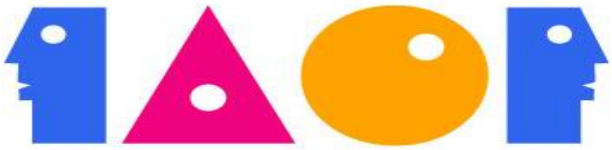

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INFORMATION REGARDING
THE INTERNATIONAL JOURNAL OF ORGANIZATIONAL INNOVATION

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SOCIAL INNOVATION? LET'S START LIVING INNOVATION AS A COLLECTIVE ADVENTURE

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Abstract

After a short analysis of some reasons why teamwork is not effective, this article describes a way to optimize collective achievement along the innovation process, and complete « a whole greater than the sum of the parts ». Belief, People, Framework, Trust, and Leadership are the 5 landmarks that boost innovation team deliverables. Once the team operates collectively, it's then time for opening your innovation process to a social cooperation, harnessing collective intelligence more widely.

Keywords: teams, innovation, collective achievement

Why Teams Don't Work?

"Why teams don't work" (1), an HBR interview with J. Richard Hackman by Diane Coutu, is a great and surprising article on team work: while everyone takes team work for granted, researches from Professor Hackman, the Edgar Pierce Professor of Social and Organizational Psychology at Harvard University, show that "most of the time, team members don't even agree on what the team is supposed to be doing".

"Getting agreement is the leader's job, and the team leader must be willing to take great personal and professional risks to set the team's direction."

In brief, Professor Hackman also points out that:

> "teams underperform often their great creative and productive potential;
> teams need to be set up carefully to ensure they have a compelling direction;
> small teams whose members stay together for long periods of time perform best;
> leading a team requires enormous courage because authority is always involved,
> which arouses great anxiety in team; great team leaders often encounter
> resistance so intense it can put their jobs at risk".

Let's make the whole more than the sum of its parts

Reversely what we want to achieve is Confucius mantra, « a greater whole than the sum of its parts », and to use the team as a leverage for innovation.

So let's assume you're the team leader, and go through some dimensions that will help you glue together the team work.

1. Belief

A team will gather around a shared vision, which is a foundation for your innovation; so the very beginning is to express your belief or the metaphor (2) for the innovation you want to raise: innovation is design, it requires a clear intent, before translating concept in a simple and elegant realization. For example, in the Silicon Valley, there is an aspiration to make the world a better place (3) with their innovation, others want to solve a specific problem they've been facing for years, a few "think different"(Apple claim) ...

You don't have to build this alone like an hermit: for our Smart TV design, the key principle of Openness (TV experience opening doors to Internet content & services) came in the early days of our team work. For our social TV work, we picked up "Social Belief", meaning that

social conversations around TV are not just noise, but, if well collected and filtered, they can help your content discovery.

2. People

Brainstorming about a belief featuring your innovation target is fun! In my experience, setting-up the team is the most difficult part. A friend of mine at HEC told me: if you really want to know if you're going to get along with this person, have lunch with him and see if you get bored! Bottom line: recruiting successfully takes time. That's why they spend substantial time on recruitment at Ideo (4) or Google (5).

The paradox is that you're in an innovation hurry: control the haste is then your first resistance act as team leader. You need the right skills to go the long innovation way: you have to select the best in a range of functions: idea generator, designer, engineer, user observer-sociologist, market watcher, product marketing, ... Each of them should show an ability to listen and debate, collect ideas from each other (for immediate use or kept on the shelf to use later), take risks, test new things, call into question established systems (what Professor Hackman calls "deviant thinking, opening up more ideas, getting more originality").

T-shaped people portrays them Tim Brown (6) . If regular involvement of all team members in debate is necessary, it's not always a natural movement for everyone, especially for expert engineers not used to speak up: help them by fostering attention when they express.

Harnessing collective intelligence is what you want, it involves the customer as well. "Support and feedback is what our customers are telling us, product is what we're telling our customers, presenting one cohesive story to the world" spots Twitter's founder, Jack Dorsey (7). Switching from monologue to dialogue with customer is an uneasy thing the team will have to complete as a whole. Help your team to value customer feedback as a lever to rebound on innovative items.

You know you have succeeded when team members start spontaneously sharing views in meeting, out of their traditional role's boundary. Last time I saw this was when everyone was excited to discuss about the logo of our social TV service, Blended TV!

You may benefit from starting with a small number of people to build a core team. Moreover, big teams over double digits "usually wind up wasting everybody's time".

While your team need stability so people get "comfortable and familiar with one another", you might want to adapt team composition overtime, when approaching the market place: marketing processes, brand, or commercial launch of a product or service will have more importance. One thing that really paid off in one TV service I developed was to have all functions involved from the start, including sales and customer service. Those people acted as a regular link with the customer and retails shops, very precious at the early stage and along the

process. Their involvement was light at the beginning, just expressing their feeling as market representatives, and it became more important as they had to anticipate market launch, and eventually the hand over of the project when product got running.

Bringing together a “dream team” of talent to participate in the innovation project is one of the most difficult task. Like in innovation, failure is part of the game, and player can be replaced as in any sport game. No need to make someone guilty, complete substitution in due course. Try to learn fast, what kind of people you fit with, and share a common innovation timing.

3. Framework

A framework for the team work is something quite well known: first of all, "team must be bounded, with explicit membership" as highlights Professor Hackman; you need then to provide a clear organization of tasks and responsibilities (without corseting...), set-up stretched goals to electrify team motivation, help narrowing the scope to avoid depressing hesitation, handle launch and regular follow-up meetings, and arbitrate conflicts with no delay: a latent conflict is some sure innovation killer.

