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Contents

Abstract

These proceedings consist of academic papers on decision-making under uncertainty, smart decision, stochastic optimization, fuzzy optimization, management simulation and their applications. It presents some attractive and valuable results on the cutting-edge modelling methods and the practical case studies in the operation management process for power, transportation, logistic companies.

Study on Modeling of Distributed Energy Resources in Smart Distribution System

Menghua Fan, Zhe Wei and Su Yang

Abstract Smart grid has been become a new type of electrical power system. This new system structure physically focuses on expansive capabilities of network operations to coordinate distributed energy resources (DERs). And we present strategies for adapting conventional system simulation methods to the new requirements of complex adapted system. In this paper, we emphasize the steady-state modeling of DERs models in detailed distribution system level and focus on the latest development of cumulative methods and make comparisons with conventional approaches. Distribution system load models are also discussed. And the load modeling of smart distribution is a key problem for smart distribution system modeling to find a reasonable way to represent residential or commercial end-use loads. Top-down and bottom-up techniques are both implemented into loads modeling procedure as aggregated tools.

Keywords Distributed energy resource (DER) · Cumulative model · Probabilistic flow (PPF) · The load modeling

1 Introduction

Grid will be the next evolution in electric power system technology and has some specific physical features. As a new type of electrical power system, smart grid firstly requires pre-implementation simulation theory that will effectively and reasonably support offline and or online analysis. Currently, extensive researches have been conducted in this field, such as IntelliGrid (EPRI), Advanced Distribution Automation (ADA, EPRI), Modern Grid Initiative (DOE & NETL), GridWise (PNNL & DOE), and Advanced Grid Applications Consortium (GridApps) [1]. Basically, the power system constructed by smart grid technologies can be

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characterized as a "transactive" system [2, 3], which has seven key benefits for consumers, business, and utilities [3, 4]: (1) Self-healing; (2) Consumer motivation and participation;(3) Attack resistance; (4) Advanced power quality; (5) Adaptability for all generation and storage options; (6) Enabling markets; (7) Assets optimization and operational efficiency. In order to achieve these benefits, it is required that the electricity system has been restructured and the market-based signals have been incorporated into the operational decision making of a power system. The purpose of market participants is to behave in ways that improve the overall operational effectiveness of the physical system.

The basic application range of smart grid modeling is to practically interface new market models in different physical system levels and to describe the interactions with economic processes and physical system operations. The initial simulation work is to flesh out a reasonable representation of physical components and integrate them into an interactive system. The new system structure physically focuses on expansive capabilities of network operations to coordinate distributed energy resources (DER), including distributed generation, renewable and storage, as well as the load models with demand response features. A prospective smart grid can be divided into two parts: the primary system (generators, line, transformers and loads etc.) and the secondary system (sensors, advanced components, and integrated communications and controls). Both parts play important roles in decision and operation support. This paper focuses on the specific simulation issues in the primary system and presents an overview about different component models and integration system analysis based on relevant research achievements in this area. Primary system modeling involves the application of different analytical techniques, which depend upon the timeframes and the characteristics of the research objectives including degrees of objective dominances.

Considering time-scale allocation for smart grid simulation, this paper addresses system-level component modeling technologies and presents strategies for adapting conventional system simulation methods to the new requirements of complex adapted system. Specifically, in distribution system level, the steady-state models of distributed energy resources (DERs) and detailed load models with individual appliances behaviors, which reflects anticipated response to signals that encourage curtailment for demand control response are suitable to be integrated into three-phase power flow solutions in time varying conditions (i.e. cumulative power flow). In transmission system level, the stability models of DERs and the feeder-level equivalent loads to model different market-driven load aggregated schemes should be integrated into traditional power system dynamic simulator. The new transmission dynamic simulator needs to couple with wholesale market operations. To highlight the roles and limitations of current simulation tools in simulating the smart grid operations, the technical capabilities of available tools will also be summarized in this paper.

This paper is organized as follows: Sect. 1 is introduction part. Section 2 emphasizes the steady-state modeling of DERs models in detailed distribution system level, and Sect. 3 discusses distribution system load models based on bottom-up methods. And Sect. 4 is conclusion.

2 Steady-State Models of DERs

Depending on different time-scale allocation, the DERs models can be basically classified into two categories: dynamical and steady-state (and the like). Dynamical model focuses on fast dynamics of power electronics, such as the energy conversation units and the electromechanical interaction between DERs and power grid. Steady-state model is suitable to be integrated into longer timeframes and the latest method for smart grid application is the so-called cumulative model or quasi-steady state model in time varying conditions. Earlier models, which can be divided into deterministic and statistical, have been expanded into the cumulative model. This section will focus on the latest development of cumulative methods and make comparisons with conventional approaches. The application tools available for cumulative analysis in relevant studies and papers are also reviewed.

2.1 Non-cumulative Models

The deterministic models are the early steady-state models which have been integrated into conventional transmission and distribution power flow. Wind turbines are modeled by induction generator and power curve impacts [5–7]. Solar is usually integrated into power grid as a PV source which considers DC-side V-I characters and maximum power points tracing (MPPT) constraints, as well as PWM inverter controls [8–10]. Fuel cells and micro turbines can be treated as inverter-based grid-connected system, steady-state models of which are dominated. The deterministic models are primarily determined by PWM inverter control patterns [11].

We can characterize PHEVs as constant power loads (CPL) or constant impedance loads (CIL) based on their charging techniques [12]. And we can also model their charging process as one demand model [13] based on queuing theory [14], which considers maximum capacity of plug-in EV at each load bus with limited applicability. The PHEV charger models are also expanded into harmonic loads [15] by some studies.

Considering the random characteristics of DERs, especially for renewable and electrical vehicles, statistical models are proposed using the probabilistic power flow (PPF) methods, which can reveal the status of the whole system in different conditions. A probabilistic model for WTGs equipped with induction generators is developed in [16], which takes into account the probabilistic nature of short-term wind velocity forecasts. PPF is used in [17] to analyze the influences of wind power plants on voltage quality in distribution systems. Probabilistic performance models are discussed in [18] and comparison with deterministic models is conducted. A new formulation and solution for probabilistic constrained load flow (PCLF) problem is represented in [19], which is suitable for electric vehicles (EV) demand or supply. In [20], the categories of PPF methods are indentified for correlated power sources and loads, including Monte Carlo technique [21], interval method [22, 23] and fuzzy theory [24].

2.2 Cumulative Models

In order to enhance system performance, the future energy system will apply the expansive capabilities of market operations to coordinate DERs with detailed distribution system resources, such as load demand control. Retail market operations range from hourly pricing response to multi-year contracts. To meet the requirements of price responses, which are produced by the time-series load demand as shown in Fig. 1, Fig. 1a shows the end-use shape such as non-thermostatically

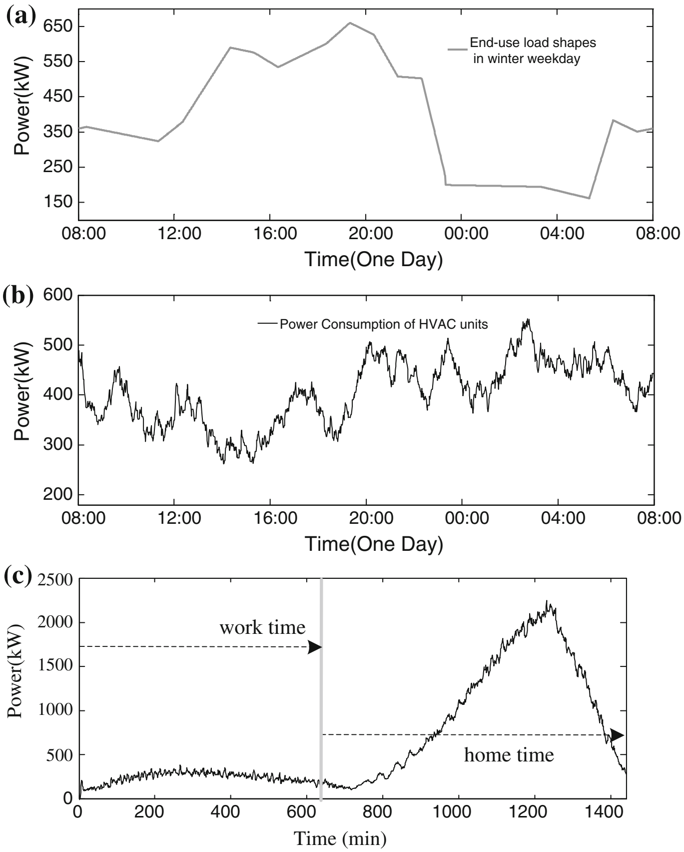

Fig. 1 Time-series deferrable and non-deferrable load demand models. **a** End-use load shape in winter/weekday (non-deferrable load). **b** Power consumptions of HVAC group (deferrable load). **c** PHEV load shape in charging mode (deferrable load)

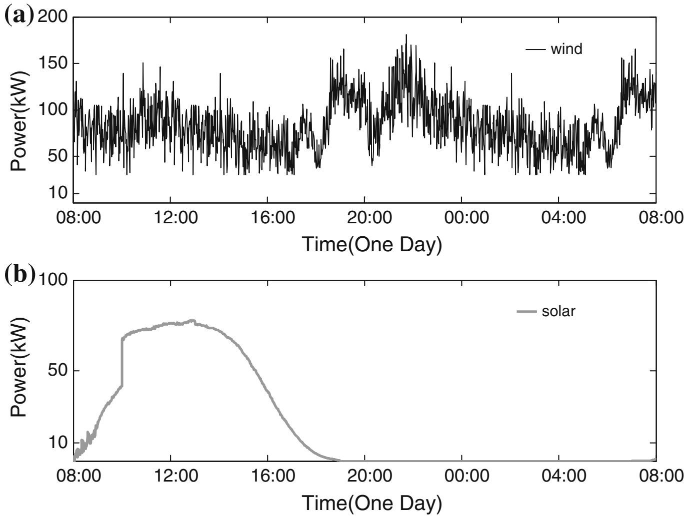

Fig. 2 Time-series renewable generation models. **a** Wind generation portfolio. **b** PV generation portfolio

controlled appliances (no-TCAs) in winter/weekday in residential house. Figure 1b illustrates the power consumption of HAVC group as thermostatically controlled appliances (TCAs) in house. Figure 1c illustrates the PHEV loads shape in charging mode. Both of (b) and (c) are deferrable loads. The generation portfolios must be adequate as shown in Fig. 2a, b. Thus, the assumption that power output is known only holds for historic and real-time analysis, while forecast estimates have to be used for any future scenario. Current or future system status should be determined by both real-time information and historical data, and the whole analysis process has the "cumulative or memorial" features.

Both deterministic and probabilistic models are applied to snapshot power flow algorithm and there are no cumulative functions involved. In order to reveal the status of the whole system over corresponding period of time, deterministic power flow needs to be repeated for many times. This leads to heavy computational burden but still cannot give a full reflection. Due to the complexity of the statistical distributions of load variations driven by market price signals, it is difficult to define a typical base case operating point for PPF. From a utility's point of view, it is more straightforward to directly apply the time series obtained for the area of interest. Provided that a representative period of time is covered, i.e., generally one to several years, the overall result will be a good description of the system behavior. Moreover, each single time step is meaningful to the utility, and detailed analyses for specific time windows can be carried out. The time series of demand and generation are directly applied to the input data which cannot be derived from statistical distributions. Such time series methods have been successfully used to determine the impact of wind turbines [25, 26] and to estimate distribution system load characteristics considering solar power [27].

3 Physically-Based Load Models Based on Bottom-Up Methods

The load modeling of smart distribution system basically exhibits probabilistic behavior of load averaged over various time intervals of minutes, hours and days. These models are different from the conventional load models (such as the induction generator load models or some others) which have been widely used in power system stability or transient simulation and represent system faster dynamics. Aggregated contributions of the load models can be reflected from many different types of appliances and equipments used in industry, commercial buildings and homes. For large industrial customers, the load demand can be considered as deterministic, since it is directly related to the production process of the consumers. On the contrary, the residential or commercial electricity demand involves, to a large extent, stochastic processes. Therefore, it is a key problem for smart distribution system modeling to find a reasonable way to represent residential or commercial end-use loads. Basically, the loads can be divided into thermostatically and non-thermostatically controlled appliances. Combined with feeder power flow results, the equivalent feeder load model can be obtained by aggregated analysis techniques. Top-down and bottom-up techniques are both implemented into loads modeling procedure as aggregated tools.

3.1 The Top-Down Methods for Load-Shape

If a single, lumped model is derived considering the contributions from all load components within the feeder, the modeling strategies can be regarded as top-down methods. These models are based on historical data, which are collected at the substation level and used to account for uncontrollable factors such as weather patterns and customer behavior. Probabilistic calculations of aggregated storage loads [28, 29] and the duty cycle approach [30] have been developed for aggregated load models using top-down methods. Around the middle of the 1980s, in order to reflect load heterogeneity, some strategies were proposed to assemble houses into different classes. In [31], a classification method is presented based on the air conditioner ratings. For each class, a random sample is obtained from its population and the duty factor is equal to the probability of the air conditioner being on during that hour. In [32], the component loads are classified into several homogeneous groups according to the similarity in the functional—state of the component—and electrical—electrical load demand—device model behavior. In each group, the state of each individual device is simulated through stochastic load model, and the aggregated demand is generated by Monte Carlo process. A predictive system-level model based on physical grounds can also be pursued by system identification techniques. In this way, large computational burden deduced from individual load simulation can be reduced. In [33], a static first-order equivalent thermal parameter (ETP) description is implemented to pursue this process. As a result, an ARMAX system-level model is obtained which is capable of providing the desired regulatory behavior. To extend this idea for future work, higher-order models and dynamic ambient conditions should be addressed.

Top-down modeling is used within probabilistic load flow analysis since the aggregated feature of this type of model is easier to be integrated into conventional algorithms. But it is inherently difficult for these approaches to simulate the effects of interactions between the individual loads, as well as the periodic and thermodynamic attributes apparent in many load types, which contribute to the aggregate load shape at the head of a feeder.

3.2 Physically-Based Load Models Based on the Bottom-Up Methods

Lately, the advent of demand management systems, which control specific types of appliances, such as HVAC and water heaters, has begun to change these models. Demand responsive model for end-use loads is an important component in a market-driven based smart distribution system. Price or other signals responsive loads can be modeled from the details of individual electric appliances interacting at the distribution feeder level. These models can be integrated into in demand-side management (DSM) programs such as distributed generation and storage. Therefore, it becomes increasingly necessary to implement the accurate and detailed electric load models, which consider the thermodynamic and cyclic features of the loads and their controls strategies, for the description of the aggregated load group trajectory under market-driven effects. A bottom-up load synthesis approach basically includes three adopted levels [34, 35] as shown in Fig. 3.

- Level 1: Creation of a physically-based load model (PBLM) for a single individual appliance or equipment used in industrial company, commercial buildings and home houses.
- Level 2: Aggregation of a single individual appliance or equipment so as to produce an individual demand profile.
- Level 3: Aggregation of the synthetic load-shape so as to derive the area load profile and implementation into transmission system simulator combined with distribution power flow solver.

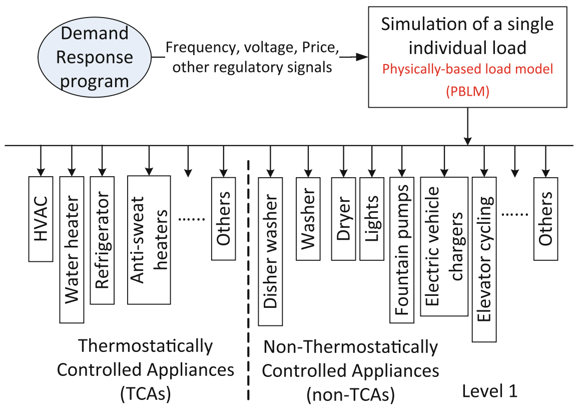

Fig. 3 Load-synthesis procedure using a "bottom-up" approach

Various aggregation methods for TCAs and non-TCAs have been presented during the last decades as a solution to specific necessities.

Almost all the early distribution heat load forecasting is empirically determined. That is, most approaches for determining load growth and load profiles are based on some combinations of measurements and probabilities [28, 29]. Then the thermostatically controlled appliance model is developed to simulate TCAs, which takes an equivalent thermal parameter (ETP) approach. Each classified appliance is modeled in a similar manner. In the case of a building-HVAC ETP model, the combined diversity of internal elements and stochastic disturbances result in a system which often performs outside the stipulated in the design-level simulations. In this case, model structures can be obtained through metering studies [36, 37]. However, this strategy becomes extremely time-consuming across a large heterogeneous population. Instead, through the application of advanced metering infrastructure (AMI), online system identification methods can be pursued to invoke the opportunity to obtain dynamic operational data in real-time. This results in an accurate ETP model based on the in situ operating characteristics of the building, which adapts well to the changing indoor structures and varying ambient conditions [38]. Such models can not only be utilized to implement efficient measures at the building-level [39, 40], but also provide a pathway to a detailed aggregate model at the system-level, which can be used to develop insights into the effectiveness of load control strategies.

The first application examples can be found in [42, 43] which focus on air conditioner appliances for a long duration. In [44], a truncated Taylor series is applied to obtain the random power demand. In [45], the stochastic aspect of the individual customer loads is also taken into account. Then the PBLMs are extended in [46–49], in which the first-order deterministic or stochastic differential equations are widely used.

