Building a Dynamic Manpower Planning Model: Focused on the Information Security Manpower Policy of Korea

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Abstract

The ability to forecast manpower requirements is crucial for an industry. On the demand side, companies rely on these forecasts to formulate their manpower planning strategies, while, on the supply side, they provide job seekers with a basis to assess the attractiveness of a given sector. Forecasts of supply and demand for manpower also make an important contribution to the governmental policy-making process by serving as pointers, to avoid redundant investments and achieve efficient and balanced growth for an industry. Meanwhile, forecasts based on an inaccurate market analysis can be a cause for imbalances such as undersupply or oversupply of labor. Static and unilateral analyses are the most common culprits for erroneous predictions of supply and demand for manpower.

In this paper, we elaborate a model of manpower supply and demand for the information security industry, one of today's fastest-growing sectors, using the system dynamics method. Using this model, we will predict how the labor supply in Korea's information security industry will evolve in the coming years, determine causes for any demand/supply imbalances and propose solutions to resolve these imbalances from a dynamic perspective.

Keywords: Manpower Policy, Information Security, Ubiquitous Computing, System Dynamics

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Ⅰ. Introduction

The ability to predict manpower needs is crucial for an industry. On the demand side, companies formulate manpower planning strategies based on these forecasts, while, on the supply side, they provide job seekers with a basis to assess the attractiveness of a given sector. Manpower forecasts are also important for assisting the government in the policy-making process by serving as pointers to help avoid redundant investments and achieve efficient and balanced growth for an industry. Meanwhile, forecasts based on an inaccurate market analysis can cause imbalances such as undersupply or oversupply of manpower. Forecasting errors most often stem from a superficial and partial analysis of a market, which overlook its structural characteristics, or one that is narrowly focused on the present, or a given industry, without taking into consideration dynamic changes that may occur over time or delayed feedback effects, or linkages the market may have with other related industries. Static and unilateral analysis, in sum, is the most common culprit for erroneous predictions of supply and demand for manpower. These approaches can yield particularly severely flawed forecasts with cutting-edge industries and emerging industries which, while entertaining complex relationships of interdependence with other industries and experiencing rapidly-growing manpower demand, are characterized by a longer period required developing needed human resources.

Assumptions about the future demand and the performance are essential for decision making for a given industry. For example, how much to produce; how much capacity and other resources to acquire; what products to develop; and how much financing will be needed by the business, etc. Sometimes decision makers tend to make the naive forecast, assuming that the future will be like the past or the past trend (Lyneis, 2000). Meanwhile, in other cases, efforts are made to estimate future demand and supply, using statistical techniques or mathematical models. However, the existing methodologies, due to their fundamental limitations, fall short of enabling dynamic structural analysis or identification of delayed feedback effects. Actions undertaken based on inaccurate demand forecasts can occasionally produce results that are opposite to the intended ones. Underestimates of demand can lead to self-fulfilling prophecies as feedbacks, often through product or service availability, drive sales to equal the capacity provided to meet the forecast (Lyneis 1980). Also, decisions taken due to overestimates of demand can lead to over-capacity and financial difficulties. These instances are easily found from the electric utility industry in the 1970s, the petroleum industry in the 1980s, and the personal computer industry in the late 1980s (Barnett 1988). In the meantime, agriculture is perennially affected by this type of imbalance with only the crops hit by the problem changing from year to year.

As a result of forecast inaccuracies and potential misuses in decisions many system dynamics practitioners desire to shift managerial emphasis away from forecasting and towards understanding and policy design. Sterman (2001) contends that the purpose of modeling is not to anticipate and react to problems in the environment but to eliminate the problems by changing the underlying structure of the system.

With beliefs aforementioned, through the elaboration of a causal model and a simulation model based on the system thinking (Senge, 1989; 1990; Anderson et al., 1997) and system dynamics (Forrester 1961; Richardson and Pugh 1981; Goodman 1989; Sterman 2000) methodology, we will attempt to determine causes behind the phenomenon of supply-demand imbalances in manpower in the information security (IS) industry for which both a dramatic increase in manpower demand and a supply-demand gap are anticipated, and we shall propose solutions to correct the problem.

Ⅱ. Theoretical Perspective

1. Review of Existing Methodologies

The goal of manpower planning is to make future demand and supply in the workforce coincide optimally. Manpower planning takes into account various environmental factors of an industry (Lederer, 1987). To achieve this goal, the planning must simultaneously consider demand and supply.

For prediction of workforce demand, there are many models including regression analysis models and Delphi techniques which base the assessment on the future volume of work, size of sales or other economic indicators (Bechet et al., 1987; Milkovich et al., 1972; Gatewood et al., 1983). For the appropriate size of manpower supply, there are optimization models which consider the business strategy of the organization, changes in the industry's environment and the resulting manpower management goals (Kahalas et al., 1974; Price, 1977; Welling, 1977). What is critically needed in manpower planning to be able to meet the future demand in a given industry in spite of conflicting and mutually contradictory social, economic and organizational goals and under various restrictions, is the capability to view the workforce needed and supplied from multiple perspectives and over the entire process, from inflow to stock and outflow.

Markov Analysis (MA) is a powerful analysis technique which, used in manpower planning, can help it successfully achieve its goal. Developed in the early 1960s, it has been in use ever since. Markov chains make it possible to predict the size of manpower per category (per state) as well as transitions occurring within a given time period in the future (resignation, dismissal, retirement, death, etc.). A Markov chain, in this case, corresponds to a succession of events, each of whose probability of occurrence is affected by an event immediately preceding it. Such a chain may be considered to have a memory, in other words, the memory of the last event, and this memory determines the probabilities of future events. More importantly yet, with a Markov chain, one can obtain long-term average probabilities or equilibrium probabilities. Published examples of applications of MA to manpower planning are chiefly from the army, government and public institutions (Kalamatianou et al., 1987; Stewman, 1978; Trivedi et al., 1987; Zanakis et al., 1980). Although the statistical validity of Markov chains has been consistently verified over 30 years, their level of adoption in corporate organization-related fields is rather low. This is mainly due to the fact that in MA, Markov transition proabibilities are assumed to be constant. Hence, the need to modify transtition probabilities has been continuously pointed out, for instance by changing them into variable transition coefficients or controlled decision-making variables of some sort.

