Application Managers," *Creativity and Innovation Management*, vol. 25, no. 2, pp. 270-291, 2016, doi: 10.1111/caim.12121.
- [13] H. Terho, "A Measure for Companies' Customer Portfolio Management," *Journal of Business to Business Marketing*, vol. 16, no. 4, p. 374, 2009.
- [14] Y. Wu, H. Zhang, and H. Xu, "A Three-Dimensional Project Portfolio Management Framework for Construction Companies," *The Open Civil Engineering Journal*, vol. 10, no. 1, pp. 433-447, 2016, doi: 10.2174/1874149501610010433.
- [15] "Industry Focus on Risk Management; A critical element to success in new construction lending is managing risks in a changing environment," *National Mortgage News*, vol. 31, no. 18, p. 20, 2007.
- [16] S. H. Cox, Y. Lin, R. Tian, and L. F. Zuluaga, "Mortality Portfolio Risk

- Management," *Journal of Risk and Insurance*, vol. 80, no. 4, pp. 853-890, 2013, doi: 10.1111/j.1539-6975.2012.01469.x.
- [17] W. Eid Junior and S. C. Lee, "Portfolio construction and risk management: theory versus practice," *RAUSP Management Journal*, vol. 53, no. 3, pp. 345-365, 2018, doi: 10.1108/rausp-04-2018-009.
- [18] S. H. Han, J. E. Diekmann, Y. Lee, and J. H. Ock, "Multicriteria Financial Portfolio Risk Management for International Projects," *Journal of Construction Engineering and Management*, vol. 130, no. 3, pp. 346-356, 2004, doi: 10.1061/(ASCE)0733-9364(2004)130:3(346).
- [19] S. H. Han, Y. Lee, and J. H. Ock, "Corporate risk management for global contractors," *KSCE Journal of Civil Engineering*, vol. 6, no. 2, pp. 77-88, 2002, doi: 10.1007/BF02829127.
- [20] B.-G. Jadwiga and G. Jaroslaw, "Establishing the project portfolio management in the construction company," vol. 603, no. 5, 2019, doi: 10.1088/1757-899X/603/5/052014.
- [21] R. J. Kauffman and R. Sougstad, "Risk Management of Contract Portfolios in IT Services: The Profit-at-Risk Approach," *Journal of Management Information Systems*, vol. 25, no. 1, pp. 17-48, 2008.
- [22] S. C. Lee and W. Eid, "Portfolio construction and risk management: theory versus practice," *RAUSP Management Journal*, vol. 53, no. 3, pp. 345-365, 2018, doi: 10.1108/RAUSP-04-2018-009.
- [23] "COVID-19," *The Ottawa Citizen*, p. A.1, 2020.
- [24] G. Ientile, "COVID-19," *Drug Topics*, vol. 164, no. 4, pp. 10-11, 2020.
- [25] A. Shingler-Nace, "COVID-19," *Nurse Leader*, vol. 18, no. 3, pp. 202-203, 2020, doi: 10.1016/j.mnl.2020.03.017.
- [26] H. Markowitz, *Portfolio selection: efficient diversification of investments* (Cowles foundation for research in economics. Monograph; 16). New Haven: Yale University Press (in English), 1959.
- [27] Farid and J.-L. Prigent, "Constant Proportion Portfolio Insurance Effectiveness under Transaction Costs," *International Journal of Business*, vol. 15, no. 3, pp. 243-253, 2010.
- [28] F. Mkaouer and J.-L. Prigent, "Constant Proportion Portfolio Insurance Effectiveness under Transaction Costs," *International Journal of Business*, vol. 15, no. 3, pp. 243-253, 2010.
- [29] Rom, B.M. and Ferguson, K.W. (1994), "Post-modern portfolio theory comes of age", *The Journal of Investing*, Vol. 3 No. 3, pp. 11-17.
- [30] Roman, D. and Mitra, G. (2009), "Portfolio selection models: a review and new directions", *Wilmott Journal*, Vol. 1 No. 2, pp. 69-85.
- [31] Bawa, V.S. (1975), "Optimal rules for ordering uncertain prospects", *Journal of Financial Economics*, Vol. 2 No. 1, pp. 95-121.
- [32] Fishburn, P.C. (1977), "Mean-risk analysis with risk associated with below-target returns", *American Economic Review*, Vol. 67 No. 2, pp. 116-126.
- [33] Dowd, K. (2000), "Adjusting for risk: an improved Sharpe ratio", *International Review of Economics and Finance*, Vol. 9 No. 3, pp. 209-222.
- [34] Rockafeller, R.T. and Uryasev, S. (2000), "Optimization of conditional value-at-risk", *The Journal of Risk*, Vol. 2 No. 3, pp. 21-41.
- [35] Mailles A, Blanckaert K, Chaud P, van der Werf S, Lina B, Caro V, et al. First cases of Middle East respiratory syndrome Coronavirus (MERS-CoV) infections in France, investigations and implications for the prevention of human-to-human transmission, *Euro Surveill*. 2013;18:20502.
- [36] Gwaltney JM Jr. Virology and immunology of the common cold. *Rhinology*. 1985;23:265.
- [37] Woo PC, Lau SK, Huang Y, Yuen KY. Coronavirus diversity, phylogeny and interspecies jumping. *Exp Biol Med* (Maywood). 2009;234:1117-27.
- [38] Hemida MG, Chu DKW, Poon LL, Perera RA, Alhammadi MA, Ng H-Y, et al. MERS coronavirus in dromedary camel herd, Saudi Arabia. *Emerg Infect Dis*. 2014;20:1231-4.
- [39] Nowotny N, Kolodziejek J. Middle East respiratory syndrome coronavirus (MERS-CoV) in dromedary camels, Oman, 2013. *Euro Surveill*. 2014;19:20781.
- [40] Bin Saeed AA, Abedi GR, Alzahrani AG, Salameh I, Abdirizak F, Alhakeem R, et al. Surveillance and testing for Middle East respiratory syndrome Coronavirus, Saudi Arabia, April 2015–February 2016. *Emerg Infect Dis*. 2017;23(4):682–5. doi:10.3201/eid2304.161793.
- [41] Al-Qahtani AA, Lyroni K, Aznaourova M, Tseliou M, Al-Anazi MR, Al-Ahdal MN, et al. Middle East respiratory syndrome corona virus spike glycoprotein suppresses macrophage responses via DPP4-mediated induction of IRAK-M and PPAR γ . *Oncotarget*. 2017;8(6):9053–66. doi:10.18632/oncotarget.14754.