More complicated backward Kolmogorov equations were used in [50] to obtain the transition probability density function of the ON and OFF time periods of individual loads.

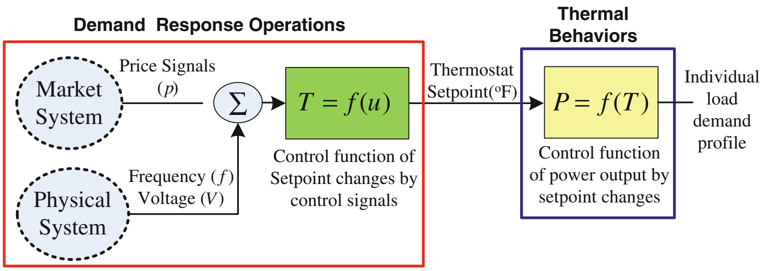

Fig. 4 Price-driven demand response controls of TCAs

Given that first-order differential equations may fail to provide an adequate fit for several hours, the third-order stochastic model is introduced in [51, 52]. This model fits satisfactorily the thermal and electrical behavior of an individual heating/cooling residential load, even on large (several hours) time intervals, and shows significant advantages over the first order model.

In [41], the discussion of a state-of-the-art aggregation technique applied on thermostatically controlled loads is presented. In this paper, a Monte Carlo process combined with either Euler-Maruyama discrete approximation method or smoothing techniques, and a numerical resolution of the Fokker-Planck partial differential equations are compared based on a stochastic differential equation (SDE) system.

To study the impacts of price response demand on the power systems, a State Queueing model (state-based model as shown as Fig. 4) is presented as an aggregated model for HVAC in [53] and for electric water heater in [54]. A TCA unit can respond to market price p by raising or lowering its setpoint T.

The chosen model provides a level of simplification, which improves its tractability but fails to give a satisfactory fit when the simulation time interval covers several hours. Besides, the proposed linear approximation of HVAC thermal characteristics can be valid inside the upper and lower limits set by the thermostat setpoint. However, it is no longer true when excursions of temperature—produced by DR programs—long simulation periods are considered.

A major feature for Non-TCAs is that, when these devices are active, the customer demand services have ubiquitous dispatch ability. The application of Non-TCA loads has brought about difficulties in load deferral, since these devices are driven by human behavior and they demand instantaneous power supply. However, a Monte-Carlo method has been applied to handle this problem [55]. With this method, operational probability distributions are defined within a state-queuing model, where,,the load deferred for non-TCAs can be computed, and used to alter operation for a given period of increased prices. And probability density function (PDF) and current operational state are two fundamental components of this process. The status and operation time for a non-TCA unit is also determined by this method. The original PDF curve and the variable queue description are combined to create a new 'Likelihood' curve. From the resulting

PDF shape and amplitude of this curve, the likelihood of load activity on any particular day and time can be revealed.

Currently, there have been a lot of researches addressing the modeling issues for residential TCAs and non-TCAs, which are affected by price changes in retail markets with different operational patterns. But fewer studies focus on other important regulated signals, such as system frequency and voltage, which have direct influences on customers and load demands locally or regionally. Meanwhile, it is highly desired to develop effective control strategies and demand response techniques for commercial buildings [56] and industrial company loads. Corresponding physically-based models should also be developed and implemented into aggregated techniques.

4 Conclusions

In this paper, the new system structure physically focuses on expansive capabilities of network operations to coordinate distributed energy resources (DERs). And to adapt conventional system simulation methods to the new requirements of complex adapted system, we emphasize the steady-state modeling of DERs models in detailed distribution system level and focus on the latest development of cumulative methods and make comparisons with conventional approaches. Distribution system load models are also discussed. And the load modeling of smart distribution is a key problem for smart distribution system modeling to find a reasonable way to represent residential or commercial end-use loads for demand response program. Top-down and bottom-up techniques are both implemented into loads modeling procedure as aggregated tools.

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Research on the Construction of Agricultural Product Virtual Logistics Enterprise

Fan Liu

Abstract With the development that the demand for agricultural products consumer market is gradually toward to the direction of complication, the existing agricultural logistics organizational model can't adapt to the characteristics of agricultural product logistics and the changes in consumer demand. Based on the analysis of virtual operation trend of agricultural product logistics enterprise, this paper explicits the concept and characteristics of agricultural product virtual logistics enterprise and proposes four steps to build an agricultural product virtual logistics enterprise, including the analysis of key elements about agricultural product virtual logistics enterprises, the needs identification about agricultural product logistics business, the project decomposition of agricultural product virtual logistics enterprise and the partner selection in agricultural product virtual logistics enterprise.

Keywords Virtual operation · Agricultural product · Virtual logistics enterprise construction

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1 Introduction

The organization mode of virtual operation with its advantage of agility of production, information sharing and risk sharing can enhance the competitiveness of enterprises and improve value-added ability of the supply chain in a relatively short time. However, the organization mode theory of virtual operation is still in its infancy in the application and practice of logistics at home and abroad and there is seldom research on virtual operation of agricultural product logistics enterprises. The scholars' research at home and abroad shows that the organization mode of virtual operation applied to logistics field is one dynamic alliance of supply chain integration mode which takes the logistics market opportunities as the driving force [1], obtaining the scale benefits in logistics field as a link, the advanced computer information network technology as the support and process optimization as the purpose [2], in this alliance, each partner contributes their own core competence at the stage of transport, storage, packaging, distribution and other stage and continues to share information in the supply chain in order to achieve the optimal allocation of logistics resources between enterprises and provide logistics service with low cost and high quality for the customers. Applying the organization mode of virtual operation to agricultural product logistics is the development direction for modern agricultural product logistics enterprises to cope with the increasingly complex personalized customer requirements and ensure the overall operational efficiency of the logistics system [3]. Based on the above background, this paper intends to discuss the problems about agricultural product logistics enterprises both from theoretical and practical aspects and explicit the concept and characteristics of agricultural product virtual logistics enterprises based on analyzing the virtual operation trend of the agricultural product logistics enterprises and then put forward the steps of constructing the agricultural product virtual logistics enterprises [4].

2 The Virtual Operation Trend of the Agricultural Product Logistics Enterprises

The division of labor and specialization of logistics aspects have become important means to improve the efficiency of agricultural product logistics because of the particularity of agricultural product itself, which also brings separation and imbalanced development between different enterprises and members of the department [5]. But the integrity of the agricultural product logistics process promotes each part isolated to fusion, one important issue that logistics organization faces is that how to effectively manage the whole process of agricultural product logistics, the development of information technology provides the possibility to solve this problem and at the same time provides the means for the integration of agricultural product logistics organization [6]. Based on the aforementioned status of agricultural logistics as shown in Fig. 1, integrating the agricultural product

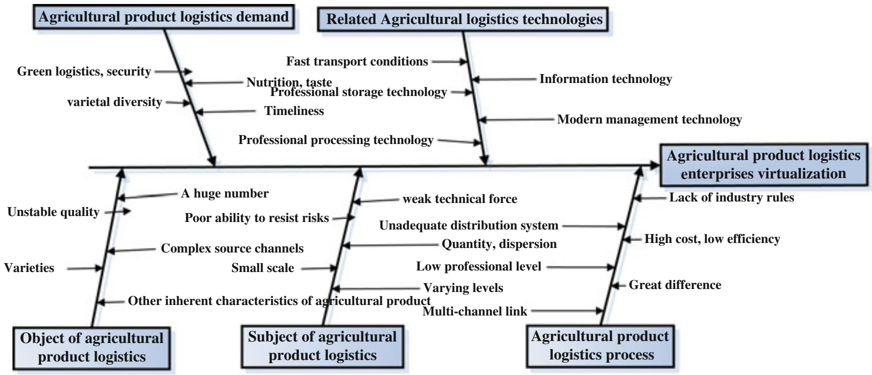

Fig. 1 Virtual trends of agricultural product logistics enterprises

logistics enterprises has become the inevitable trend considering the characteristics of logistics subjects, logistics organizations, logistics modes, logistics aspects and technology. The agricultural product virtual logistics enterprises under virtual operation with its competitiveness of organization, system and the advantage of integration and good ability to adapt to the market provide an effective organizational mode for agricultural product logistics in China.

3 The Construction Steps of Agricultural Product Virtual Logistics Enterprise

According to the concept and characteristics of agricultural product virtual logistics enterprise, its construction includes the following four steps: the analysis of key elements about agricultural product virtual logistics enterprises, the needs identification about agricultural products logistics business, the project decomposition of agricultural product virtual logistics enterprise and the partner selection in agricultural product virtual logistics enterprise.

3.1 The Analysis of Key Elements About Agricultural Product Virtual Logistics Enterprises

The primary participants of agricultural product logistics involve the supply side, the demand side and the third-party logistics enterprises. The agricultural product virtual logistics enterprises also depend on the three factors. Besides, in order to have a fast response to market by integrating external resources in a short time, they

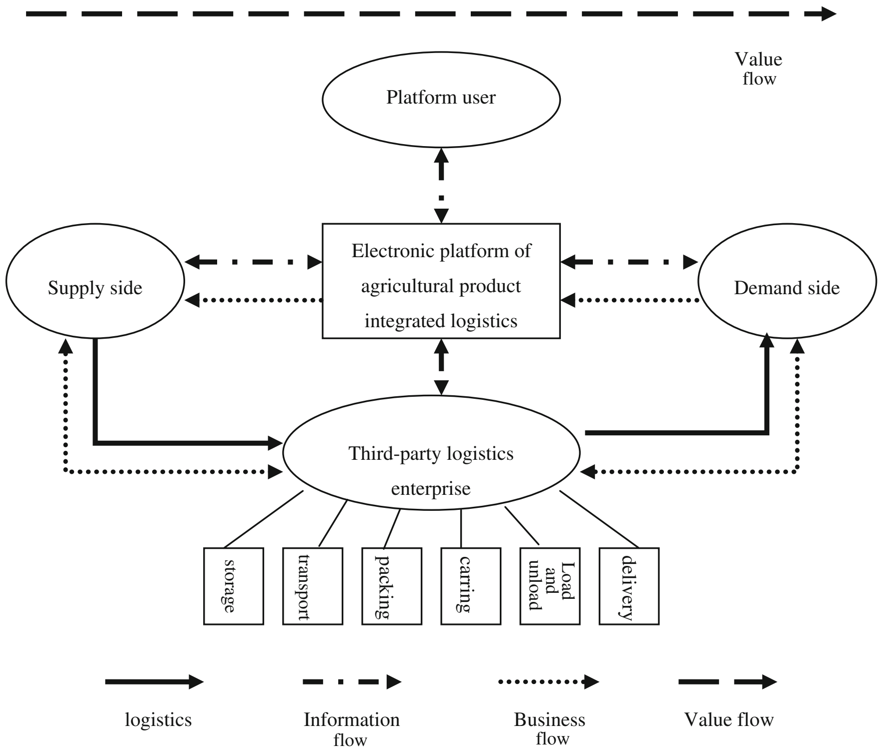

Fig. 2 The producing and flow of the value in the agricultural product virtual logistics enterprises

need to build a common information platform and infrastructures by using Internet information technology, modern logistics technology and management technology. Figure 2 expresses the producing and flowing process of the physical flow, the business flow, the information flow and the value flow in the agricultural product virtual logistics enterprises: the supply side is the beginning of the circulation of the agricultural product, the third-party logistics enterprise is the undertaker of the circulation who will send the agricultural products which satisfy the needs to the final customers [7].

Based on the above analysis, it shows that agricultural product virtual logistics enterprises need the following key factors to operate efficiently.

1. **Efficient information system and information transmission system**
   Agricultural product virtual logistics enterprise is a dynamic cooperation pattern based on logistics information Internet platform. In the situation where the range of choices of enterprise members is large, it needs a common reference standard to accomplish the process of the handing of orders, the flow of information and the upgrading of information technology, in which way instant response and

instantaneous cooperation will be achieved better. By means of high network information platform, the producing information of agricultural products and the information of logistics operation during every period can fully flow and be used; the whole process of the producing ad consuming and flowing of the agricultural products can be visible; the transaction costs of every section can be reduced; the quality loss of the agricultural products can be less; the service level of logistics can be improved and finally, every participant in the supply chain of agricultural products can get biggest benefits.

2. **High-level standardization**
   In order to guarantee the smooth logistics process of the agricultural products, it needs common standards, which include products classifications and codes, logistics terms, measurement dates and logistics services to regulate every participant's operation. Standardization is an important process to guarantee the agricultural products' quality. The standardization covers the whole process and scale of the supply chain of agricultural products which includes not only the process of the producing, harvesting, sorting, packing and quality testing, but also the process of handing, storing, transforming, loading, unloading and distributing. And the standardization covers not only the logistics devices and the logistics methods, but also the logistics technology.
3. **Developed logistics technology**
   Because agricultural products are perishable, the moisture content is high and the shelf life is short, the requirements of the transformation scale and operating time of the agricultural products are high. In order to satisfy those requirements, the logistics technologies of every section need to achieve matching levels. Accordingly, improving the level of the agricultural product logistics technology is the efficient and direct method to improve the service level of the agricultural product virtual logistics enterprises.
4. **Excellent cooperation and trust mechanism**
   The formation of the agricultural product virtual logistics enterprises is based on the temporary market chances and has high requirements for the flow ability and transparency of information. Therefore, the trust and cooperation between virtual logistics enterprises participants is the foundation of creating value and sharing benefits [8]. And excellent trust and cooperation system is not only the trust to the ability of the partners but also the level of sharing the demand and supply information and knowledge of agricultural products and logistics service between partners. With the help of the secure trust and cooperation system, every enterprise participants can communicate and exchange messages and can get changes in demand of the agricultural product logistics market. And the logistics service circle of agricultural products will be cut in a larger scale, the logistics service costs will be lower and the integral logistics operation efficiency will become higher.

3.2 The Demand Identification of Agricultural Products' Logistics Business

By means of agricultural product virtual logistics enterprise information platform, agricultural product logistics enterprises can find the demands of logistics business and seize the marker opportunities. Recognizing the market opportunity is the beginning and key of forming agricultural product virtual logistics enterprises. After the core agricultural product logistics enterprises finding and recognizing the business demands in the market, the opportunity is need to be analyzed and accessed. The opportunity feasibility needs to be strictly evaluated and then the core ability needs to be achieves and the opportunity needs to be confirmed. Finally, the most valuable opportunity is found. When the enterprises find they do not have complete grasp and ability to implement the market opportunity, in other words, they can only provide part of the main resource such as one or several functions of transportation, storage, distribution processing, handling and delivery to accomplish the opportunity, they need to adopt the mode of virtual enterprise and actively construct agricultural product virtual logistics enterprises. In this process, he enterprise who launches first must have the perfect, market information system, sensitive sense of opportunity recognition ability and scientific management methods of enterprises, then they can launch and organize the agricultural product virtual logistics enterprise.

3.3 Project Breakdown of Agricultural Product Virtual Logistics Enterprise

Depending on the resource-constrained situation, we can divide logistics enterprise project into two cases that are no consideration and consideration of resource constraints. The former refers to the adequacy of logistics recourse or small amount of materials needed to be processed during the operation of the agricultural logistics system [9]. Time-cost constraint need to be considered only. The latter refers to the shortage of logistics recourse or large amount of materials, such as the sharp rise in demand for agricultural products around the Spring Festival and transportation forces are relatively tight, and then we should give full consideration to the capacity-cost constraint and work together to complete the entire virtual agricultural logistics enterprise projects while ensuring profitability [10].

The breakdown of virtual logistics enterprise projects which base on time-cost constraint and capacity-cost can take the method of systems engineering, and define an agricultural virtual logistics network first, then establish agricultural virtual logistics network model which can be transferred into corresponding network optimization problem, through further solving and feasibility analysis breakdown of the entire agricultural virtual logistics enterprise project can be completed.

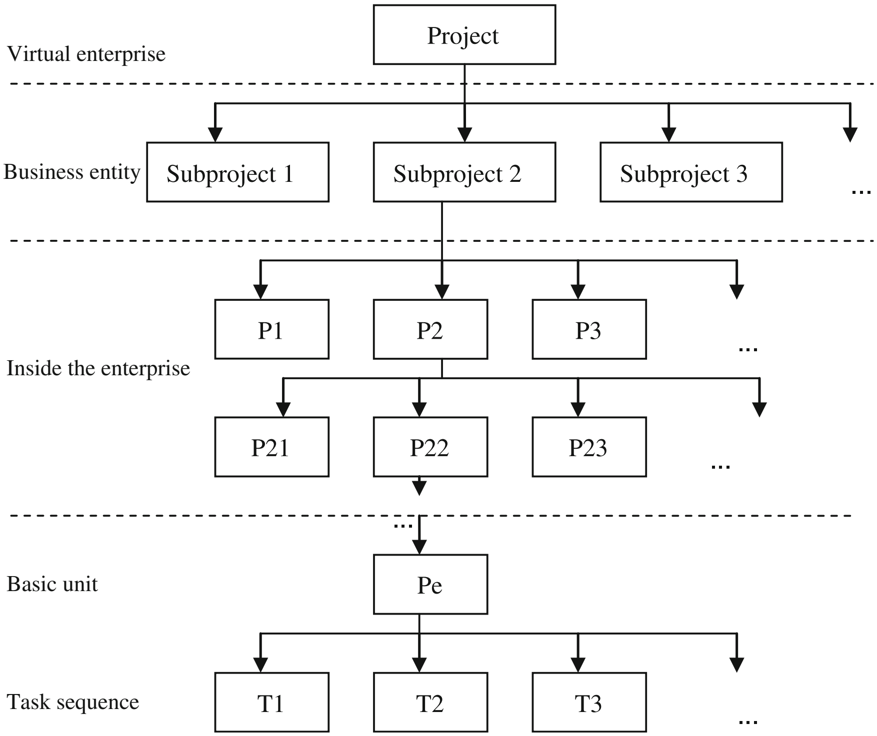

Fig. 3 Agricultural product virtual logistics enterprise project breakdown process

The project breakdown process of agricultural product virtual logistics enterprise shows in Fig. 3.