Meanwhile, many prior studies on the prediction of manpower demand resort to the macroeconomic model used by the US Bureau of Labor Statistics (BLS). This method, consisting of estimating labor demand within a macroeconomic model that describes the overall economy, is popularly adopted in labor forecast-related reports and research papers. For more than 35 years, the Bureau of Labor Statistics has developed medium- to long-term (10 years ahead) projections of likely employment patterns in the U.S. economy. Since the early 1970s, projections have been prepared on a 2-year cycle. The projections cover the future size and composition of the labor force, aggregate economic growth, detailed estimates of industrial production, and industrial and occupational employment. The resulting data serve the many users who need information on likely patterns of economic growth and their effects on employment. The information on future employment opportunities by occupation, for example, is used by counselors, educators, and others helping young persons choose a career, and by officials who plan education and training programs (BSL, 1997)

The BLS itself publishes employment forecasts based on this macroeconomic model, per industry, occupation and state. Despite new data added over the past 35 years and changes in industry and occupational classification systems, BLS data have maintained the same basic analytical framework to this day. The BLS produces its forecasts based on labor productivity estimates and industry-occupation matrices which indicate the status of employment per occupation category within an industry.

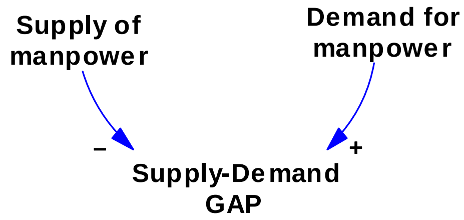
However, to predict manpower supply and demand with accuracy using a macroeconomic model, one needs a vast array of data for each of the many variables used. To collect these data, one must first get hold of sufficiently broad-ranging time series data for each industry. For this reason, a method of this type proves to be unadaptable for emerging sectors undergoing fast-paced growth with only small amounts of statistical data on the industry as a whole and manpower available. With such industries, this technique will be forced to base the estimations on a handful of factors with numerous restrictions attached, and will thus fail to reflect dynamic interactions between different variables and delayed feed effects.

2. Dynamics of Manpower Planning Model

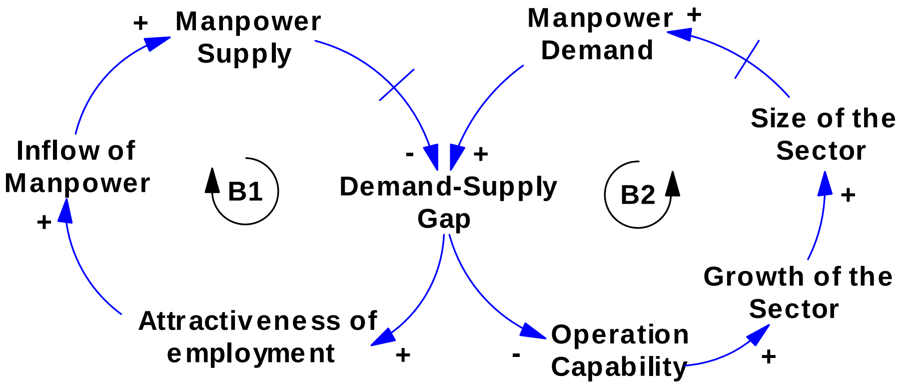
As has been discussed in the preceding section, the inherent limitations of the existing methodologies, chiefly stemming from the excessive quantity of restrictive conditions required, undercut their effectiveness as a tool to forecast suppy and demand for manpower. Furthermore, by providing vague estimates for the future or all but conceptual solutions to the problem of imbalance between supply and demand, these methods could not pin down the fundamental causes of the imbalance, and fell short of producing policy-level leverage or concretely explaining results that are to be expected from different policy alternatives. Their shortcomings are made more apparent with cutting-edge industries and emerging industries which, while entertaining complex relationships of interdependence with other industries and experiencing rapidly-growing manpower demand, are characterized by a longer period required to developing needed human resources. They overlook dynamic inter-relations between different industries or between influence factors within an industry and delayed feedback effects. They, in short, do not view supply and demand of manpower from a dynamic perspective. To approach a model of supply and demand for manpower from a dynamic perspective, one must consider the following:

2.1 Feedback Structure

Previous researchers treated supply and demand as separate systems and explained manpower models from an open loop perspective without considering the interaction between the two. As can be seen in [Figure 1] below, they viewed labor supply-demand models as simple gaps occurring between supply and demand, and analyzed them separately to produce forecasts. In reality, supply and demand, as shown in [Figure 2], interact with each other forming a single system with their respective feedback mechanisms intersecting at the supply-demand gap. Demand for workforce in one industry triggers inflow of manpower to that industry, stimulating the supply. The supply can either suppress the creation of new demand in manpower by becoming a restrictive factor vis-a-vis operational capability or, on the contrary, create new demand by enhancing the operational capability and accelerate growth of the industry. Supply-demand behavior, forming two negative feedback loops, tends toward equilibrium which is eventually attained.



[Figure 1] CLD of Traditional Manpower Supply-Demand Model



[Figure 2] CLD of Dynamic Manpower Supply-Demand Model

2.2 Time Delays

Another important element to consider when designing a manpower supply-demand model is the time delays occurring within the system. There are two types of delay: physical delay and information delay. Delays between making a decision and its effects on the state of the system are common and particurarly troublesome and delays have a significant influence on dynamic behaviors within most social systems. Delays in feedback loops create instability and increase the tendency of systems to oscillate (Sterman, 2000). Delays therefore can increase the instability of a system, leading to undesirable system behaviors. In some cases, undesirable influence factors resulting from abrupt changes within a system must be filtered out or buffered so as to maintain its stability. As a result, decision makers often continue to intervene to correct apparent discrepancies between the desired and actual state of the system long after sufficient corrective actions have been taken to restore the system to equilibrium (Sterman, 2001). Delay effects, in spite of their decisive role within decision making models, including manpower planning models, have been disregarded by most research, which is primarily due to the static nature of estimation techniques, whether mathematical or statistical, making it difficult to reflect them.