3.4 The Partner Selection of Agricultural Product Virtual Logistics Enterprise

The competitive advantages of agricultural product virtual logistics enterprises come from the complementary resources and core competencies between them. How to select partners properly is the key to success. Different from traditional agricultural logistics partnership, virtual agricultural logistics partnership is not only transaction, but also need to be consistent in the targets of reducing inventory levels and overall logistics costs, enhancing information sharing, improving the overall competitiveness. We can analytic hierarchy process for agricultural virtual logistics enterprise partnership screening. The steps are:

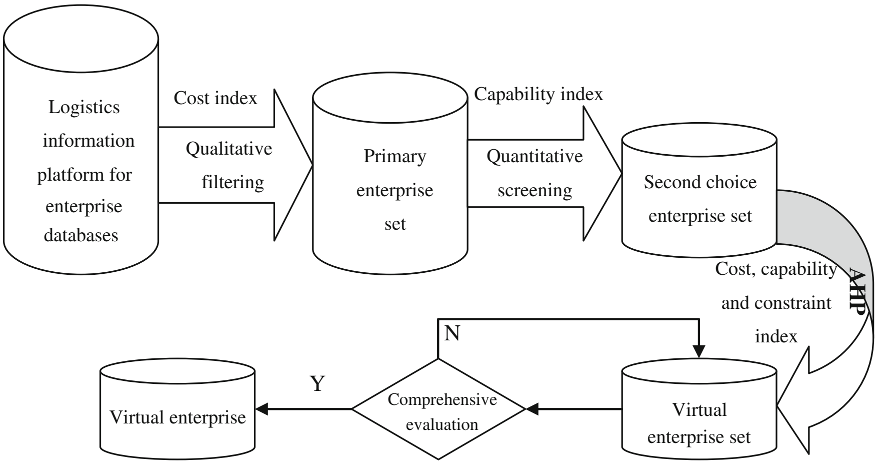

Fig. 4 Virtual agricultural enterprise partner selection process

1. Establish evaluation index system
   Based on the comprehensive study of existing literature, combined with the characteristics of agricultural product logistics, the key evaluation index of enterprise partner can be divided into three categories: the cost index, the capability index and constrained Index.
2. Virtual enterprise partner selection process
   Through the logistics information platform, initiated enterprise obtains network modules about transportation, warehousing, distribution processing, handing, distribution and other logistics functions. To construct virtual agricultural logistics enterprise, enterprise needs to select appropriate partner to join in from these network modules [11]. This selection process is divided into three stages: qualitative filtering, quantitative screening and analytic hierarchy process. Qualitative filtering reduce the number of selectable firms to a certain range through cost index; in quantitative screening stage enterprise will be further concentrated according to capacity-type index. Finally in the stage of analytic hierarchy, the most suitable enterprise can be selected to join in the virtual enterprise. As shown in Fig. 4.
   In the analytic hierarchy stage, we build a hierarchical model and the overall goal is divided into multiple targets or criteria, and then divided into some level of the criteria, standard or constraint. As shown in Fig. 5.
   After these AHP methods, the outstanding industries for every functional module have already been selected so that a virtual partners set generated. Next, we need to evaluate and optimize these partners comprehensively, take the measures of multi-objective programming, genetic algorithms and so on. To judge whether these enterprises meet the needs of the overall quality of the virtual enterprise. Finally, the best combination of Virtual agricultural Logistics enterprise can be finalized.

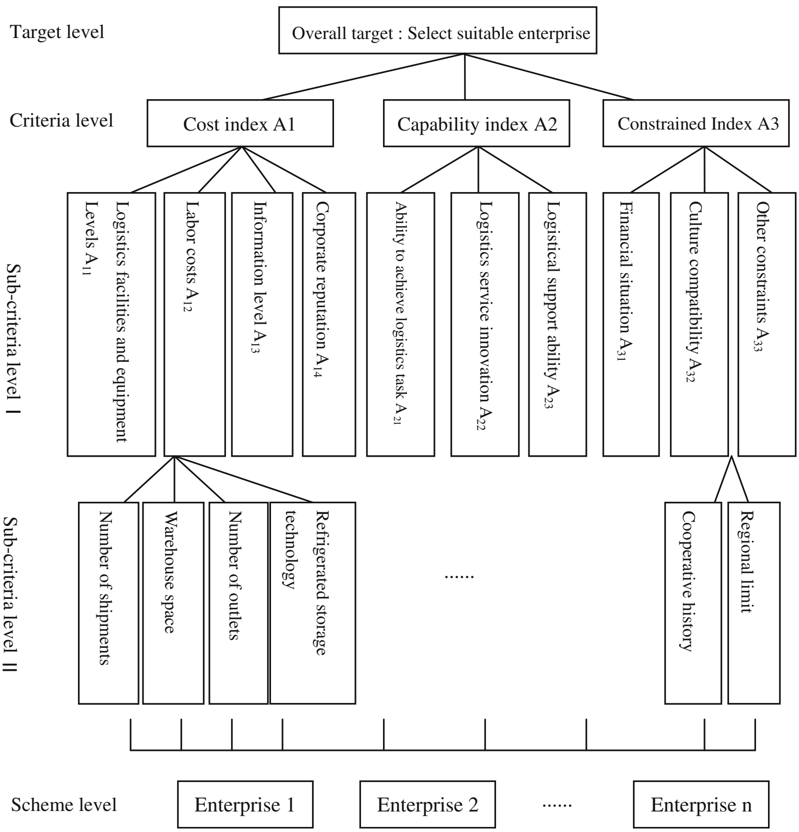

Fig. 5 Virtual agricultural logistics enterprise analytic hierarchy structure model

4 Conclusion

In the process of constructing the agricultural product virtual logistics enterprise, they must also do the following work:

1. The coordination and security of information sharing. The agricultural product virtual logistics enterprise shall put forward the coordinated security measures to ensure the successful implementation of information sharing mechanisms such as the establishment of goal management mechanism, group consultation system and incentive constraints contract;
2. The distribution of interests among the member enterprises. They should follow a win-win principle, the matching principle of risk and investment and decision-making satisfaction principle in the distribution of benefits.
3. The establishment of risk control mechanism. It is very necessary to establish the risk control mechanism for the successful operation of the agricultural

product virtual logistics enterprise. The enterprise can use information entropy risk analysis algorithm to evaluate the risk factors when having established the risk identification system for agricultural product virtual logistics enterprises, and then select the key observation factors of risk control to take the risk prevention and control measures.

4. The construction of the internal trust evaluation system. The review and assessment for the member enterprises should fully take their wishes of history, reputation, business ability, the credit grade, resource endowment, interdependence, their appetite for risk and cooperative characteristics into account. The evaluation of credit rating can be determined through the third party organization, those enterprises whose credit rating is low should not been considered.

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Simulation of SMS Emergency Service Platform in Public Crisis Rumor Management

Tuo Liu and Fuyu Yan

Abstract This paper constructs simulation model of the public crisis rumor management in various scenarios. We carry on some forecasting experiments by means of patterned chaos forecasting. The results show that the SMS emergency service platform can slow down the diffusion of the public crisis rumor and eliminate its negative effects effectively. Meanwhile, actions to mobilize the public to involve in the rumor management are also notably important. According to our research, lessening the acceptance probability of the public crisis rumor is the most effective way to manage and control the rumor. It performs better when combining with other countermeasures.

Keywords Management simulation · Rumor · Public crisis

1 Introduction

In recent years, short messages including email, QQ message, and micro-blog have become a main channel for rumor diffusion in the public crisis in China due to its popularity, convenience, and instantaneity. With the advancement of technology in crisis management, SMS emergency service platform is becoming a crucial management tool responding the crisis rumor diffusion and achieves itself in public crisis rumor (PCR) control in many provinces such as Guangdong, Sichuan, Guangxi, Zhejiang and so on [1, 2]. For instance, in reaction to the rumor "Earthquake is coming after the downpour in Zhanjiang!", Seismological Bureau and Weather Bureau activated the emergency service plan instantly—sending 2.8 million warning and refuting messages in 3 h—to avoid social panic and the further

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public crisis it may bring. In academia, rumors in the public crisis management are gaining more and general attention [3, 4]. Xiaoxiang and Yangqun [5] analyze the crisis and management process in systematic regard and point out that the evolution of public crisis is a series of effects of crisis information diffusion. The influence the public crisis exerts upon public psychology and behaviors derives from the transmission of crisis information. Jianxun et al. [6], based on the Complexity Science, preliminarily study the chaotic test, coevolution, complex adaptive system and some other characteristics of complexity. WANG Wei and JING Jipeng think that because of the characteristics of the social network structure, the PCR is endowed with highly clustering characteristic and network connectivity when flowing among all stakeholders, which, on the one hand, accelerates the rumor diffusion and causes the Ripple Effect and the Avalanche Effect. On the other side, it makes the control of the PCR possible [7]. Liu [8] defines the PCR under the Complexity Science, analyses the causes of rumor, constructs a simulation of the rumor diffusion based on Patterned Chaos Forecasting and simulates the evolution and diffusion of the PCR. Based on the research above and previous study, this paper constructs a simulation of the management of the PCR with Patterned Chaos Forecasting and stresses on studying the rumor management on SMS Emergency Service Platform in the duration of public crisis. Note that the PCR we discuss here must be the static or dynamic and real message which can be collected via routine methods.

2 Background and Assumptions

The PCR transmits through the World of Mouth (WOM) with fast speed, special hiddenness and hazard [9]. Public crisis rumor management (PCRM) is a process in which government agencies of public crisis management plan, organize, command, coordinate all the resources in hand and control the activities and whole process with the aim of controlling and eliminating rumors arising from present public crisis. In all, PCRM is set out to control the diffusion of rumors and accordingly erase their harmful effects. We set 4 assumptions in this paper. Assumption 1: PCRM is a repetition process of comparison of goals and correcting deviation effectively, namely, suppose that PCRM process consists of series of continuous and correlative management activities and behaviors, which are discrete and independent in time. Assumption 2: the execution of PCRM can be measured via the frequency of deviation correction during the process of PCRM. The more times the correction is, the stronger the execution, and vice versa. Assumption 3: every action of management can efficaciously correct deviation, that is, every time the action of rumor management in certain spatial extension and temporal duration comes into force, the affected individual would give up the rumor, while the unmanaged would remain its original state. Assumption 4: The SMS receivers are all rational men who have a credulous inclination toward the SMS Emergency

Service Platform, namely, suppose that the receiver can distinguish and adopt instantly the refuting message from the platform after receiving the rumor from his or her social network.

3 Methodology, Modeling and Scenario Design

3.1 Methodology

Based on the Chaos Theory, Patterned Chaos Forecasting is a forecasting method of the evolution of a nonlinear system. Patterned Chaos Forecasting, as a commonly used modeling approach, stresses the explanation and analysis of the formation and evolution of complex phenomena in terms of the Chao Theory. Therefore, it is universally applied in the simulation and the evaluation of complicated social and economic phenomena. Compared with the conventional mathematical models and simulation methods, Patterned Chaos Forecasting is easier to depict the interaction of primitives and can better stimulate some byzantine and indefinable phenomena and its evolution. Furthermore, it can vividly and really reflect the detailed structure and mode of interaction among large amounts of primitives and predict and generate the virtually future state of the evolution of the PCR. The diffusion and management of PCR are both two complicated and dynamic processes, hence it is befitting to apply the Patterned Chaos Forecasting to simulate and research the process. The following paper, on the basis of the simulation of PCRM constructed by the Patterned Chaos Forecasting method, demonstrates and simulates the evolution of various management scenarios in a phenomenological way.

3.2 Constructing a Model

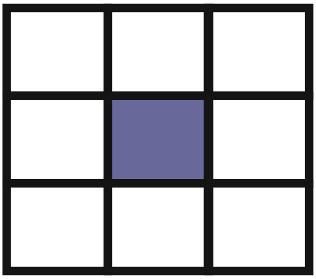
According to the Patterned Chaos Forecasting, the simulating model is as below:

$$A = (L_d, S, N, f)$$

where:

- Primitive and space (L_d): Space is the whole system space of the diffusion of PCR. Every primitive in space is the potential receiver of PCR and is the abstraction of people in reality who have a certain probability to adopt rumors. Every primitive has its state and behaviors, and exchanges information with the other primitives and external environment, which leads to the upgrade of the state of the whole system.
- Neighbor (N): Neighbor is an abstraction of interpersonal communication in the real world. They are the potential receivers of the PCR who have a close

Fig. 1 Schematic drawing MOORE Neighbor



relationship with each other. The adjacent neighbors communicate mutually with rumors. Primitives who communicate with each other form a social network of WOM. This paper employs the Moore type, which has 8 neighbors (3 above, 3 below, 1 to the right and 1 to the left) as shown in Fig. 1. The next state of each primitive is determined by its present state and its neighbors.

- State (*S*): Each primitive has two states denoted by 0 and 1. Primitive in the state of 0 is the potential receiver who does not get rumor yet. Primitive in the state of 1 has already adopted it. In each time step, primitives in the model update their state via their neighbors' state and certain decision rules. Primitives who have adopted the rumor change no more. The unreceived ones would observe the adoption situation of their neighbors and follow certain rules to decide whether or not to adopt the rumor.
- Decision Rules (*f*): Decision rules are the summarization and abstraction of the decision-making and behaviors of potential receivers during the process of PCR diffusion in the public crisis. Research shows that the potential receivers in public crisis are usually the stakeholders of the crisis events ① who are sensible to crisis information and have strong motive to collect it and most of them will inquire about it or transmit it to their close neighbors. Circumstantially, the local decision rules are defined in the following conditions: ① Are there any neighbors who have adopted PCR around a primitive. ② If any, the primitive will not adopt the PCR with a certain probability; If none, nothing happens.

3.3 Research Scheme

Set up a two-dimensional interface as the system space of the diffusion of PCR and suppose that rumor outspreads from the center. Software MATLAB 7.0 is used here to simulate the diffusion of PCR. The procedures of simulation are demonstrated in Fig. 2. Combining with the research of the operating model of SMS Emergency Service Platform in China, in this paper some primitives of the system space are randomly picked up with a certain probability (noted as *pp*) during the diffusion process. According to the assumption 4 in the previous paper, the selected primitives will recognize and disbelieve the rumor instantly. This is the simulation of

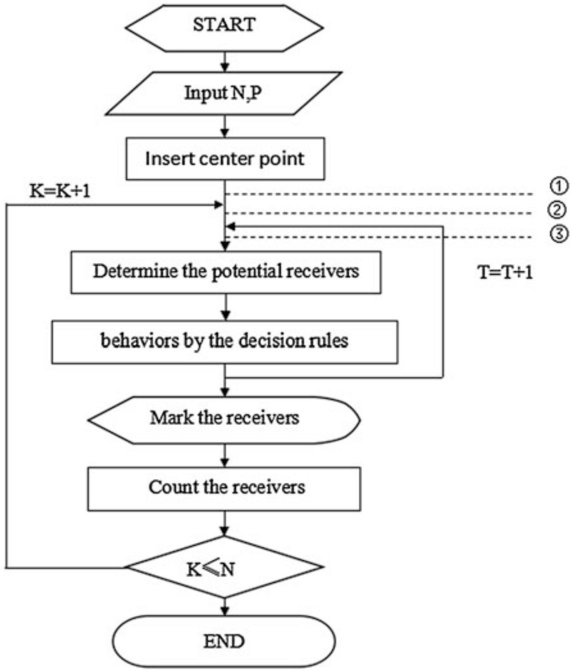


Fig. 2 Simulation flow of fake information diffusion

operating model of the SMS Emergency Service Platform in PCRM. Insertion point ①, ②, and ③ are installed into the simulation process. From the procedures of simulation, we can learn that the frequency of code execution in each point is different. The code in point ① only works in early simulation, the code in point ② will execute N times in the whole process (Inputting N in program initialization) and the code in point ③ will execute $T \times N$ times in the whole. In simulation experiment, codes imitating the operation of SMS Emergency Service Platform are inserted respectively at point ①②③ to simulate management performance of the SMS Emergency Service in different situations phenomenologically and the relevant simulation scenarios are noted as EI, EII and EIII. It can thus be seen that EIII lasts longer than EII, since the interval in two procedures before and after EIII are shorter than EII, which means that EII and EIII represent respectively the discrete management and persistent management in reality. The probability *pp* represents the intensity of the short rumor message sending, namely the intensity of management and control, in reality. Considering the correspondence of simulation scenarios, the PCRV in the real world and practical value of the scenarios, this paper only analyze the simulation scenario EII and EIII.

Note: P is the adoption probability, N is the maximum number of iterations, T is the distance from the center point (diffusion source), and program loop K is the virtual clock which can be used to simulate the cumulative effect of the diffusion process in each iteration.

4 Results and Analysis of Simulation

In order to keep generality and ease of observation, the adoption probability p is set up as 0.3, virtual clock is 25, simulation interface is 100 × 100 and the receivers are defined as the coordinate points of positive integers between (0, 0) and (100, 100) in two-dimensional coordinate space. For the ease of plotting, in this paper the following system evolution pictures are generated by these uniform definitions: (1) The horizontal axis is *X* axis and the vertical axis is *Y* axis; (2) The diffusion source of PCR is the point in coordinate of (60, 60); (3) Analyze only the evolutions within a circular region whose center is (60, 60) and radius is 50. If primitives (potential receivers) in this circular region adopt the PCR, the coordinates of the primitives will be marked and the amounts of the receivers will be counted, or there will be no marking and counting. (4) Primitives which have adopted rumor will be marked by a black square with a blue frame. We observe and measure simulation results and management performance through the changes and comparisons of direction and speed of the diffusion of PCR, the spatial distribution and amounts of the receivers in various situations. Must point out that owing to the design of the process of simulation, what demonstrated in this paper is the final diffusion distribution of each scenario, namely, the evolution figures when $K = 25$. However the maximum value of the horizontal axis in figures of the amount changes of rumor receivers in each scenario is 24 (namely, $K = 24$).

4.1 Situation A: The Simulation Results of Invariant Intensity of Management and Control and Discrete Management

Set up random distribution rate pp respectively as 0.01, 0.05 and 0.1 to study the sensibility of the diffusion of PCR under different value of pp. The result of simulation suggests that in Scenario EII, as shown in Figs. 3, 4 and 5, the diffusion of PCR is getting irregular and the speed of diffusion slows down with the increase of the rate of random distribution. As shown in the curves of amount change in Figs. 4, 6, and 8, when K = 15, the amount of receivers in each sub-situation are respectively more than 300, less than 300 and near 200. When K = 24, the final amount of receivers in each scenario decreases successively as more than 600, near but less than 600, and larger than 500 slightly (Fig. 7).

Fig. 3 Scenario of EII while $pp = 0.01$

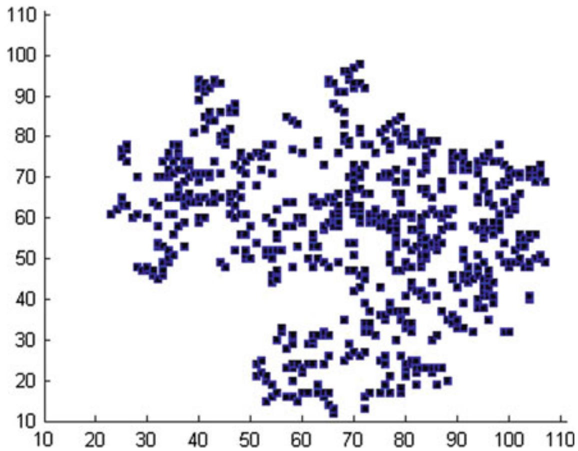


Fig. 4 Quantity of EII while $pp = 0.01$

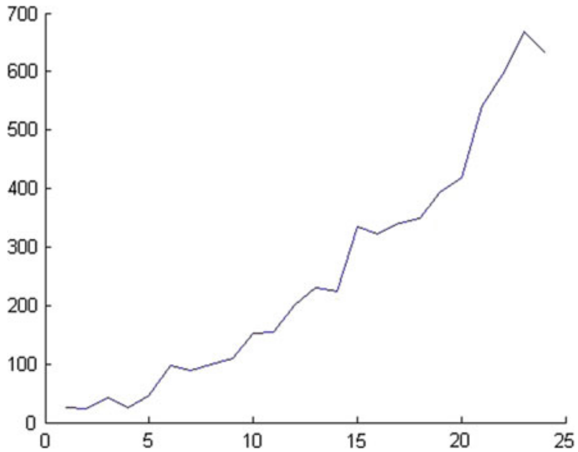
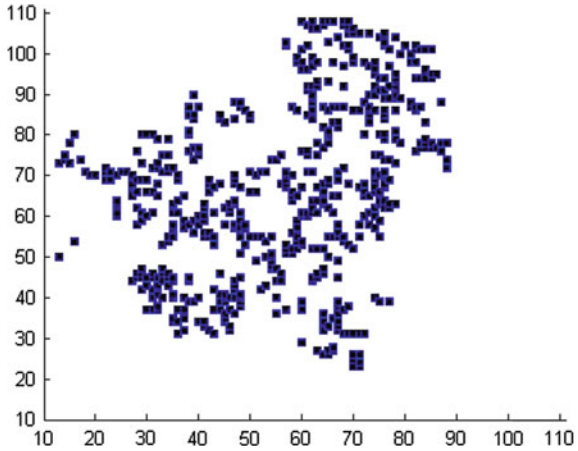


Fig. 5 Scenario of EII while $pp = 0.05$



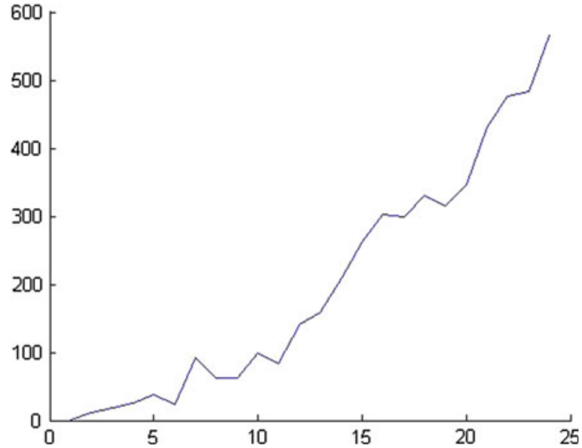


Fig. 6 Quantity of EII while $pp = 0.05$

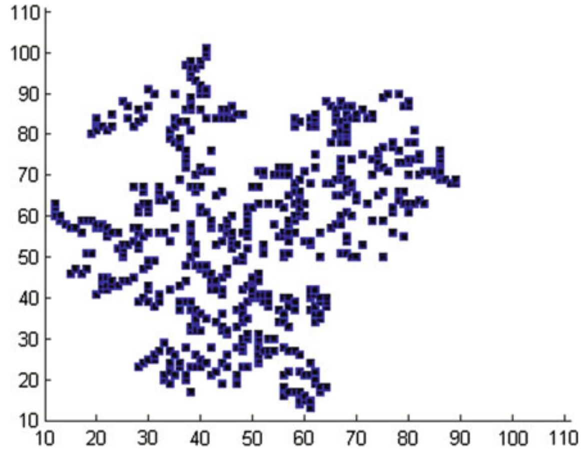


Fig. 7 Scenario of EII while $pp = 0.1$

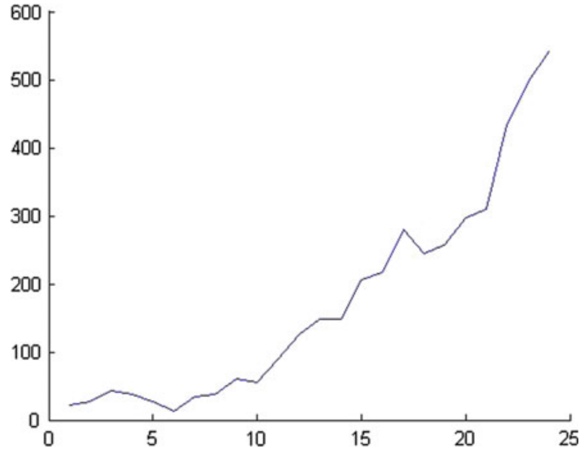


Fig. 8 Quantity of EII while $pp = 0.1$

4.2 Situation B: The Simulation Results of Invariant Intensity of Management and Control and Persistent Management

We can learn from the experimental results of Scenario EIII that with the increase of the random distribution rate *pp*, the diffusion of PCR is getting harder. Compared with the situation of Scenario EII when *pp* = 0.01, the speed of diffusion of PCR is very slow in Scenario EIII when *pp* = 0.01 (Figs. 9, 10 and 11). The amount change is more violent and more peaks appear. The final amount of receivers is up to near 250, much less than the amount of Scenario EII when *pp* = 0.01. When *pp* = 0.05, the diffusion of PCR is affected strongly and several points become the rumor receivers. The change of amount tends to be stable and the largest amount of

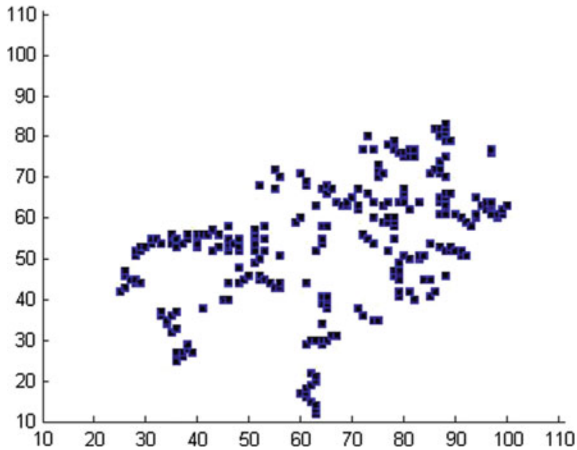


Fig. 9 Scenario of EIII while *pp* = 0.01

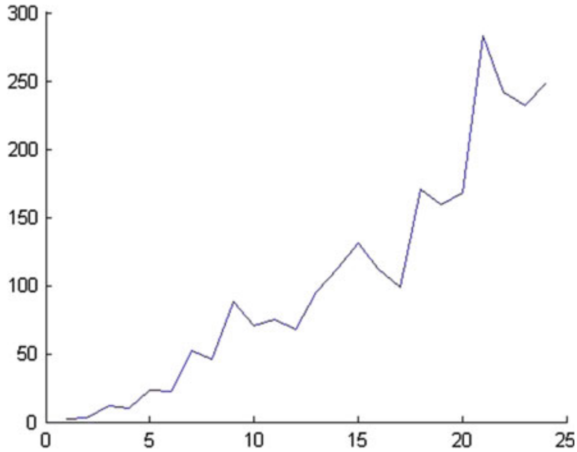


Fig. 10 Quantity of EIII while *pp* = 0.01

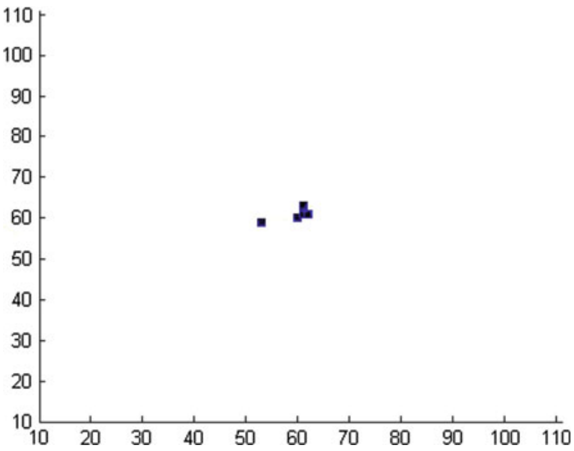


Fig. 11 Scenario of EIII while *pp* = 0.05

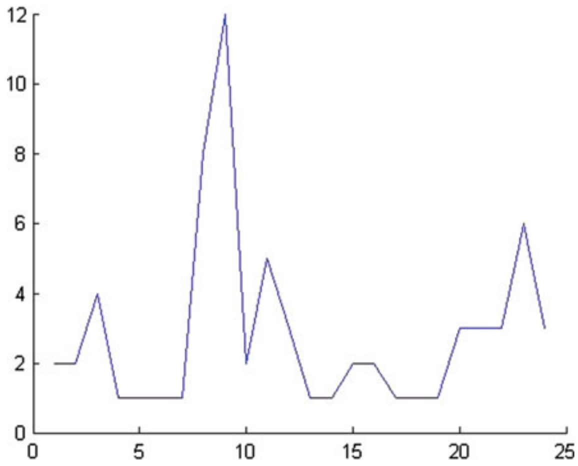


Fig. 12 Quantity of EIII while *pp* = 0.05

receivers is 12 (Fig. 12). When the *pp* = 0.1, there even appear several times of the failure of diffusion of the PCR, namely, the initial random distribution point happens to pick up the center point. This result indicates that the Situation B can prevent the rumor from formation to a certain degree and effect a permanent cure for the problem, even the PCR can “fortunately” escape and diffuse (Fig. 13). The rumor receivers in this situation are quite rare. The largest amount of it is only 3. Experiments above suggest that the persistent and adaptive management of the PCR can promptly and effectively limit the diffusion of the rumor. The more exoteric and adaptive the strategy is, the slower the diffusion of the PCR is. When the openness and reach a certain level, for instance, there are 1 % of public activated to participate in the control of the diffusion of PCR (namely, *pp* = 0.01), the diffusion and diffusion of the PCR can be conspicuously limited. The result has a managerially significant value and profound inspiration to the operation of the PVRM: it is

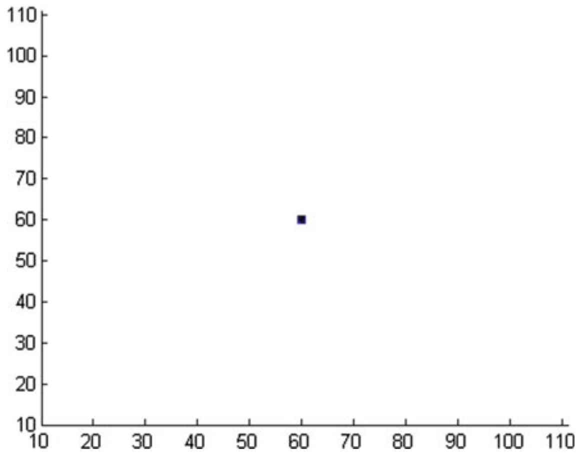


Fig. 13 Scenario of EIII while *pp* = 0.1

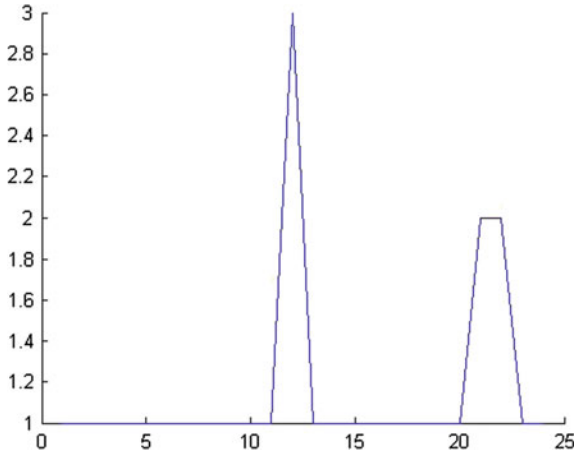


Fig. 14 Quantity of EIII while *pp* = 0.1

advisable to look for and even cultivate these 1 % positive activists.[1] Therefore, it is necessary to encourage the nongovernmental organization to play a more positive role in PCRM practice. When the openness an adaptability expand further (as *pp* = 0.05), the control upon the rumor can be more overwhelming and forceful (Fig. 14).

[1]Plentiful investigations of SARS also find out that 85 % of public learn the rumor of SARS event in the earliest via interpersonal channel.