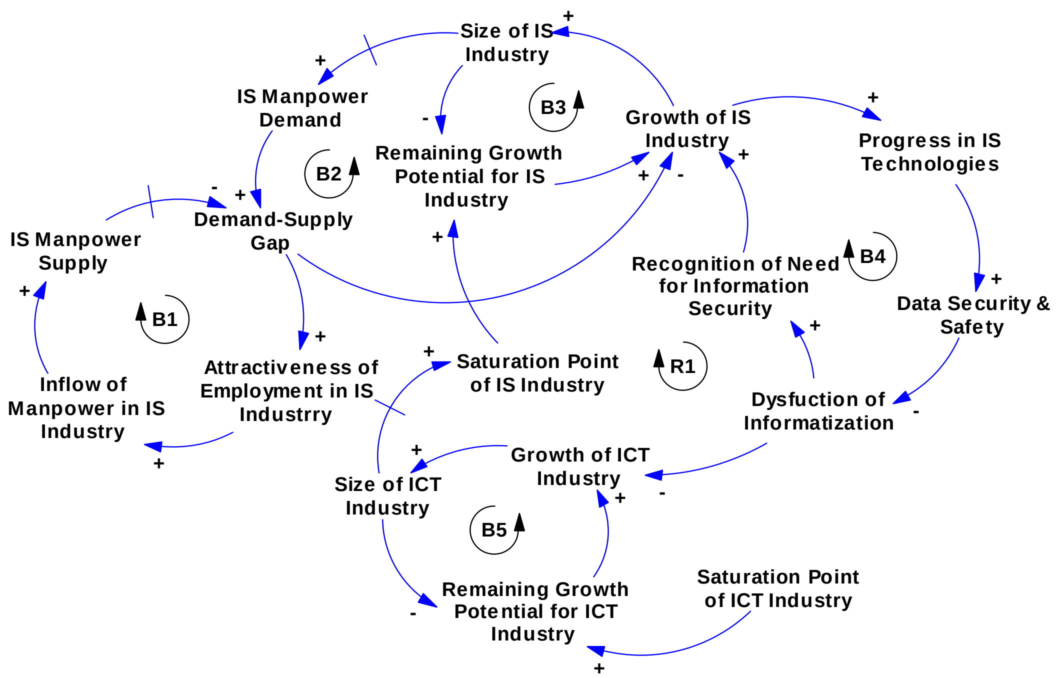
Delays of both types, physical and information delays, must be considered also in a supply-demand model for manpower. In [Figure 2], the straight lines cutting across the arrows connecting one variable to another mark the presence of delay effects. Within a manpower supply-demand system, physical delays occur on the supply side, due to the time required to develop the workforce, and information delays, on the demand side, due to the time elapsed before coming to the realization of the need for additional workforce arising from the growing size of an industry. In other words, even if a supply-demand gap triggers the inflow of manpower in an industry, it takes a considerable amount of time to actually fill the demand and reduce the gap. On the other hand, information delays occur either because manpower planning relies on past years' data to assess the size of current demand or additional labor force is requested on an as-needed basis, or due to imaginary demand prompted by desire to secure manpower in advance, before actual demand arises.

To sum up, while a shortage of manpower sparks supply, the supply/demand gap is filled only gradually. During this delay, the market continues to feel that the supply of manpower is insufficient. This perception can sometimes persist even after a sufficient supply of manpower and cause an oversupply. Meanwhile, the market can also excessively reduce the supply based on a perception of oversupply which persists even after a reduction by an adequate size, causing a labor shortage.

2.3 Flexible Saturation Point

Most demand prediction models are based on diffusion theory, explaining the growth cycle of industries whose growth has not yet reached its peak. If demand for workforce arising within an industry is related to the size of that industry, additional demand in manpower ultimately depends on its degree of diffusion within the market and its growth. The model developed by Bass (1969), by modifying and expanding the coefficients of innovation (external influence factor) and imitation (internal influence factor), two determinants of demand diffusion, has been widely adopted in the marketing field and in technology diffusion models (Mahajan, et. al., 1990).

However, diffusion theory-based demand prediction models, if used for young industries or industries whose growth is to a large extent dependent on that of others, can yield severely erroneous results, as these methods set a fixed saturation point and require a pre-determined market size. A saturation point, set too low, can result in an underestimation of demand, while one set too high can cause an oversupply by overestimating the speed of growth. Errors of estimation can be even more flagrant with industries like the information security industry, which heavily depends on other key industries for growth. As can be seen in [Figure 3] below, the ICT industry and the information security industry are two interdependent industries, forming a single system. To prevent errors resulting from the saturation point assumption, for the information security industry, whose growth is profoundly affected by the conditions of other related industries, one can assume a flexible saturation point which shifts over time. Contrary to a fixed saturation point, a flexible saturation point would be one which fluctuates along with the growth behavior of other related industries that are more mature, and for which predicting a saturation point vis-à-vis the overall market is comparatively easier.



[Figure 3] Dynamic Interaction between ICT Industry and IS Industry

One can model demand behavior in the information security industry by choosing a saturation point which moves along with the size of the ICT industry, as the size of the former is generally viewed to correspond to about 10% of the latter. The introduction of ubiquitous computing(ubicomp) further increases risks of overestimation or underestimation for a manpower demand forecast based exclusively on the size of the information security industry, as this new growth engine for the ICT industry is bound to produce huge spillover effects also on it.