4.3 Situation C: The Simulation Results of Increasing Intensity of Management

Here we study the evolution of PCR in Scenario EII and Scenario EIII in the condition in which *pp* is increasing. Initialize $pp = 0.01$ and make it increase 0.01 or 0.05 in each circle loop of the virtual clock from $k = 1$ to $k = 25$, which represents the force of adaptive management is enhancing gradually. The experimental results of simulation suggest that, in Scenario EII if *pp* increase 0.01 every time step, the diffusion of PCR is still in an irregular and unstable state, but it has been suppressed obviously and the final amount of receivers is less than the one in Scenario EII when *pp* invariantly equals to 0.01 (Figs. 4 and 16). However, in spite of the suppression, the rumor can still outspread at a low speed and the amount of receivers does not decrease with the increase of the random distribution rate *pp* (Fig. 15). ①

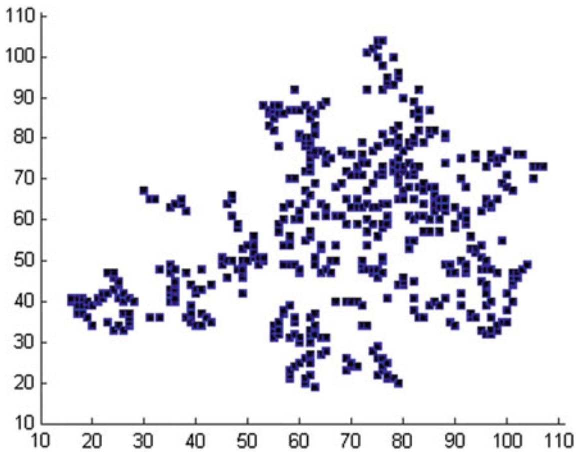


Fig. 15 Scenario of EII while $pp' = 0.01$

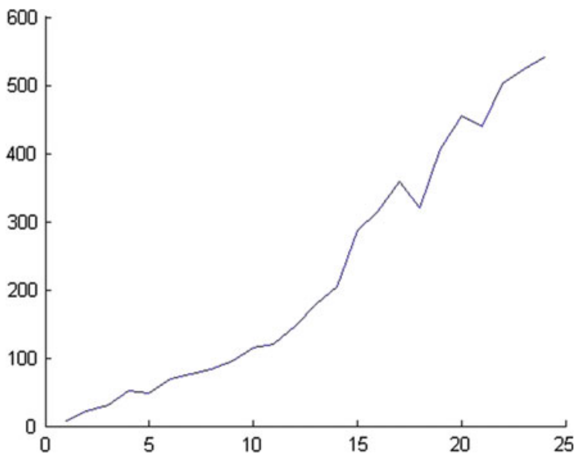


Fig. 16 Quantity of EII while $pp' = 0.01$

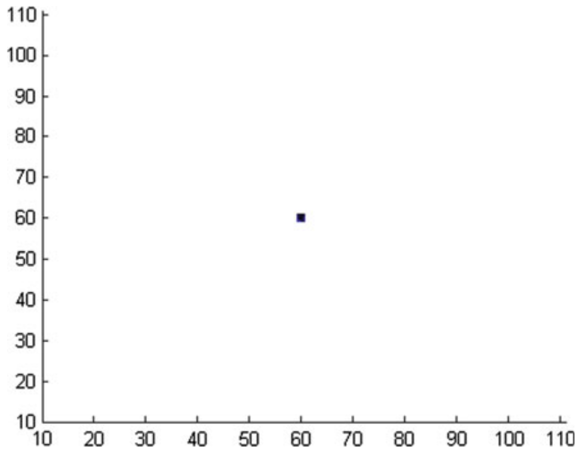


Fig. 17 Scenario of EII while *pp′* = 0.05

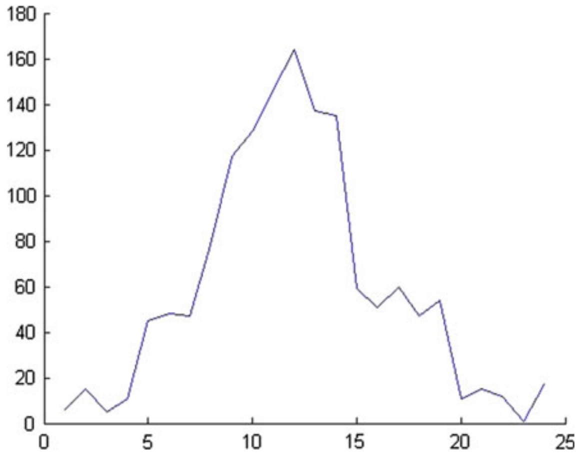


Fig. 18 Quantity of EII while *pp′* = 0.05

Here goes the further study of the situation that the random distribution rate *pp* is larger than the reception possibility *p*. The simulation experiment suggests that along with the diffusion process (Fig. 17), there is an apparent inflection point at the curve of change of the amount of receivers. Before pp reaches a certain value ($pp = 0.56$ while $K = 12$), the amount of receivers arrives at its maximum (more than 160), which is near the one of Scenario EII when $pp = 0.01$ (Fig. 4). After that ($K > 12$), the amount of receivers of the PCR starts to fall. In Scenario EIII, the tendency of decrease is more sensible and the change is quicker than in Scenario EII (Fig. 18). It is pointless that in this situation, the inflection point of receiver amount change curve appears when the random distribution rate $pp = 0.56$ ($K = 12$) is larger than the adoption probability p = 0.3, which fully reveals that the elimination of the PCR has a certain time lag; hence the adaptive management of PCR cannot achieve

Fig. 19 Scenario of EIII while $pp' = 0.01$

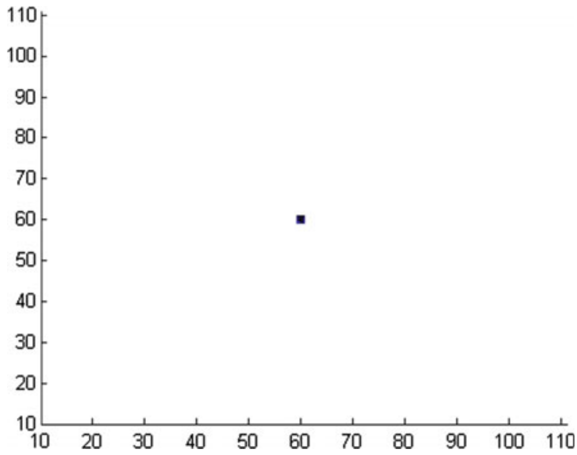
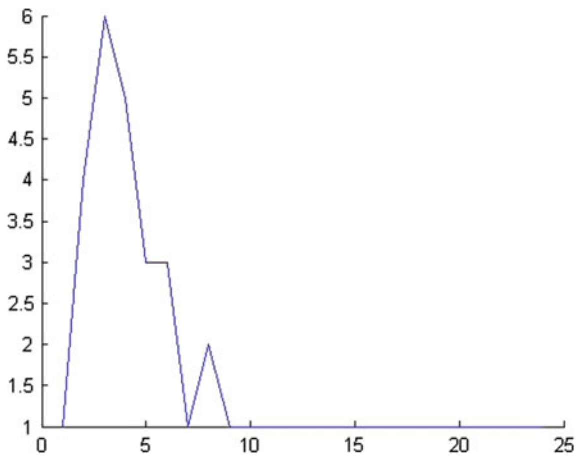


Fig. 20 Quantity of EIII while $pp' = 0.01$



itself in one go and should be regarded as a persistent management process with continual enhancement (Figs. 19 and 20).

Actually, neither in this situation the diffusion of rumor cannot be completely eradicated, nor as the amount of receivers becomes monotonically decreasing when pp reaches a certain value (like $pp > 0.56$). On the contrary, the variation tendency of the amount of receivers demonstrates nonlinearly. Say in Fig. 14 when $K = 23$, the amount of receivers is 0 and when $K = 25$, there appears a sign of rebound of the increase. If at this moment the intensity of PCRM weakens, the diffusion may reoccur, which indicates that the adaptive management of PCR contains certain repeatability (it embodies the complexity of management). In comparison, in Scenario EIII when the rate of random distribution increases 0.01 at a time, the amount of receivers is much less than the other situations, with its maximum 6 ($K = 4$), as demonstrated in Figs. 6 and 8. This reveals that the diffusion of PCR is suppressed more effectively.

5 Conclusion

Through the experiment results of simulation we arrive at the following conclusion:

1. The speed of diffusion is quite fast and the PVR is detrimental enough to be attended extensively. The supervision and control upon rumor in the public crisis management must be enhanced. The diffusion and transmission of rumor should be disposed of timely and eliminated instantly.
2. SMS emergency platform can effectively slow down and eliminate the diffusion of PCR, but cannot control the direction of diffusion. Therefore, when the public crisis organizations activate the platform, they should place more focus and efforts on animating individuals or groups to participate positively in the prevention and control of rumor.
3. When the platform involving in the process of PCRM, the intensity of rumor management execution must be strengthened and every management decision and measure are supposed to work with persistence and continuity.
4. Lowering down the PCR adoption probability is the most essential and effective management methods. If this cannot be realized, the strategy of persistent management should be applied to prevent the rumor from further diffusion and transmission. However, it demands immense workload and high management cost. Therefore it is advisable to combine several countermeasures.

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Research on Strategic Performance Evaluation Model of Power Grid Enterprise Based on Fuzzy Integral Evaluation

Ma Li and Liu Tuo

Abstract This paper analyses the correlative relationship between the financial indicators and non-financial indicators of power grid enterprises, and accordingly sets up an evaluation indicator system of the strategic performance evaluation of the enterprises. Using the system, the Fuzzy Integral Evaluation theory, and Balanced Scorecard Theory, a strategic performance evaluation model of power grid enterprise is established and tested with an empirical research of the Five-year Development Program of the State Grid Corporation of China.

Keywords Strategic performance · Fuzzy integral · Power grid enterprise

1 Introduction

The strategic performance evaluation is very important to the grid power enterprises. So, this paper established a strategic performance evaluation model of power grid enterprise, basing on the Fuzzy Integral Evaluation theory and Balanced Scorecard Theory.

2 The Evaluation Indicator System of the Strategic Performance Evaluation of the Grid Power Enterprises

Using the Balanced Scorecard Method, we design the evaluation indicator system suitable for grid power enterprises in four layers: finance, customers and society, internal business process, and learning and development. These indicators include both quantifiable financial indicators and qualitative or other non-financial indicators.

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There are a linear relationship and nonlinear relationship, or even indirect relationship among them. This chapter extends its analysis from financial and non-financial respects. The interplay among the key financial performance indicators of grid enterprises is demonstrated as below (Fig. 1).

The non-financial indicators reflect the significant influencing factors during the process of realization of the enterprises' strategic objectives, the interplay relationship among which is presented below. The "+" indicates that the start indicator of an arrow has a same change trend as the end indicator of the arrow. "_" indicates that the indicators in two sides of arrows change reversely. Those key performance indicators not used in this essay are noted with a dotted circle (Fig. 2).

Based on the Balanced Scorecard Principle and the key performance indicators raised above and considering the specific features of strategic planning and performance evaluation of the State Grid Corporation of China, we design the company strategic planning and performance evaluation indicator system as a comprehensive multi-layer hierarchical indicator system shown in the following table. The performance indicator system from top to bottom constitutes four layers as "Strategy Layer—Objective Layer—Evaluation Layer—Indicators Layer". Note that in the Evaluation Layer and Objective Layer there are evaluation scores and weights need to be determined (Table 1).

3 Principle of Fuzzy Integral Evaluation

L. A. Zadeh, an American expert in Control Theory, put forward the notion of the Fuzzy Sets and deduce the structure of the Fuzzy Mathematics. Sugeno, a Japanese Scholar, firstly gave the definition of the Fuzzy Measure and correspondingly defined the integral of the measurable function concerning the Fuzzy Measure.

Sugeno defined a type of fuzzy integral in the basis of the Fuzzy Measure, which is named as Sugeno Integral. The definition is: Set (X, F, g) is a fuzzy measure space, $f : X \to [0, 1]$ is the measurable function in X, and $A \in F$. Hence the Sugeno Fuzzy Integral of f in A regarding the fuzzy measure g is determined as:

$$\int_A f dg = \sup_{\alpha \in [0,1]} (\alpha \wedge g(A \cap F_\alpha))$$

where α is the threshold value, $F_\alpha = \{x | f(x) \geq \alpha\} (\alpha \in [0, 1])$, A is the domain of definition.

Calculation Steps of the Fuzzy Integral Method:

(1) Determining the fuzzy density
By the way of questionnaire, relevant experts draw the semantic value of the fuzzy density of each measurement indicators according to the semantic variable table of the fuzzy density. Then infer the value of the fuzzy density by

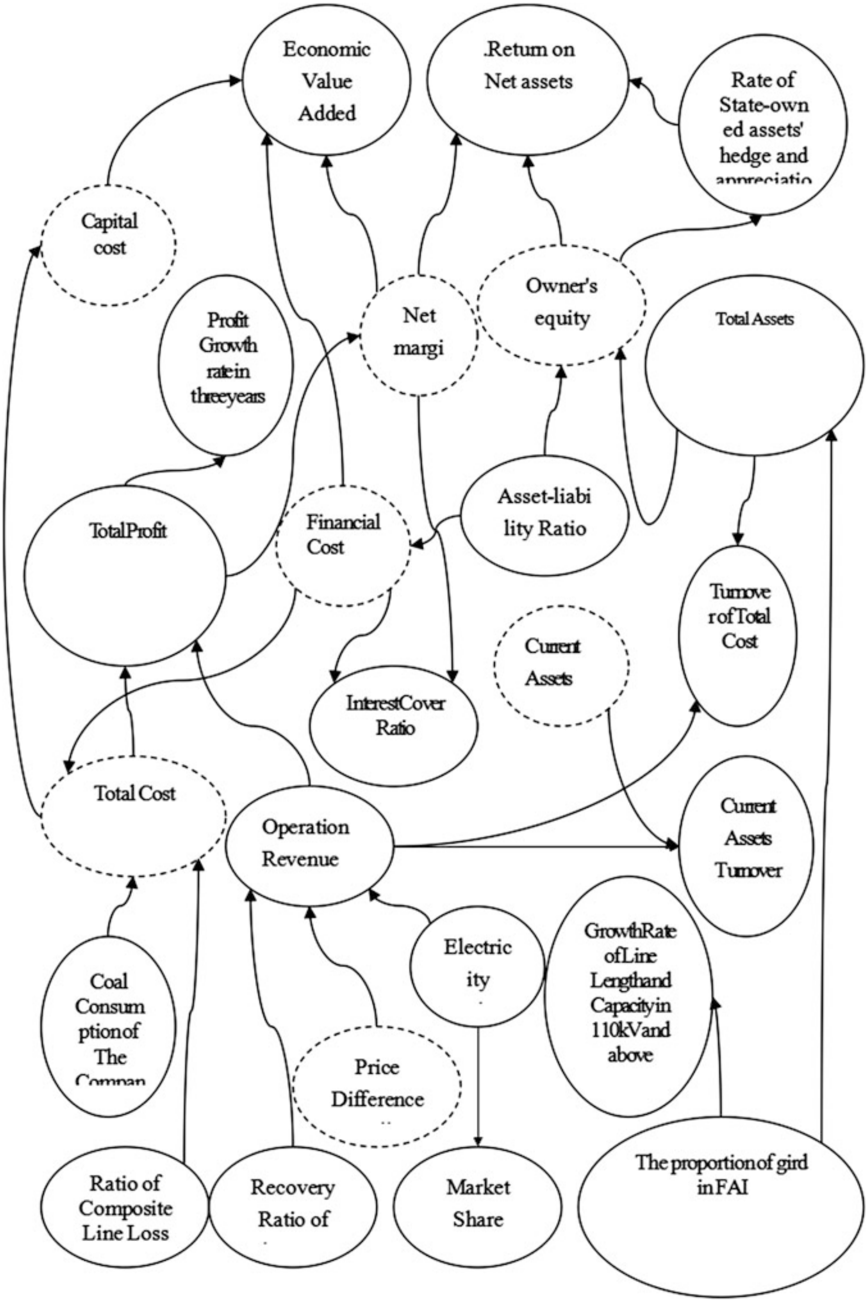

Fig. 1 The relationship among the key financial performance indicators

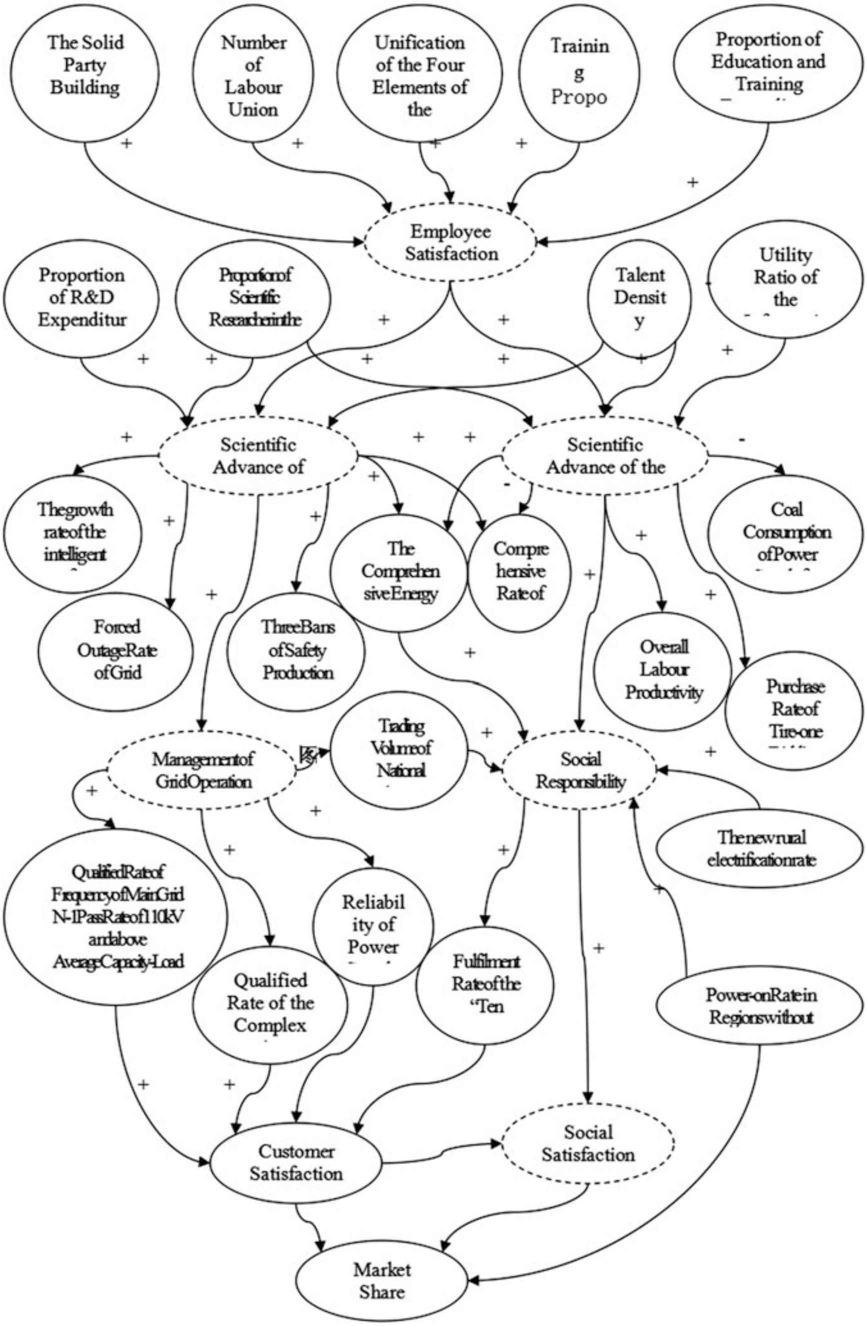

Fig. 2 The relationship among the key nonfinancial performance indicators

Table 1 Strategic performance evaluation indicators system

Evaluation layer	Indicators layer
Firm grid	Grid construction investment (100 million yuan)
	AC Lines in 220 kV and above (per 10,000 km)
	Capacity in 220 kV and above (10,000 kV)
	Maximum peak load in operating region (10,000 kW)
	Grid accidents (times)
	Equipment accidents (times)
	Scientific-technological input (100 million)
Sound assets	Total assets (100 million)
	Asset-liability ratio
	Return on equity (%)
	Main business income
	Total profit (100 million)
	Turnover of total capital (times)
	Rate of return on total assets (%)
High-quality service	Qualified rate of complex voltage in urban area (%)
	Qualified rate of complex voltage in rural area (%)
	Reliability of power supply in urban area (%)
	Reliability of power supply in urban area (%)
	Fulfilment rate of "Ten Commitments of Power Supply" (%)
	Accumulated newly-added power-on clients of "Sending Electricity to Every Household" project
Outstanding performance	Electricity sales of enterprises
	Market share (%)
	Line loss rate (%)
	Transaction in national electricity market (100 kW h)
	Labour productivity of total workers (%)
	Education and training expenditure (100 million yuan)
	Training proportion of total employees (%)

defuzzification calculation. Note that the fuzzy density stands for the frequency of indicators in importance, hence this paper replaces it with weight.

(2) Solving the value of λ (Table 2)
Use the deduced fuzzy density $g = \left\{g\left(x_i^k\right) | \mathrm{k} = 1, \ldots, \mathrm{n};\ \mathrm{i} = 1, \ldots, \mathrm{n_k}\right\}$, to calculate the λ of all indicators.

$$\min\left|1 - \frac{1}{\lambda_k}\left[\prod_{i=1}^{n_k}\left(1 + \lambda_k g\left(x_i^k\right)\right) - 1\right]\right|$$
$$\text{s.t.} -1 < \lambda < \infty$$

Table 2 Degree of consideration and the principle of setting the value of λ

Value of λ	Requirements and objectives of evaluation
Value approaching −1	Laying more consideration on evaluation object who excels in single or more indicators
Less than 0 and approaching 0	Laying more consideration on evaluation object who is good at some aspects and over-rounded in every aspects
Equals to 0	Laying more consideration on evaluation object who performs consistently in each aspect
Bigger than 0 and approaching 0	Relatively laying more consideration on evaluation object who performs consistently in each aspect
Approaching ∞	Strictly punishing evaluation object who has negative indicators

(3) Ordering the value of indicators.
Reorder the indicators of each samples in a descending way, $f\left(x_{i_1}^k\right) \geq \cdots \geq f\left(x_{i_{nk}}^k\right)$.

(4) Calculating the fuzzy measure

$$g_\lambda(\{x_1, \ldots, x_n\}) = \frac{1}{\lambda}\left|\prod_{i=1}^{n}(1+\lambda g(x_i)) - 1\right|$$

(5) Calculating the result of Fuzzy Integral evaluation

$$\begin{aligned} f(x_k) = {} & f\left(x_{i_{nk}}^k\right) g_\lambda\left(\left\{x_{i_1}^k, \ldots, x_{i_{nk}}^k\right\}\right) + \cdots + \left(f\left(x_{i_{nj}}^k\right) - f\left(x_{i_{n(j+1)}}^k\right)\right) g_\lambda\left(\left\{x_{i_1}^k, \ldots, x_{i_{nj}}^k\right\}\right) \\ & + \cdots + \left(f\left(x_{i_{n1}}^k\right) - f\left(x_{i_{n2}}^k\right)\right) g_\lambda\left(x_{i_1}^k\right) \end{aligned}$$

In comparison with other evaluation methods, the Fuzzy Integral method stresses the importance of the indicators and the equilibrium and accumulation of them, which bring about advantage in selecting sustainable and comprehensively developed samples. Also, due to the stress, the Fuzzy Integral Method applies nonlinear Boolean operation mode in indicators, which erases the multi-collinear effect among indicators and lead to the more scientific conclusion.

According to the nature of the Fuzzy Measure, the key of comprehensive evaluation based on the fuzzy integral is the determination of the fuzzy measure. And the value of has become the key factor of the value of the fuzzy measure. Research shows that: ① when the value of is approaching −1, evaluation emphasizes on the size of the value of indicators, which can stand some evaluation object with specific advantages out. Therefore, the aim of rewarding object with excellent indicators and encouraging focus working can be attended; ② when the value of is positive, valuation focus more on the Equilibrium among indicators, which brings out the generally-developed object and discourages the backward objects and motivates the comprehensive development; ③ when the value of is smaller than zero and approaching zero, the evaluation considers both the quantity and equilibrium of indicators, which selects out object who boosts both specialty in some aspects and well-rounded development.

4 Evaluation of the Performance of "the 12th Five-Year Plan" Strategy of State Grid Corporation of China

According to the degree of influence the indicators on the evaluation result, and we determine the weight of indicators and the score of quantitative indicators from the experience and judgment of relevant experts by the way of questionnaires. Thereafter, we sort out the indicators from the questionnaires and infer the weight of all indicators with the Fuzzy Integral Method. Further, according the features of the strategic performance evaluation, we apply ten-point system (0 the minimum, 10 the full mark) and integrate the feedback and opinion of experts with the Fuzzy Integral Evaluation Method. During the inference of the score of indicators, we translate the evaluation value of experts into the semantic variable in the basis of expertise and Trapezoidal Fuzzy Numbers. We then gather the semantic value of each indicator from expertise to build up semantic value set of indicators. Consequently, we determine the value of is -0.1, namely, attach more importance in some outstanding indicators while considering the general and balanced development of all aspects.

After the processing of the evaluation from experts, we calculate the fuzzy density of each indicator and finally deduce the gross score of Evaluation of the performance of "the 12th Five-Year Plan" Strategy of State Grid Corporation of China. The value of the fuzzy density of the four evaluation layer: Sound Assets, High-quality Service and Outstanding Performance and so on are 0.666191, 0.482675, 0.666191, and 0.666191. After normalization the weights are 0.26849, 0.194529, 0.26849, and 0.26849. Scores after evaluation are 0.986888, 1, 0.999966 and 0.9954, which after adjustment are 9.86888, 10, 9.99966, and 9.954. The final score of the Evaluation of the performance of "the 12th Five-Year Plan" Strategy of State Grid Corporation of China.

In general, the evaluation model of the performance the strategy of grid power enterprises in this essay has a firm grounds both in theory and mathematics. The model fulfill the equilibrium and accumulation of the importance of indicators and value of indicators. In addition, it makes a better selecting-out of well-rounded and sustainable samples. With the application of nonlinear Boolean operation mode, the model are able to diminish the multi-collinear effects between indicators and hence draw out a more scientific conclusion.

Study About Bench-Marking Based on Index Properties in Power Enterprises

Haixu Song, Shangdong Yang, Yi Zhu and Menghan Li

Abstract From the perspective of index classification and index properties, this paper studies the index type and evaluation methodology in power enterprises. Taking A company as the study object, the result shows that most indexes belong to normal distribution or skewed distribution, and it is necessary to choose appropriate method based on considering the distribution pattern. The paper provided theoretical support for bench-marking of power enterprises, which could promote the scientificity and systematicness of bench-marking management.

Keywords Bench-marking management · Index properties · Index evaluation · Power enterprises

1 Introduction

Bench-marking management is to compare with first class enterprises both inside and outside of the industry. The company improves its own shortcomings and catch up with the model enterprises by learning the advanced experience of them. So bench-marking is a virtuous cycle to pursuit strong performance constantly. It is

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necessary to evaluate enterprise's overall performance and management level, looking gap with other companies, analyze the causes and make out improvement measures [1].

Study on bench-marking management and evaluation is always the focus of academia. Many scholars analyze and evaluate enterprises' corporate strategy, operational processes and business performance using certain methods, through internal bench-marking, competitive bench-marking, process bench-marking and other forms of evaluation.

Goncharuk (2008) studied the performance bench-marking of oil and gas companies using DEA method [2]. It used domestic and international performance bench-marking to estimate the key factors affecting operating efficiency and performance, and thus reveals the overall reserves and potential growth capacity. Deville (2009) took bench-marking of the bank branches using cost-income ratio and other key financial indicators, to analyze overall operating efficiency and capital efficiency of the bank and provide decision basis for bank financial institutions [3].

Herzog (2009) used bench-marking management and PDCA circulation together to achieve the strategic goal of lowering costs [4]. Xu et al. (2011) established bench-marking evaluation model using entropy TOPSIS, and selected six international oil companies to evaluate the relative merits of domestic oil business groups and make policy recommendations for them [5]. Li et al. (2014) studied the bench-marking index system and management model of rail transport companies [6]. On the whole, researchers have gotten abundant achievements about bench-marking management, but less considering the index properties. Most studies assumed that all indicators are evenly distributed or normal distributed, which may not match the actual distribution of indicators. In view of this, this paper studies the index type and evaluation methodology in power enterprises, from the perspective of index classification and index properties, which not only can provide theoretical support for bench-marking of power enterprises, but also promote scientificity and systematicness of bench-marking management.

2 Theory Analysis on Index Properties and Evaluation

2.1 Index Characters of Power Enterprises

Power enterprises are the important foundation energy industry in the process of economic development, which are capital-intensive and technology-intensive. So the bench-marking index system also has its own character.

(1) The index system covers many aspects. Power enterprises provide power for economic and social development and it is the top priority to ensure electricity safe and stable. So it is necessary to evaluate some physical indexes, such as the safety of power facilities. Power enterprise is a capital-intensive business, which has a lot of equipment and assets. And most power enterprises are

state-owned business, having responsibility for preservation of assets, so it is necessary to evaluate some indexes about assets. As a company, it is the basic mission to create good performance, so it is necessary to evaluate financial index. At the same time, power enterprises provide electricity for economic and social development and service is an enterprise's basic ability. So it is necessary to evaluate some indexes about service.

(2) Most indexes are quantitative index. Bench-marking index contains qualitative index and quantitative index. Qualitative index evaluate object by describing and analyzing, which cannot be directly calculated by the data. Quantitative index can be measured accurately to set out quantified performance goals. Because that qualitative index cannot be measured and assessed as accurately as quantitative index, most indexes are quantitative indexes, laying the foundation for evaluation, assessment and analysis.

(3) The indexes have different properties. From the point of statistical view, the index data is a random variable, being divided into two distribution types: discrete distribution and continuous distribution. Discrete distribution contains 0–1 distribution, binomial distribution, geometric distribution, Poisson distribution and so on. Continuous distribution contains uniform distribution, exponential distribution, normal distribution, skewed distribution and so on. According to the preliminary analysis of bench-marking index in power enterprises, the indexes have different distribution types, which have different characteristics.

2.2 Analysis on Index Properties

By analyzing historical data in power companies and exploring their distribution regularities, we found that the bench-marking data are mainly 0–1 distribution, uniform distribution, normal distribution and skewed distribution.

(1) 0–1 distribution. Set random variable X only can take 0 or 1. The distribution law is $P\{X = k\} = p^k(1-p)^{1-k}, k = 0, 1\ (0 < p < 1)$ and X is the 0–1 distribution with parameter of p.

(2) Uniform distribution. If the continuous random variable X has probability density $f(x)$, X is the uniform distribution in the internal (a, b).

$$f(x) = \begin{cases} 1/(b-a), & a < x < b \\ 0, & other \end{cases}$$

(3) Normal distribution. If the continuous random variable X has probability density $f(x)$, X is the normal distribution with parameter of μ. and σ.

Fig. 1 Uniform distribution

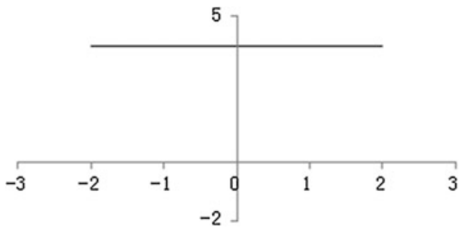
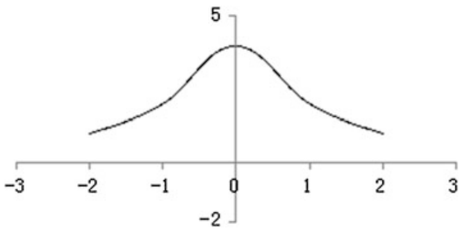


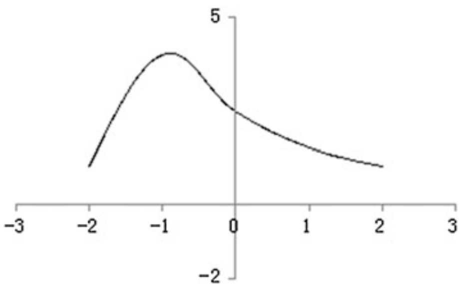
Fig. 2 Normal distribution



$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}}, \quad -\propto < x < \propto$$

(4) Skewed distribution. Under skewed distribution, the frequency distribution is asymmetric and the centralized location tends to one side, which means that peak value is different from mean value. Skewed distribution has two characters. One is that the left and right is asymmetric. The other is that it tends to normal distribution when the sample increases. Skewed distribution can be divided into positive and negative ones according to the peak value and mean value. Skewness is used to describe the degree of deviation. When skewness is positive, most value are less than mean and peak value shifts to the left. When skewness is negative, most value is more than mean and peak value shifts to the right (Figs. 1, 2, 3, 4).

Fig. 3 Right-skewed distribution



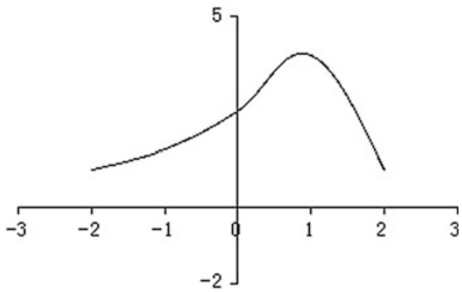


Fig. 4 Left-skewed distribution

2.3 Analysis on Index Evaluation

In the evaluation of bench-marking evaluation, the most common method is sectional evaluation.

(1) 0–1 distribution. 0–1 distribution belongs to discrete distribution, so these indexes can only be divided into two categories. If the index is positive, one belongs to A segment and zero belongs to B segment. If the index is negative, zero belongs to A segment and one belongs to B segment. Companies should maintain or strive to enter the A segment, otherwise the ranking is influenced greatly.

(2) Uniform distribution. In uniform distribution, the probability of every value in (a, b) is equal. These indexes can be divided into five categories by quartiles. If the index is positive, $((4b + a)/5, b)$ belongs to A segment, $((3b + 2a)/5, (4b + a)/5)$ belongs to B segment, $((3a + 2b)/5, (3b + 2a)/5)$ belongs to C segment, $((b + 4a)/5, (3a + 2b)/5)$ belongs to D segment, $(a, (b + 4a)/5)$ belongs to E segment. If the index is negative, $(a, (b + 4a)/5)$ belongs to A segment, $((b + 4a)/5, (3a + 2b)/5)$ belongs to B segment, $((3a + 2b)/5, (3b + 2a)/5)$ belongs to C segment, $((3b + 2a)/5, (4b + a)/5)$ belongs to D segment, $((4b + a)/5, b)$ belongs to E segment.

(3) Normal distribution. In uniform distribution, the probability of every value is unequal, but it is symmetric. So these indexes also can be divided into five categories by quartiles. The four points is $\mu - 1.96\sigma$, $\mu - \sigma$, $\mu + \sigma$, $\mu + 1.96\sigma$. If the index is positive, $(\mu + 1.96\sigma, \propto)$ belongs to A segment, $(\mu + \sigma, \mu + 1.96\sigma)$ belongs to B segment, $(\mu - \sigma, \mu + \sigma)$ belongs to C segment, $(\mu - 1.96\sigma, \mu - \sigma)$ belongs to D segment, $(-\propto, \mu - 1.96\sigma)$ belongs to E segment. If the index is negative, $(-\propto, \mu - 1.96\sigma)$ belongs to A segment, $(\mu - 1.96\sigma, \mu - \sigma)$ belongs to B segment, $(\mu - \sigma, \mu + \sigma)$ belongs to C segment, $(\mu + \sigma, \mu + 1.96\sigma)$ belongs to D segment, $(\mu + 1.96\sigma, \propto)$ belongs to E segment. The probability of A, B, C, D, E are 2.5, 13.37, 68.26, 13.37, 2.5 % respectively. Most data belongs to C segment. If the value in C is close to the critical value of B, the enterprise should strive for the last segment. If the value in C is close to the critical value of D, the enterprise should pay attention to prevent index falling. If the value is in B, the enterprise should measure the

cost-benefit ratio and strive for A. If the value is in D or E, the enterprise should redouble its effort and strive for C at least.

(4) Skewed distribution. In skewed distribution, the probability of every value is unequal and it is dissymmetric. So these indexes will be divided through cluster analysis. Cluster analysis can make the similar data together, which is the basis of sectionalization. The enterprise should enter aggregated region at least and strive for advantage region.