3. Dynamics of IS Manpower Planning in UbiComp Environment

3.1 Overview of UbiComp and Resulting Changes in the IS Environment

Computing is becoming ubiquitous (Yoo et al., 2005). The word 'ubiquitous,' stemming from the Latin word 'ubiquitas,' means 'being everywhere at the same time.' In the ICT field, this word is used to refer to the new computing and communications paradigm shared by concepts like ubiquitous computing and ubiquitous network. The word 'ubiquitous' makes its first apparition in the information field in 1988 when Mark Weiser (1952-1999), a researcher at the Xerox Palo Alto Research Center (PARC), proposed the concept 'ubquitous computing.' The concept is about integrating computation into the environment (real space) by embedding it into objects and places. People can more naturally and conveniently interact with these invisible computers that are no longer distinct objects and are pervasively present in the everday environment, each with their own special functions (Weiser, 1991; Weiser, 1993). "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." So began Mark Weiser's seminal 1991 paper that described his vision of ubiquitous computing (Weiser, 1991; Satyanarayanan, 2001).

Friedemann Mattern (2001), a researcher at the ETH Zurich who further elaborated Mark Weister's concept, describes ubiquitous computing as a new technology capable of bridging the real and the virtual world. He predicts the advent of an era of 'many computers (mainframes) for everyone,' where people have ubiquitous access to information, from anywhere, at any time, using any devices and for whatever purposes, in which all things/machines will be intelligent, forming an internet of things. In this age of embedded and invisible computing, he says, computers will silently and autonomously operate, requiring no human intervention or complicated manipulations. Ubiquitous computing, based on networks made up of massive quantities of chip sensors, interlinked through wireless connection and accessible using mobile devices from virtually anywhere and at any time, is expected to bring major changes to our lifestyle. This technology will further provide an environment conducive to the introduction of useful applications of previously impossible types. Meanwhile, the impact of the IT field on other fields and its ability to spur progress and growth in them will become more consequential than ever.

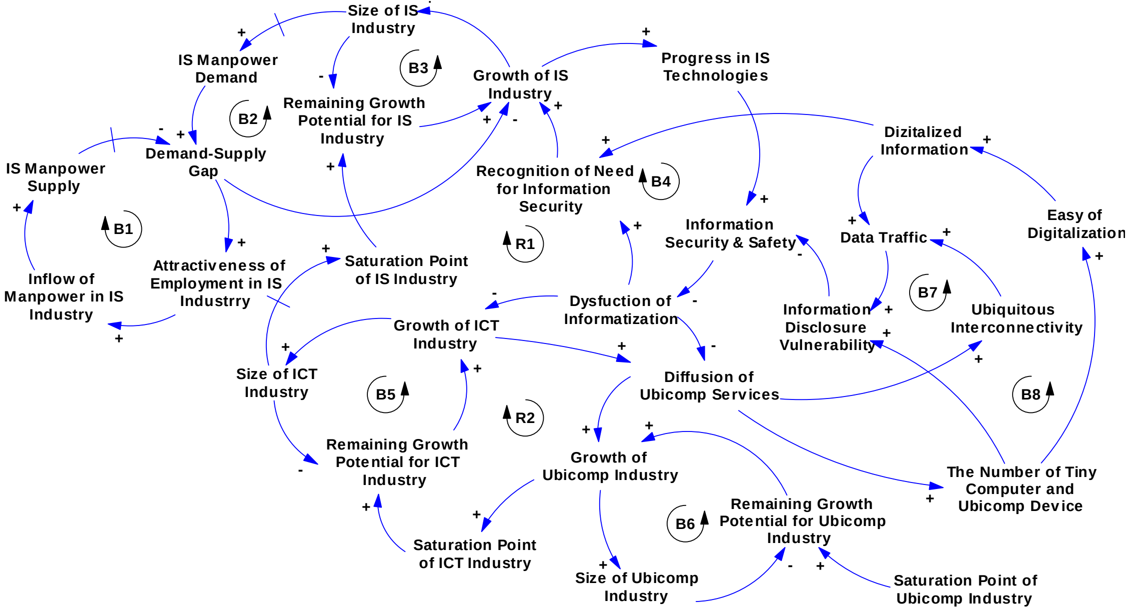
However, computing has since mobilized itself beyond the desktop PC. Significant hardware developments-as well as advances in location sensors, wireless communications, and global networking-have advanced Weiser's vision toward technical and economic viability. Moreover, the Web has diffused some of the psychological barriers that he also thought would have to disappear (Saha et al., 2003).

On the other hand, this change of paradigm in ICT is also expected to entail major changes in the information security environment. Below are some of the most important ramifications of ubiquitous networking for information security:

First, a computing environment centered on portable devices, and no longer fixed PC-based devices, would reveal various information security vulnerabilities of previously unknown kinds. Also, due to the reliance on batteries as power sources, mobile devices have more moderate CPU processing capabilities than traditional PCs, which undercut the performance of hardware-based encryption in these devices.

Second, it is more difficult to guarantee confidentiality and integrity of data within a wireless network environment. Data communicated over a wireless network is more vulnerable to interception and wiretapping. Moreover, as local-area communications are expected to be the chief category of traffic within ubiquitous wireless network environments, the risk of exposure to interception is bound to be greater.

Third, advances in digital technologies and growing capacities of data transmission coupled with the wide penetration of portable devices make it possible to digitalize various types of analog information, including contextual information on a real time basis, and send it over the network, in addition to standardized information like files, which also magnifies the risk of information disclosure vulnerability.



[Figure 4] Dynamic Changes Occuring to ICT and IS Industries Following the Introduction of Ubiquitous Computing

In sum, these changes brought about in the information security environment by the introduction of ubiquitous information technologies are likely to create new demand for information security manpower and trigger continuous demand for technological workers trained in new technology fields.

3.2 Dynamic Changes Brought About in the ICT Industry by UbiComp

The diffusion of ubiquitous computing is likely to present a new opportunity for growth for the ICT industry. In the information security industry, this will give rise to new demand in manpower as well as demand for technological manpower to underpin development of new technologies required in the new computing environment.

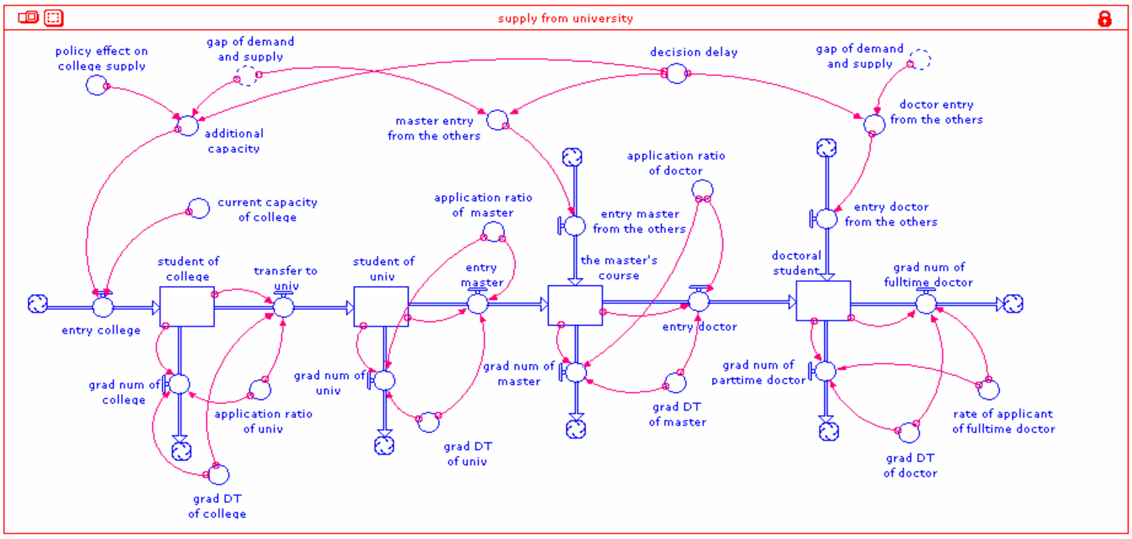
As can be noted in [Figure 4] below, the ICT industry grows in parallel with the information security industry. The growth of the information security industry, by resolving negative side effects of informatization, provides the ICT industry with a stable basis for growth. The growth of the information security industry furthermore creates new demand for workforce, and additional manpower brought in benefits the industry, serving as a basis for its stable growth. The ICT industry, forming a symbiotic relationship with the information security industry, upon the introduction of ubiquitous computing and with resulting changes in the ICT environment, will be positively propelled by it and receive stimulus for growth. Meanwhile, a ubiquitous computing environment will see a decline in information security and safety and an increase in information disclosure vulnerability, even as the main priorieties of confidentiality, integrity and availability of data are upheld. This heightens the risk of information security breaches, which in turn gives rise to the need for new security technologies and demand for additional manpower. The information security industry, therefore, maintains an intimate linkage to ICT, its upper-level industry, and evolves through dynamic interaction with it. With the emergence of a new technological paradigm like ubiquitous computing, its ecology is undergoing further changes and developing a more complex nexus of dynamic interaction, whose correct understanding requires a detailed analysis.

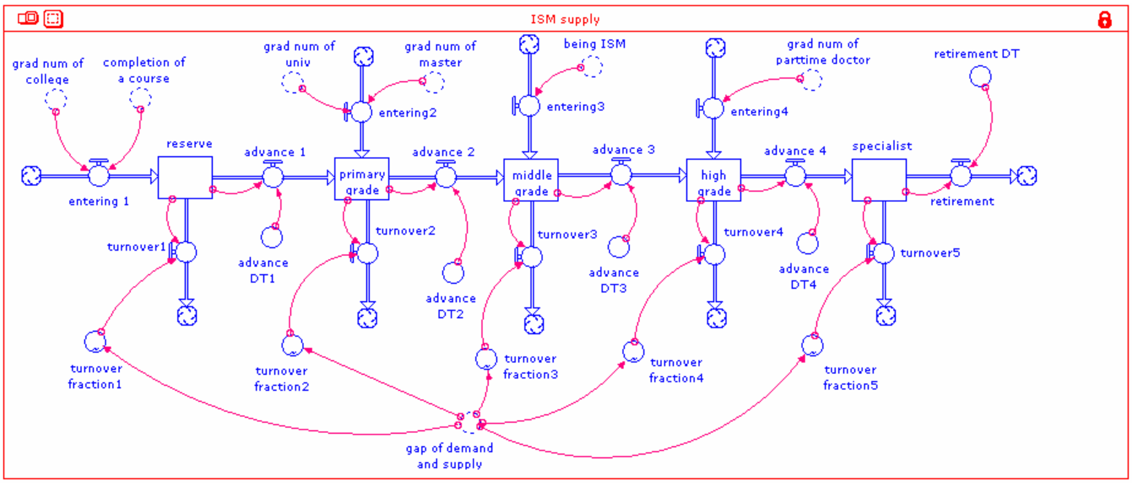
Ⅲ. Elaboration of a Dynamic Manpower Planning Model