3 Empirical Analysis on Index Properties and Evaluation of Power Enterprises

3.1 Empirical Analysis on Index Properties of Power Enterprises

Based on theory of index properties, the paper tests it using samples of A power company from 2012 to 2014. Considering the smoothness of sample, it filters the data on the rules as follows: (1) Reject samples whose data is missing. (2) Reject samples which have made important adjustment from 2012 to 2014. (3) Reject indexes which were changed from 2012 to 2014. At last, the paper gets 12 key indexes and 25 samples. Taking capacity-load ratio 500 (300) kV as example, test result is in Table 1.

Firstly, the paper does descriptive statistical analysis and tests whether capacity-load ratio 500 (300) kV accords with 0–1 distribution or not The result shows that the minimum is 1.59, the maximum is 2.95, the mean is 1.92, the median is 1.89 and the standard deviation is 0.25. Because that capacity-load ratio 500 (300) kV is continuous not discrete, it doesn't belong to 0–1 distribution.

Secondly, the paper tests whether capacity-load ratio 500 (300) kV accords with uniform distribution or not. Under K-S method of non-parametric test, null hypothesis is that the sample consistent with a uniform distribution. If test value is more than significance level, it retains null hypothesis. If test value is less than significance level, it refuses null hypothesis. The result shows that uniform distribution test value of capacity-load ratio 500 (300) kV is 2.93 and sig. value less than 0.05, so it refuses null hypothesis, i.e. capacity-load ratio 500 (300) kV doesn't accords with uniform distribution.

Thirdly, the paper tests whether capacity-load ratio 500 (300) kV accords with normal distribution or skewed distribution or not. Under K-S method of non-parametric test, null hypothesis is that the sample consistent with a normal distribution. If test value is more than significance level, it retains null hypothesis. If test value is less than significance level, it refuses null hypothesis. The result shows that skewed distribution test value of capacity-load ratio 500 (300) kV is 1.24 and sig. value more than 0.05, so it retains null hypothesis, i.e. capacity-load ratio 500 (300) kV doesn't accords with uniform distribution or skewed distribution.

Table 1 Descriptive statistical analysis and properties test of capacity-load ratio 500 (300) kV in A company

	Descriptive statistics						Uniform distribution test	Normal distribution test	Skewed distribution test	
	Sample number	Min	Max	Mean	Median	Std.	K-S test	K-S test	Skewness	Kurtosis
Capacity-load ratio 500 (300) kV	25	1.59	2.95	1.92	1.89	0.25	2.93(0.000)	1.24(0.091)	3.20	13.58

Table 2 Key index properties of A company

Index	Properties
Capacity-load ratio 500 (300) kV	Skewed distribution
Capacity-load ratio 200 kV	Normal distribution
Capacity-load ratio 110 kV	Skewed distribution
Electric reliability in city power network	Skewed distribution
Voltage eligibility rate in city power network	Skewed distribution
Electric reliability in rural power network	Skewed distribution
Voltage eligibility rate in rural power network	Skewed distribution
Current asset turnover	Normal distribution
Asset-liability ratio	Skewed distribution
Contribution margin growth rate	Skewed distribution
Return on equity	Normal distribution
EBITDA	Normal distribution

At last, the paper tests whether capacity-load ratio 500 (300) kV accords with skewed distribution or not. Under K-S method, if $S_k > 0$, it is positive skewness. If $S_k < 0$, it is negative skewness. If $K_u > 0$, the curve is steep. If $K_u < 0$, the curve is smooth. The result shows that S_k of capacity-load ratio 500 (300) kV is 3.2 and K_u is 13.58, so it accords with skewed distribution and the curve is steep.

Using the similar method, the paper test 12 key indexes in A company, as shown in Table 2. The result shows that capacity-load ratio 500 (300) kV, capacity-load ratio 110 kV, electric reliability in city power network, voltage eligibility rate in city power network, electric reliability in rural power network, voltage eligibility rate in rural power network, asset-liability ratio and contribution margin growth rate are skewed distribution. Capacity-load ratio 200 kV, current asset turnover, return on equity and EBITDA are normal distribution.

3.2 Empirical Analysis on Index Evaluation of Power Enterprises

Based on the index Properties, the paper segment the index. Taking capacity-load ratio 500 (300) kV as example, it is skewed distribution and should take cluster analysis. Classification result is in Table 3. The result shows that the first group has 1 company whose value is 2.95, the second group has 5 companies whose mean value is 2.04 and standard deviation is 0.057, the third group has 11 companies whose mean value is 1.9 and standard deviation is 0.031, the forth group has 7 companies whose mean value is 1.77 and standard deviation is 0.046, the fifth group has 1 companies whose value is 1.59.

If we don't take cluster analysis and hypothesis that capacity-load ratio 500 (300) kV is normal distribution directly. Then the first group has 1 company, the

Table 3 Cluster analysis of capacity-load ratio 500 (300) kV in A company

	The first group	The second group	The third group	The fourth group	The fifth group
Number	1	5	11	7	1
Mean	2.95	2.04	1.9	1.77	1.59
S.D.	–	0.057	0.031	0.046	–

second group has 4 companies whose standard deviation is 0.058, the third group has 11 companies whose standard deviation is 0.04, the forth group has 7 companies whose standard deviation is 0.046, the fifth group has 1 companies.

By comparison we find that the standard deviation under skewed distribution is less than the one under normal distribution directly in every group. So index evaluation based on properties is more accurate.

4 Empirical Analysis on Index Properties and Evaluation of Power Enterprises

From the perspective of index classification and index properties, this paper studies the index type and evaluation methodology in power enterprises. Taking A company as the study object, the result shows that most indexes belong to normal distribution or skewed distribution, and it is necessary to choose appropriate method based on considering the distribution pattern. The paper provided theoretical support for bench-marking of power enterprises, which could promote the scientificity and systematicness of bench-marking management.

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SOEs' Investment and China's New Characteristics of Business Cycle—Analysis with DSGE Model

Junming Tu

Abstract This paper constructs a theoretical causal link between investment expansions from SOEs in 2008 with the new characteristics of business cycle after 2008 with the DSGE model. The author finds that SOEs' investment against cycle will moderate the whole economy. At the same time, it will also lead to high inflation, crowd out private economy and reduce the aggregate consumption.

Keywords SOE investment against cycle · Business cycle

1 Question About Investment from SOEs and China's New Characteristics of Business Cycle

In the year of 2008, facing large-scale reduction in external demand and the economic crisis spread, China's central government launched the "Four Trillion" investment promotion plan, which were mainly implemented by state-owned enterprises (SOEs). The plan rapidly filled the demand gap left by the decline in exports, reversed the decline of aggregate demand caused by the economic recession, and maintained a stable economic growth. At the same time, we observed other phenomena, including high inflation, state economy crowding out private economy and consumption downturn.

Whether the investment promotion from SOEs has a causal link with the new characteristics of business cycle after 2008? What's the specific mechanism between them? This paper attempts to answer the question above in a dynamic stochastic general equilibrium framework, to supplement the existing research.

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2 Literature Review

Gong and Lin [1] found out that investment stimulus in the early nineties caused deflation from 1998 to 2002. From their points, overinvestment in production capacity firstly created excess demand and accelerated inflation, and after the completion of production capacity, excess capacity then resulted in deflation. Zheng and Zhang [2] found out that there was no causal link between investment stimulus plan in 1998 and economic recovery in 1999, because of government's small effects of automatic stabilizers and discretionary policy. Wang and Lu [3] found out that from perspective of spending structure "Four Trillion" investment promotion plan was short of considerations of China's core force of economic growth in the long term. Li [4] believed that China's fiscal decentralization and the new system of SOEs are the key reasons for the success of the "Four Trillion" investment promotion plan. The new system of SOEs provides a convenient channel for implementation of the economic stimulus plan. Wei [5] used the counterfactual research method and found that the effects of "Four Trillion" investment promotion plan could last for only one year. Huang and Ma [6] used the CGE model and found that "Four Trillion" investment promotion plan increased GDP by 1.42 % and increased employment by 3.44 % every year, but at the same time it crowded out a large number of private consumption, resulting in a serious decline of residents' welfare.

Existing literature mostly focused on empirical assessments of "Four Trillion" investment promotion plan and lack a systematic theoretical research framework, while few studies have concerned the mechanism of SOEs' investment against the business cycle. This paper attempts to provide a new framework with dynamic stochastic general equilibrium model to analyze the impact of investment promotion from SOEs and constructed a causal link between investment promotion from SOEs and the new characteristics of business cycle after 2008.

3 Model

The whole economy is divided into two sectors, non-SOEs and SOEs. The goal of non-SOEs is to maximize the welfare of non-SOEs' residents. The goal of SOEs is the combination of minimization of economic intervention and minimization of total output fluctuation. Specific model is as follows.

Non-SOEs:

$$\underset{C_{1t},I_{1t}}{\text{Max}} \sum_{t=0}^{\infty} \beta^t \log C_{1t} \tag{1}$$

$$s.t. Y_{1t} = C_{1t} + [1 + (\log P_t - \log \overline{P})] I_{1t} \tag{2}$$

$$Y_{1t} = A_t K_{1t-1}^{\alpha} \tag{3}$$

$$K_{1t} = (1-\delta)K_{1t-1} + I_{1t} \tag{4}$$

SOEs:

$$\underset{I_{2t}}{\text{Min}}(\log I_{2t} - \log \overline{I_2})^2 + \lambda\left[\log(Y_{1t} + Y_{2t}) - \log(\overline{Y_1} + \overline{Y_2})\right]^2 \tag{5}$$

$$s.t. Y_{2t} = A_t U(I_{2t}) K_{2t-1}^{\alpha} \tag{6}$$

$$U(I_{2t}) = 1 + b\left(\log I_{2t} - \log \overline{I_2}\right) \tag{7}$$

$$K_{2t} = (1-\delta)K_{2t-1} + I_{2t} \tag{8}$$

$$C_{2t} = Y_{2t} - \left[1 + (\log P_t - \log \overline{P})\right] I_{2t} - \sigma\left(\log I_{2t} - \log \overline{I_2}\right)^2 I_{2t} \tag{9}$$

$$C_{2t} > 0 \tag{10}$$

Sums:

$$Y_t = Y_{1t} + Y_{2t} \tag{11}$$

$$C_t = C_{1t} + C_{2t} \tag{12}$$

$$I_t = I_{1t} + I_{2t} \tag{13}$$

$$\log P_t = d\left(\log I_t - \log \overline{I}\right) + e \log P_{t-1} \tag{14}$$

Shocks:

$$\ln A_t = \rho \ln A_{t-1} + \varepsilon_t \tag{15}$$

$$\varepsilon_t \sim N(0, \sigma_{\varepsilon}^2) \tag{16}$$

C_{it}, I_{it}, Y_{it} and K_{it-1} represent consumption, investment, output and capital stock of sector i in time t; P_t represents relative investment price (consumption price equal to one) at time t; A_t and ε_t represent technology level and shock at time t; U represents capital utilization of SOEs; $\overline{X}$ represents X at steady state.

4 Calibration, Algorithm and Impulse Response Experiment

4.1 Calibration

The parameters we need to calibrate are α, β, δ, b, λ, σ, d, e, ρ, σ_ε and $\overline{I_2}/\overline{I}$. α, β, δ, ρ and σ_ε are calibrated according to Tu [7]; d and e are derived from regression investment price on aggregate investment fluctuation and investment price in the previous time; $\overline{I_2}/\overline{I}$ is valued at 0.5 according to the calculation of statistics in 2013. b, λ and σ are valued at 0.5, 100 and 10 according to common practice (Table 1).

4.2 Algorithm

Dynamic system deduced from the model above consists of 17 equations, including first-order conditions and constraints. In this dynamic system, there is only one dynamic path satisfying transversality condition and that is solution we need. Specifically dynamic path can be represented by transfer equations and policy equations.

At a reasonable set of parameters, we can use second order perturbation method [8] to get transfer equations and policy equations to the dynamic system. We use software of DYNARE to solve the model and do the impulse response experiment.

Table 1 Result of calibration

Variable	α	β	δ	ρ	σ_ε	d	e	b	λ	σ	$\overline{I_2}/\overline{I}$
Value	0.5	0.931	0.108	0.842	0.019	0.218	0.843	0.5	100	10	0.5

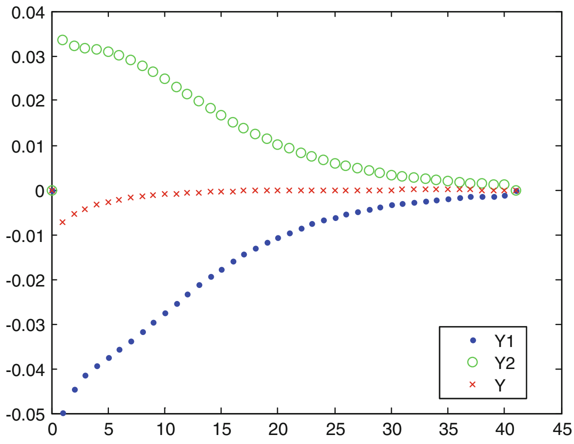

Fig. 1 Impulse response of output

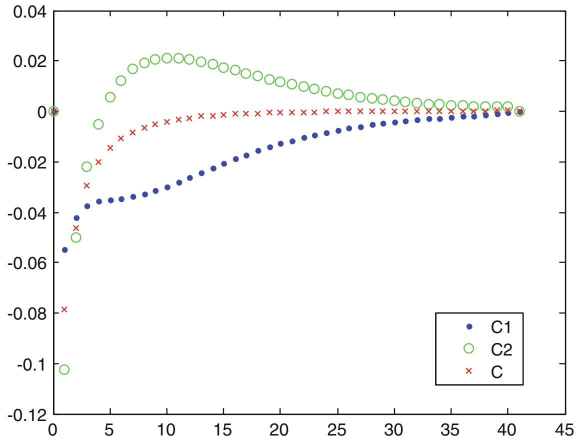

Fig. 2 Impulse response of consumption

4.3 *Impulse Response Experiment*

The author uses 5 % disposable negative shock of technology as an impact source, so that the entire economy is in the "economic crisis" state. Results are shown in Figs. 1, 2, 3, 4, 5 and 6.

When the economic crisis appears, the output, consumption and investment of non-SOEs are declining to different extents. Specifically the output and investment of non-SOEs decline at 5 and 7.92 % respectively. On the contrary, the output and investment of SOEs are increasing substantially, which increase at 3.37 and 17.46 % respectively, while consumption of SOEs appears a significant decrease of 10.26 % due to crowding out by investment and losses induced by administration system. So we see the phenomenon of "a stable economic growth" and "state economy crowding out private economy".

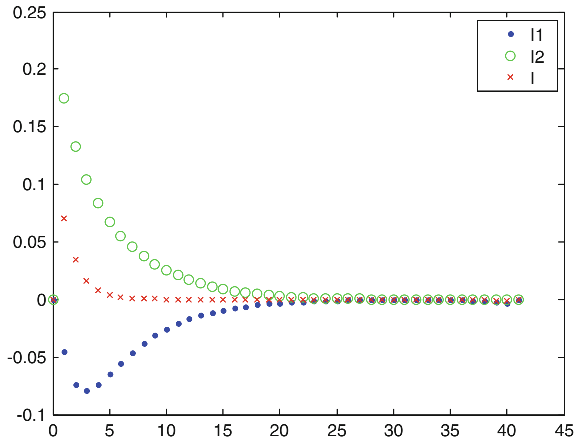

Fig. 3 Impulse response of investment

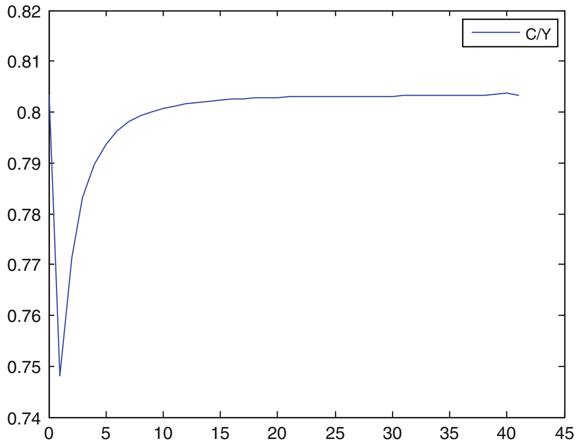

Fig. 4 Impulse response of consumption output ratio

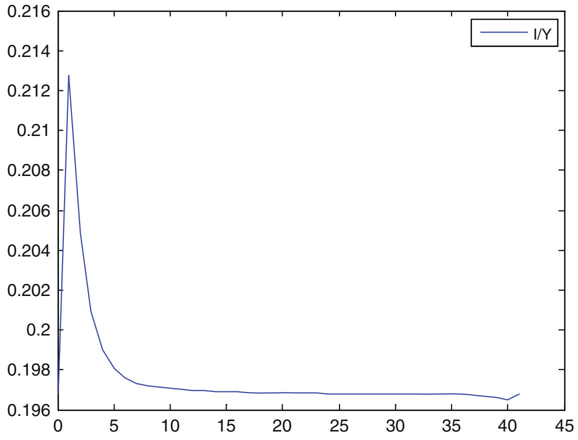

Fig. 5 Impulse response of investment output ratio

From the view of aggregate volume, the increase of the output of SOEs offsets most of the decrease of non-SOEs, and the total output decreases at only 0.73 %. The increase of investment of SOEs offsets the decrease of non-SOEs, and the total investment increases at 7.06 %. The decrease of consumption of SOEs aggravates the decrease in total consumption and total consumption decreases at 7.85 %. The increase of total investment demand raises the investment prices at 2.09 %. So we see the phenomenon of "consumption downturn" and "high inflation".