1. Designing a Simulation Model

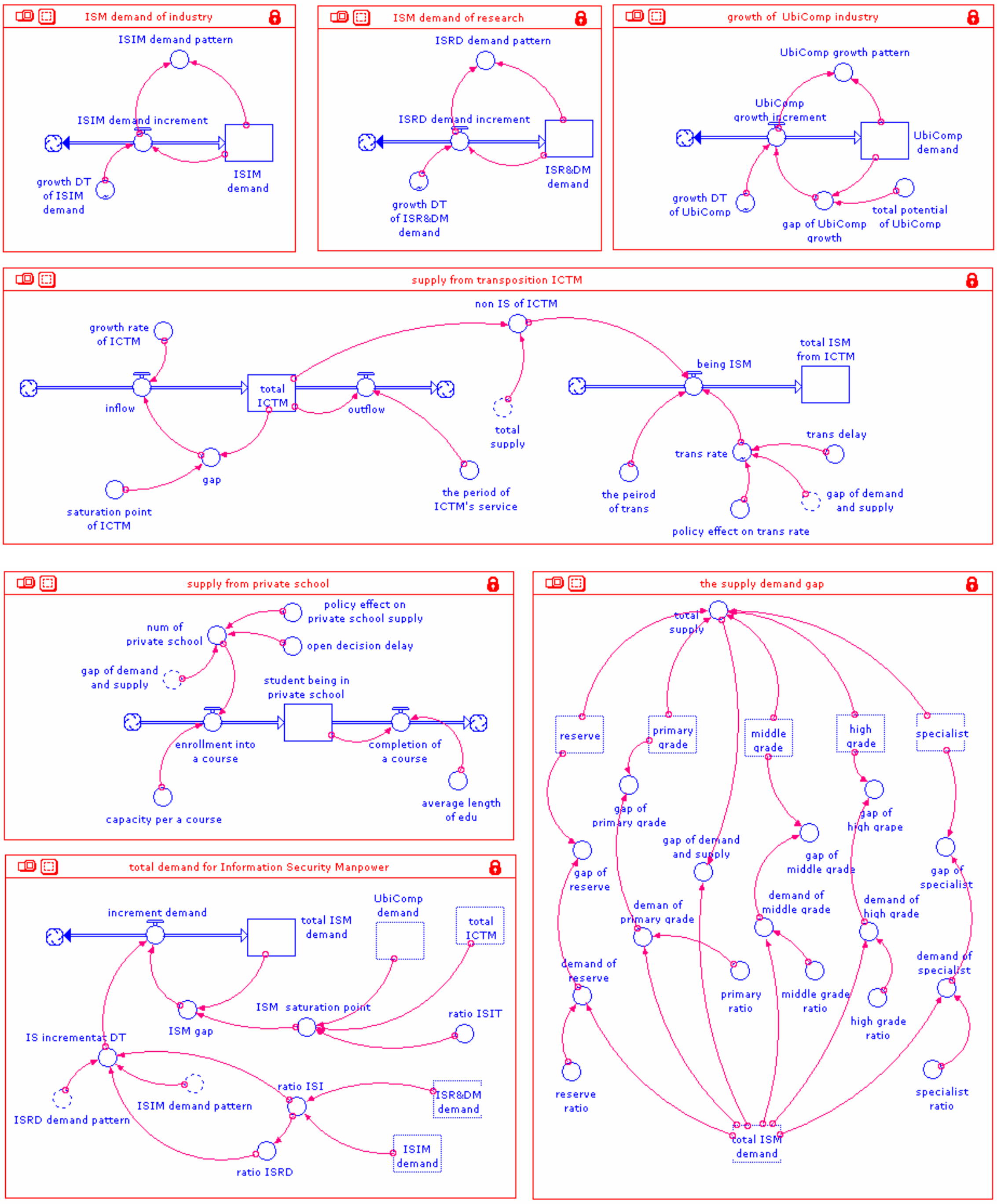
Based on the causal-loop diagrams presented in the preceding section, we designed stock-flow diagrams as shown in [Figure 5] above for computer runs with system dynamics simulation package, 'STELLA.' Currently, there are several computer programs that support simulations using the system dynamics method. We used STELLA, chosen in appreciation of its graphic performance and the ease of comparing results following adjustment of variables. Constants are calculated with raw data prior researches (Kim, 2003) retain and some external variables and variables hard to be quantified are given default values or ratios. Decision-making related factors are treated as external variables to experiment diverse scenarios.

Information security manpower may be supplied from sources such as educational institutions (undergraduate colleges and graduate schools) and private vocational training institutions (non-university institutions and university vocational programs) as well as from other related industry sectors. The yearly new supply corresponds to the sum of graduates and certification holders produced annually from these sources and workforce created from manpower conversion. The total supply is the cumulative net flow, calculated by subtracting outflow, including resignation and retirement, from the total new supply. Demand for information security manpower was distinguished into that originating from information security companies and that from related industries and research instutitions. Total demand is the sum of new demand, corresponding to the total of projected numbers of new recruits for a given year in each of the demand sources, and additional demand created from the introduction of ubiquitous computing. The projected number of new recruits is assumed to be determined on the basis of the forecasted sales and R&D budgets. As for the size of market, the model was designed so as to allow a delay of one year before it is reflected in the size of actual manpower demand. Next, models of total supply of manpower from different supply sources and total demand from different demand sources were each created, marking them as separate areas. Finally, a model of supply/demand gap was designed using the difference between the two values, which was also expressed as a separate area. The supply-demand gap, in this case, affects the supply of information security manpower.





[Figure 5] SFD for Dynamic Manpower Planning



[Figure 5] SFD for Dynamic Manpower Planning (continued)

For university-trained manpower, those who completed the first two years of a 4-year college (pre-major programs) were grouped together with 2-year college graduates, separate from those who completed all four years, in other words, those who also completed the major programs. The lengths of MA and PhD programs were set to 2 years and 5 years, respectively.

Furthermore, as shown in [Table 1] below, manpower was classified depending on the level of education and experience into five grades, ranging from reserve, primary and middle grades to high and specialist grades. Workers of each grade are designed to move up to the next grade after a given period of service. Demand per manpower grade is a percentage value of the share in the overall demand.

[Table 1] Definitions of Manpower Grades and Their Shares of Demand

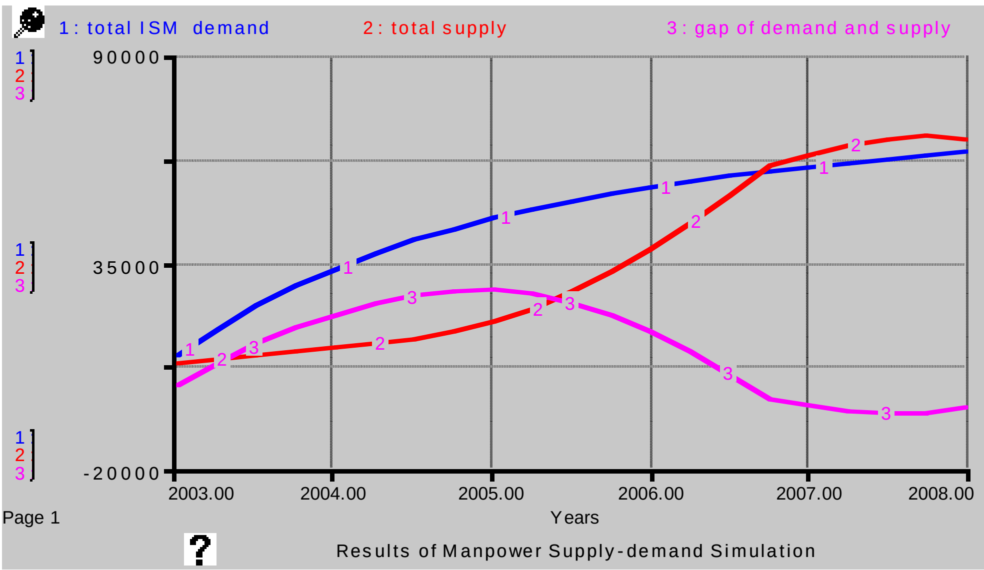
Grade	Definition	Demand Share
Reserve	- 2-year college graduates having majored in related fields - Those who completed a short-term program at a private non-university institution.	20%
Primary Grade	- 2-year college graduates having majored in relevant fields with 2 or more years of experience working in information security-related fields - Holders of a BA or a MA in relevant fields	20%
Middle Grade	- 2-year college graduates having majored in relevant fields with 9 or more years of work experience in related fields - BA holders and MA holders in the revelant fields with 6 or more years or 3 or more years of work experience, respectively, in related fields. - For the sake of simplicity, 20% of primary-grade workers were assumed to annually move up to the middle grade level.	35%
High Grade	- 2-year college graduates having majored in relevant fields with 12 or more years of work experience in related fields - BA holders having majored in relevant fields with 9 or more years of work experience in related fields - Holders of a MA in relevant fields with 6 or more years of work experience in related fields - PhDs in relevant fields - For the sake of simplicity, 1/3 of middle-grade workers were assumed to annually move up to the high grade level.	15%
Specialist	- 2-year college graduates having majored in relevant fields with 15 or more years of work experience in related fields - BA holders having majored in relevant fields with 12 or more years of work experience in related fields - Holders of a MA in relevant fields with 9 or more years of work experience in related fields - PhDs in relevant fields with 3 or more years of work experience in related fields - For the sake of simplicity, 1/3 of high-grade workers were assumed to annually move up to the specialist grade level.	10%

2. Model Implementation and Policy Implications

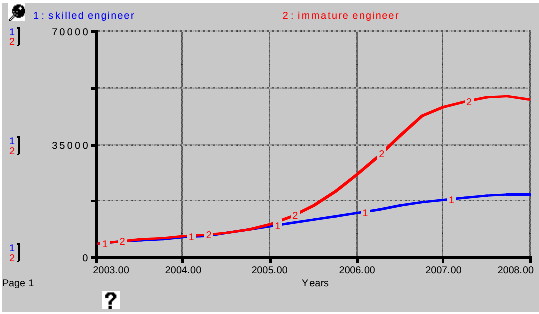
As can be noted from the simulation results in [Figure 6] below, the current manpower supply and demand behavior in the information security sector reveals an excess of demand over supply, in other words, a shortage of manpower. With the diffusion of unbiquitous computing, such imbalance between supply and demand is expected to be worsened for the foreseeable future. To alleviate the shortage of manpower, various initiatives are currently underway, including creation of new information security-related academic departments and programs in higher education institutions, manpower conversion programs to retrain workers in the IT field, and initiatives to expand training outlets by harnessing private institutions. Thanks to these measures, the imbalance is likely to be corrected within the next five years.

Also, the information security specialist certification program operated by KISA and ICU since 2001 is expected to help relieve the imbalance to some degree.

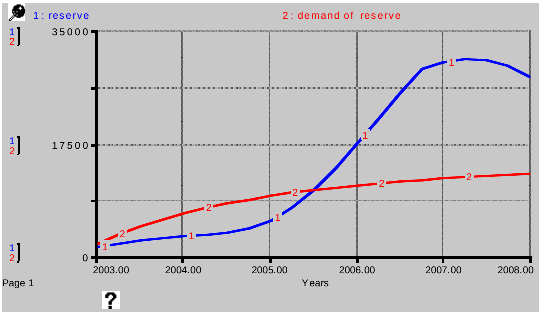
However, an analysis by manpower grade indicates that supply improvements, as can be seen in graphs in [Figure 7] to [Figure 12], are limited to reserve and primary-grade manpower, coming out of relatively short training programs, and that, as for workers of middle grade and above, that are more urgently on demand in the market, the shortage appears to be persistent. In other words, whereas the supply of reserve and primary-grade manpower with scant on-the-job experience quickly surpasses demand, in the cases of middle-grade and more experienced manpower, demand is expected to continue to exceed supply. What this suggests is that the current solutions to the imbalance between supply and demand, while they may be able to correct the problem within the next five years at a quantitative level, cannot bring about required qualitative improvements, pointing toward a necessity to invest in the development of high-quality human resources. Clearly, a prolonged manpower shortage in the information security industry can be detrimental to the growth potential of the IT and ubiquitous computing-related industries.



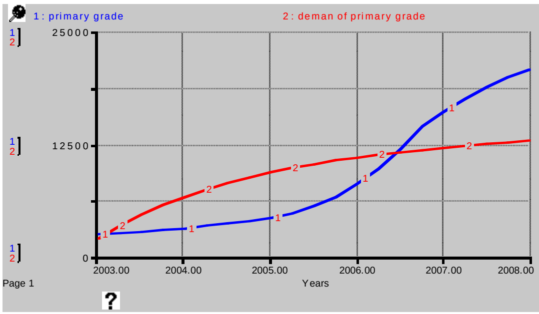
[Figure 6] Manpower Supply-demand Behavior (overall)