In the short time, the influence of SOEs' investment against the business cycle eases the state of "economic crisis" and overcomes the downward trend of the economy. However, it will also bring large price fluctuations, investment failure, efficiency decline and so on, which will lead to a dangerous hazard to the economy in the long term.

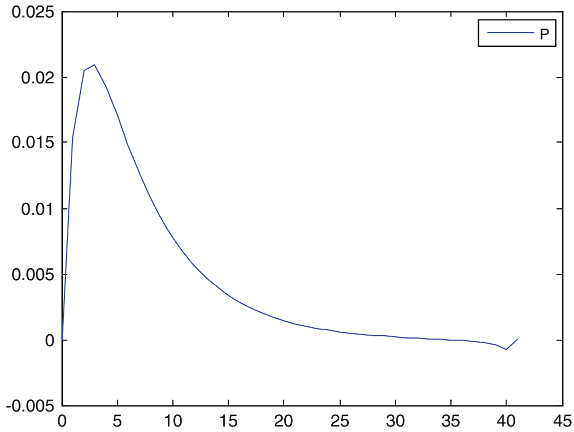

Fig. 6 Impulse response of investment price

5 Summary

In this paper, a new framework is constructed to make a causal link between SOEs' investment against the business cycle and new characteristics of China's economy after the year of 2008. With the help of response of impulse experiment, we verify that SOEs' investment against the business cycle is the main reason for China's economy after the year of 2008. At the same time we find that too much emphasis on SOEs investment will bring the economy a huge risk of uncertainty.

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The Engineering Stakeholders' Contradiction Analysis of Multinational Oil and Gas Pipeline from the Perspective of Transaction Cost

Yong Wang, Hongming Qi, Zhiguang Liu and Zipu Liu

Abstract With more and more participation of Chinese enterprises in multinational pipeline project construction, the contradictions of stakeholders are also gradually prominent. This thesis analyzes the contradictions of stakeholders from the perspective of transaction cost, regarding asset specificity, uncertainty of transaction, frequency of transaction and information asymmetry as the determinants. Based on the bounded rationality and opportunism, it also puts forward the countermeasures of establishment of a powerful organization, coordination and command system, which is oriented in the project management contract, and establishment of independent and standardized procurement and contract management system.

Keywords Multinational oil and gas pipeline · Stakeholder · Transaction cost · Asset specificity

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1 Introduction

With the development of industrialization and energy structure optimization, while making a further exploitation of the civil oil and gas, China actively propels the diversification of import trade of oil and gas and has reached many agreements on establishing multinational oil and gas pipeline with neighboring countries. As the first multinational oil pipeline in China, the Sino-Kazakhstan pipeline project is an significant measure to adjust energy strategy, as well as a critical project concerned by both Kazakh and China. The Central Asia-China gas pipeline is a significant milestone for China to participate in the international energy cooperation, which is the longest in the world and the first multinational long-distance and overland import strategy gas pipeline in China.

Based on the theory of stakeholders, it is to make a deep analysis on the contradictions including asset specificity, uncertainty in transaction, transaction frequency and so on, as well as the relative countermeasures form the perspective of transaction cost. So far, it is seldom to make an inquiry into the contradictions of stakeholders from the perspective of transaction cost, especially from the perspective of multinational pipeline project. Consequently, employing the theory of transaction cost is significant to broaden the viewpoint and path, as well as to provide a reference for practice on the basis of analysis of the causes of contradiction.

2 Complexity of Stakeholders in Multinational Pipeline Engineering Project

The concept of stakeholders was first mentioned by the American Stanford Research Center in 1963, which was defined as: without their support, organizations no longer exist. In following, the theory of stakeholders has wildly been popular in the fields containing cooperation organizational program, strategic management and so on, and has made a great progress in concept and classification.

The stakeholders refer to the individuals or the group which can have certain special investments and can take certain risks, the activity of whom can influence the achievement of firm targets. When stakeholders participate in corporate governance, they put an emphasis on not only the stockholders' equity, but also the superintendence to managers by other stakeholders; and not only the authority of managers, but also the actual participation of other stakeholders.

In the process of the construction and production operation of the multinational pipeline engineering project, the stakeholders can include investors, construction units, supervising units, bilateral or multilateral governments, stockholders in both companies, manager representatives, contractors, material providers, credit institutions, employees and so on. Compared with the domestic project, the multinational pipeline project is mainly involved with the entities including bilateral (or multilateral) governments, construction units, supervising units coming from different countries, where there is an diversification in laws, traditions in project, culture, the style of cooperative management operation. Since there is a gap in recognizing and dealing with issues between them, it is prone to divergence and contradiction. In the paper, it mainly takes the multinational particularity into consideration, neglecting the contradictions of general domestic stakeholders, so the stakeholders in the multinational pipeline engineering project refers to governments, investors, construction units, supervising units, contractors, credit institutions, employees in different countries.

Take the Central Asia-China gas pipeline as an example, which concerns four countries including Turkmenistan, Uzbekistan, Kazakhstan and China. The Central Asia is in a geo-politics and plays a crucial role in the world energy situation accompanying fierce competition in the acquisition of gas and oil among big energy-consuming countries. The central Asia countries are in a tense relationship such as outstanding national contradictions and less communications. The difference of history and culture in each country leads to the diversity in the pattern to deal with their business problems, which is easier to trigger controversy. It is too difficult to reach a complex and changeable agreement or establish a joint for the existence of long historical grievances and current benefit contradictions among the central Asia countries. At the meanwhile, resulting from the lower openness in the Central Asia, the local project cooperates seldom participate in the international large scale projects so as to the states of weak consciousness of international cooperation, backward management philosophy, partial understanding of international standard of construction, and lagged far away from reaching the requirements in construction ability and equipment furnishment. Simultaneously, the difficulties also consist in the followings: lack of local talents and scarcity of supply of labor, no uniform legal status on account of the diversification resulting from the ambiguous legal status of joint venture subject, no mature pattern to use. The results are inefficient countermeasures and great difficulties in negotiation so that Chinese stockholders' revolution delays. Every country strives for more engineering quantity and benefits. For the difference of cultural backgrounds, it is too difficult to fuse in operating cooperation. Additionally, the diversifications in the employees' thinking mode accompanying different cultural background, values, customs and benefits lead to the inefficient countermeasures, which will influence the daily operation of firms.

3 Causes of Transaction Cost

Ronald Coase defines transaction cost as the cost expended in measurement, definition and guarantee of rights, in discovering the transaction object and transaction price, in bargaining and making contract, and in supervising the strict performance of contract terms. Williamson argues that the existence of transaction cost lies in limited rationality, opportunism and assets specificity. Perceived at a profound level, the transaction cost is closely relevant to the human nature. Generally, trust can reduce transaction cost in the aspects of concluding, implementing and supervising contract, as well as in formal bargaining.

Assets specificity refers to the situation that certain investment, once forming some kind of special use, is difficult to change itself. It will cause an economic loss while changing to other uses, that is, the assets cannot be used in another deal without the loss in the assets' efficiency or increase in the assets' cost expended in a new deal. In the contractual relationship with assets specificity arrangement, there exists an occupying specificity quasi rent and an ex post opportunism behavior, which is called "holdup" in transaction cost economics.

Transaction uncertainty includes two aspects: on the one aspect, both sides cannot accurately predict the possible events, on the other aspect, the uncertainty caused by asymmetric information of both sides. The higher dependence on the other side, the more disadvantage in transaction, consequently, the higher risk by the uncertainty.

The more frequency of transaction, the more cost in establishing and operating transaction can be compensated. Consequently, multiple transactions are better than one-off ones, and transaction frequency plays an important role in the choice of the ways of transaction coordination. The transaction of both sides is so frequent as to construct a special governance structure for it since the latter cost can by shared in many transactions.

An important cause of transaction cost lies in information asymmetry for it is to pay the cost in obtaining information related to the contract. Sometimes the cost is quite high. For the existence of information asymmetry, the trader who is apt to opportunism will avoid risks to the greatest extent by using it, and transfer the transaction cost to the other party.

4 Analysis on the Mechanism of the Contradiction Cause of Stakeholders

4.1 Asset Specificity Generates the Contradictions of Stakeholders

Multinational pipeline engineering project has a great influence on alleviating the energy pressure of oil and gas import and improving the foreign exchange income of the oil and gas exporters. Therefore, in addition to the both companies to participate in it, the government has also been involved. In the multinational pipeline project, pipeline and other fixed assets have a strong specificity, the investment in which is the non-recoverable sunk cost. So the construction units upfront invest certain capital and human and construct, once the national policy, situation, local contractor performance and so on are in trouble in the transit countries (or resources countries), the assets invested will become specificity asset and held up. Since both parties are in different countries, the communication will cause higher transaction cost than in the domestic. Additionally, the policies of the examination and approval department in foreign governments is greatly different from the domestic, and the national interests demand in the international pipeline is not consistent either, especially in the case of international oil and gas price fluctuations, the benefits compared with signing the original contract will undergo great changes. Some foreign company and governments will generate new interests conflicts, which causes fierce contradictions.

4.2 Uncertainty of Transaction Generates the Contradictions of Stakeholders

Since multinational pipeline projects involve many stakeholders, governments and enterprises in different countries, they are generally larger, time and fund -consuming and facing complex location and environment, which increases a lot of uncertainty and causes great difficulties in biding, contract negotiation and dispute handling. When the negative factors appear, various stakeholders easily seek to amend the contract. Because of different national systems, government's targets, company's payment habits, it is not as easy to resolve these contradictions as domestic. If the implementation process or completion of project fails to meet the requirement of investors, because different stakeholders have different nationalities, but supervision enterprises and contractors, especially sub-contractors are enterprises of country which the project is located in, construction methods and standards are not uniform, so there will be contradictions between stakeholders who try to protect their own interests. And because the contradictions would appear in the future, it is difficult for stakeholders to adjust in advance.

4.3 Frequency of Transaction Generates the Contradictions of Stakeholders

Multinational pipeline project is generally larger, time and fund-consuming, but they are not necessarily multiple transactions. If one party thinks a project is just a one-time deal, opportunistic behaviors are likely to be present. Especially when multinational pipeline project involves some socially and politically unstable countries and areas with poor social security, many contradictions between stakeholders will appear. There may be long-term cooperation between the investors and construction companies and the general contractors, but there are one-off deals between the sub-contractors and construction workers and local governments, so it is not easy to align the interests of all parties. Multinational pipeline project is not only a collaboration of technology, capital and management, but also the integration of different cultures. Different languages increase the difficulty of the project implementation. The mismanagement of employees with different cultural backgrounds will lead to improper construction, lower efficiency and higher transaction costs, thereby adversely affects the operation of the project and causes the stakeholders' contradictions of interests.

4.4 Information Asymmetry Generates the Contradictions of Stakeholders

Information asymmetry is common and prominent problem in multinational pipeline project. There is a lot of hidden information between stakeholders. Different parties have different views on the same question, so it is difficult for them to reach a tacit understanding. Some stakeholders also deliberately conceal some information, for other parties, it costs higher to collect more information. To familiar with various preferences, habits, credit, stakeholders would pay very high transaction costs, which leads to contradictions between them inevitably.

In the bidding of Central Asian gas pipeline project, local contractors took on the design and construction of all or most of the pipeline project with their special political background and domestic monopoly positions, bidding a price with large deviation. But in fact, the local contractors are lack of experience in the design and construction of large diameter high pressure natural gas pipeline. Moreover, their construction capacity is very limited and technical level is relatively backward, which seriously affects the quality and progress of the project.

4.5 Bounded Rationality and Opportunism Generate the Contradictions of Stakeholders

In order to understand how to reduce the contradictions between the stakeholders of the multinational pipeline project from the perspective of reducing transaction cost, we firstly explore the main causes of transaction cost based on the transaction costs mechanisms. The existence of bounded rationality and opportunism tendency of people are the main causes of transaction costs.

Because of the complexity and uncertainty of bounded rationality and the external environment, people neither in advance to cover all the information in the contract terms, nor predict various contingencies that may arise in the future, and unable to draft the appropriate countermeasures in the contract for a variety of contingencies and determinate the results of the contract afterwards. So there must be contradictions between stakeholders which can only be reduced but not completely avoided.

Opportunism means using improper means to maximize one's own interest, so it can be said that opportunism behavior is an expression of maximizing one's own interest. Due to the incompleteness of the contract, that is to say, because there are some loopholes in the signed contract, the related parties will show opportunistic behavior. Opportunism is the use of limited rationality. Opportunism behavior means one party suppresses the other in order to obtain greater interest taking advantage of limited rationality and the contract loopholes.

5 Countermeasures of Reducing Stakeholders' Contradictions of Multinational Pipeline Project

5.1 Establish Incentive-Compatibility Mechanism and Inhibit Opportunism

All parties in a multinational pipeline project need to establish a good system to avoid transaction costs and inhibit opportunism. To establish compatible incentive mechanism, stakeholders should share the sunk costs generated by asset specificity, and be linked with long-term interests. The benefit-sharing agreements should be signed by professionals on behalf of the related parties to reduce uncertainty. Try to find organizations with long-term relationship as stakeholders, or to seek to cooperate with the well-known companies. If the contradictions with foreign government appear, try to ask for the help of domestic government. Collect enough information ahead and find a professional consulting company to do business research work, because the cycle of multinational pipeline project is longer, so the preliminary investigation must be careful and deeper, which can reduce the transaction costs generated by information asymmetry.

5.2 Establish a Powerful Coordination and Command System Taking Project Management Contract as Core

Management of multinational pipeline projects should introduce internationally accepted model, namely the joint management of owner's project department (group), project management contractor (consulting firms) and independent third-party inspection contractor. Owner's project department (group) consists of many company departments (or the relevant professional and managerial staff) and manages the whole process of the project. Project management contractor (consulting firms) on the one hand provides technical support to the project owners, on the other hand is responsible for the management of project contractor. The independent third-party inspection contractor is responsible for on-site and mill supervision.

Build an independent and specific system of procurement and contract management. Strengthen the management and standardize the execution of contracts. Review, monitor and control the legality, authenticity, rigor and feasibility of the contract and timely detect problems, reduce the risk of contract claim, and ultimately maximize the company's interest from the project while balance the various stakeholders' interests. Technical standards are the fundamental basis for the design of the pipeline project, so company should be familiar with local technical standards. Most countries tend to use their own traditional practices and customs, so the standard specifications which the multinational project design is based on lies differences. Therefore, the related parties should fully understand the relevant national standards and practices and unified the standards and specifications as possible, which can eliminate differences for the design of the project.

5.3 Establish Multinational Coordination Mechanism

Establish Chinese enterprise's dominant position and the Chinese enterprise aligns the interests of all parties. Break the dogma and the routines and establish new rules for international cooperation. Chinese enterprise should break through the constraints of foreign law. To avoid prevarication and low efficiency, the related parties should establish multi-country coordination mechanisms and centrally manages the disputes.

Because of inconsistent interests of all parties, Chinese enterprise should analyze foreign parties' demands and align Chinese and foreign interests. All parties are jointly responsible for functions and balanced power would guarantee the interests of all parties. Every major decision should strictly follow the decision-making procedures and meeting minutes binding on all parties should be formed. Plan in advance and determinate the status of the joint venture in the inter-governmental and inter-company agreements. Actively negotiate with foreign companies the management structure and job quotas and deploy more people on behalf of Chinese enterprise in key positions.

Set up negotiation team and deploy elite forces to form negotiation preparatory group with appropriate scale, reasonable structure, high quality and efficiency. Negotiation team should have a deep understanding of national characteristics, ways of thinking and culture of other stakeholders. The negotiation style should compliance with the local ethnic tradition. With the diplomatic power and influence of the group company, Chinese enterprise should build negotiating power through inter-governmental and inter-company agreements and prompt the foreign parties to accelerate the pace of the negotiation.

6 Conclusion

Multinational pipeline project is an important component part of international project and participation in these projects is an important way for Chinese enterprises to strengthen self-construction. Due to the different interests, religious and cultural backgrounds, there are contradictions between various stakeholders in international projects. This thesis analyzes these contradictions from the perspective of transaction costs, regarding asset specificity, uncertainty of transaction, frequency of transaction and information asymmetry as the determinants. When the degree of asset specificity is low, regardless of uncertainty or transaction frequency, the related parties to the transaction will sign the classical contract. When the degree of asset specificity and uncertainty is higher but not the highest, the related parties will sign different relational contracts. When the degree of asset specificity and uncertainty is very high, the related parties generally sign the relational contract. Furthermore, bounded rationality, opportunism and asymmetric information will affect the interests of stakeholders to some extent. Due to their own bounded rationality and incomplete information and positions in the transaction, stakeholders as transaction participants have different advantages and opportunistic behaviors further exacerbate the contradictions between them. According to the causes of contradictions, this thesis proposes that the related parties should establish a powerful coordination and command system which is oriented in the project management contract, build an independent and standardized system of procurement and contract management, be familiar with the local technical standards. These countermeasures can be implemented in the future pipeline projects.

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