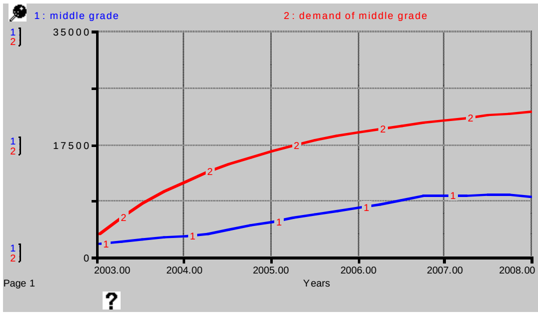
[Figure 7] Supply behaviors in skilled(1) and immature(2) manpower



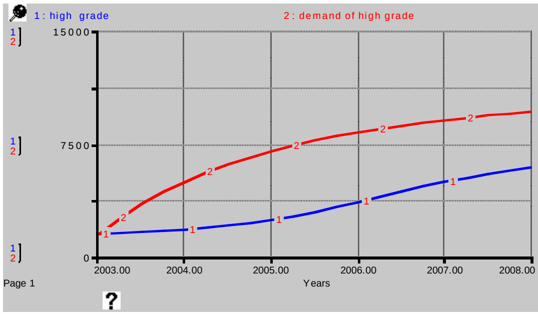
[Figure 8] Supply(1) and demand(2) behavior in reserve manpower



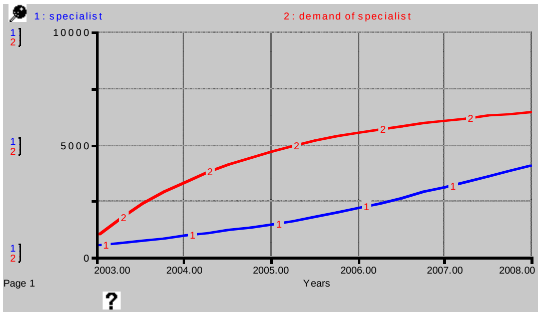
[Figure 9] Supply(1) and demand(2) behavior in primary-grade manpower



[Figure 10] Supply(1) and demand(2) behavior in middle-grade manpower



[Figure 11] Supply(1) and demand(2) behavior in high-grade manpower



[Figure 12] Supply(1) and demand(2) behavior in specialist manpower

The fact that the overall increase in manpower supply in the information security industry fails to be accompanied by qualitative improvements and satisfy demand in high-quality labor force is explained by the following reason:

Supply and demand in manpower maintain a dynamic relationship with one another. An increase in demand can often trigger a rapid growth of supply in lower-grade manpower, as short-term private training institutions and non-university vocational programs are especially sensitive to demand fluctuation. However, as the supply of lower-grade workers cannot satisfy demand for more qualified workforce, the manpower shortage continues unabated. Meanwhile, supply continues and the labor market heads toward an oversupply. In other words, there is a time-lag between the occurrence of demand for information security manpower and the supply of higher-grade manpower, as it takes a considerable amount of time before workers of the latter category become available for the market (time to complete required training and acquire desired number of years of experience). This delay also explains phenomena like the concurrence of an unemployment crisis and manpower shortage on the employer side.

Based on these results, we propose the following solutions for correcting the supply/demand imbalance in information security manpower:

First, as developing manpower is a lengthy process, especially for highly-qualified workforce, manpower supply-related policies must be implemented in a timely manner, preferably as soon as an increase in demand is anticipated. Also, given that core manpower in the information security industry is supplied through postgraduate programs, a measure to incite more prospective graduate students to enroll in information security-related programs can yield direct results in matching supply with demand by increasing the pool of manpower that is actually needed by the industry. This measure may be more effective, if coupled with others such as those to increase the size of government research grants and to facilitate joint research projects between Korean research institutions and academic societies and their overseas counterparts.

Second, as the role of private vocational training institutions is fundamentally limited to that of suppliers of lower-grade manpower churned out through short-term programs, to develop high-quality labor force for the sector, one must instead invest in manpower conversion programs to re-train qualified IT workers, and in university-based vocational education programs.

Third, one must look into modifying the current qualification system, assigning class 2 to primary-grade workers and class 1 to middle-grade workers, to create a three-tier system, for instance, with skilled worker (primary grade), technician (middle grade) and technologist (high grade) as its principal categories.

Ⅳ. Conclusion

Forecasting supply and demand of manpower is an indispensable step for an industry, providing companies with a basis for manpower planning. Meanwhile, supply and demand forecasts allow job seekers to gauge the attractiveness of employment in a given field and offer the government important indicators for coordinating its policy efforts to help an industry achieve a balanced growth and avoid redundant investments. However, forecasts of supply and demand for manpower have thus far been often seriously flawed. They were either based on superficial data and lacked a comprehensive examination of the structural characteristics of the market, or were the results of the assessment of the present state within an industry, disregarding dynamic changes that may occur over time, or of one that is narrowly focused on one industry while overlooking linkanges with related industries. These problems inevitably led to frequent overestimations or underestimations of both supply and demand. These approaches can yield particularly severely erroneous forecasts with cutting-edge industries and emerging industries which, while entertaining complex relationships of interdependence with other industries and experiencing rapidly-growing manpower demand, are characterized by a longer period required to develop needed human resources.

In the present paper, we analyzed the problem of imbalance in manpower supply and demand in the information security industry from a dynamic perspective, and proposed solutions to correct it. This study, although it has the merit of concretely explaining causes to imbalances between supply and demand for manpower and suggesting practical solutions to the problem, has nevertheless several limitations. For example, manpower supply and demand is an issue which requires an even consideration of both quantitative and qualitative aspects, and the qualitative aspect cannot be simply discussed in terms of general qualification levels. For greater analytical accuracy, future research must consider more detailed supply and demand behaviors per component technology. Furthermore, while we tried to base our model as much as possible on actual data, referring to prior research on the subject, concerning some policy-related variables, we used either a base value or a ratio value. Hence, to an extent, we have sacrificed the accuracy of parameters, a fundamental principle in the system dynamics method, for the sake of understanding the general supply/demand behavior and its structural pattern. As a consequence, the resulting measurements leave something to be desired in terms of accuracy.

Future researchers must therefore look to add precision to this model and expand it by providing an analysis of supply/demand behavior which considers technologies possessed by manpower, and is based on actual measurement values.

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