Consistency and cohesion are the two legs of your innovation team: every one shall have the same fight, designers and developers ..., everyone shall understand how it makes sense with regards to the innovation belief.

I have put it in other words in "creative tension is good for you! (8)" talking about knowledge circulation as the key indicator of a good team framework.

4. Environment of trust

Innovation team needs protection. While providing the team with appropriate distance from mainstream operations and issues, it requires headquarter manager to be humble, to slightly set back as well.

Osman Can Ozcanli (9) speaks about "in vitro method", consisting in finding innovative and autonomous people, and letting them free in a flexible framework. He gives a few fruitful tips:

"Tell them you want them to innovate, give them a budget and some direction to work with, and let them experiment.

Help them select a product concept that is in line with your family of products.

Don't get in their way, just finance them.

Let them own the vision for their product, but give them deadlines."

I would add: use your license to kill without sorrow, celebrate failure, and learn fast!

5. Leadership

Last but not least, your role as a team leader is the cement for the process to flow effectively and harmoniously.

I believe in a leader that helps co leaders to raise, that ask team members to develop their

autonomy, give them a framework to develop their growth and learning, empower people, and let the people find what is meaningful and self-motivating for them. This leader acts as an orchestra conductor, he provides inspiration as the stakeholder of the belief: thus he doesn't hesitate to arbitrate and keep the focus (11).

I like the way Twitter's founder, Jack Dorsey puts it: "I think every leader in any company is an editor. Taking all of these ideas and you're editing them down to one cohesive story, and in my case, my job is to edit the team, so we have a great team that can produce the great work and that means bringing people on and in some cases having to let people go."

Conclusion

I definitely live innovation as a collective adventure, which makes it so rewarding. Once the team is set-up in a way to operate collectively, you have a strong basis and landmarks (belief, people, framework, leadership) for opening your innovation process to a social cooperation, cocreation, harnessing collective intelligence more widely. By activating the intelligence of many , social innovation allows to make a very different impact.

Because people are never more involved that when sharing your belief, and then translating it in a personal drift develop one's own worth; our goal should be to make the best of collective and personal expectations in "an organization where people serve their goal" as Gary Hamel (11) expresses it.

Other related reading: setting-up an innovation entity (timeline)

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RISKS AND OPPORTUNITIES FOR FOREIGN MULTINATIONAL COMPANIES IN CHINA

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Abstract

For multinational companies, the appraisal of China's huge potential markets against the risks of assaults on their competitive advantages needs reevaluation is an important consideration. An important characteristic of multinationals are their investment in their intangible assets, such as development and research, reputation, advertising and managerial skills which give them competitive advantages over local enterprises' knowledge of conditions and local markets. Multinationals need strategies that protect their long term investments in intangible assets and secure returns on investments. The Chinese market has several potential obstacles that effective multinationals must consider. This article shows risks associated with doing business in China, including copyright violations, market potential, corruption and politics. The article, in summary, recommends effective strategies by multinationals operating in China.

In this study, foreign direct investment in China after they became a WTO member is explained. This is followed by multinational companies expectations in China. This study shows examples of intellectual property right and copyright violations. It also discusses regulatory risks and the effects of politics, as well as corruption. Finally, it illustrates the competitive power of small business networks in China.

Keywords: Asian Post-Crisis Management, Foreign Multinationals in China.

Foreign Direct Investment in CHINA After Becoming a WTO Member

With China's entry into the WTO, multinationals' interest and enthusiasm in the Chinese markets increased greatly. China wants to maintain its status of having the largest of FDI among developed nations. China is the second only to the USA in Foreign Direct Investment (FDI) inflows. The WTO helped to revitalize enthusiasm in investing in China. Many multinationals, in joint ventures, buy out local partners, normally penurious state-owned enterprises. China has witnessed an increase in FDI contracted investment, ad commitments as opposed to actual investment. Moreover, commitments to invest in China appear to carry more weight with their businesses and government than in prior years. China has great interest and incentive to encourage FDI.

Multinational Companies' Expectation in China

As the most populous nation in the world, China offers awesome potential markets for multinationals. Currently, multinationals dominate FDI in China, but they are faced with very different risks and characteristics from the local Chinese enterprises that have traditionally served as China's major investors. Among the multinationals, automobile and telecommunications enterprises dominated the major multinationals in China, in terms of sales. An example is Shanghai Volkswagen Automotive Co., a 50-50 joint venture between Shanghai Automotive Industry Corp and Volkswagen AG. Telecommunications and automobiles in china offer two of the largest potential markets in the world, and have had high sales. The Chinese market presents obstacles for multinationals in making returns on their investment. In the late 1900's, the Chinese market attracted a large number of various multinationals, each expecting that vast potential profits lay just around the corner. However, those periods of investment, often resulted in broken contracts, corruption, counterfeiting and bureaucratic red tape. Various

markets and profits became entangled with many problems, such as: infant distribution channels, inability to ascertain the markets true size, copyright violations that strike at the core of the multinationals' competitive advantages, corrupt business environments and high regulatory risks.

The Chinese central government supports the automobile industry by financing car purchases with bank loans. Most Chinese still look cars as luxury items. In spite of their high sales, foreign automobile manufacturers' aggressive expansion in China prove to be an erroneous strategy in view of the nation's relatively small but highly protected market. Foreign automobile companies currently account for the majority of the nation's car sales. But China's passenger car market is relatively small compared with other nations. In other industries, there are plans to open plants manufacturing glucose syrup, sweeteners dextrose, bulking agent, dried glucose, and malto-dextrin, all sales aimed primarily at the Chinese market. In the West, they hope to export products such as pharmaceuticals and thickeners in food. In China, 40 percent of starch products include the flavor enhancer monosodium glutamate. As a consequence in China. the price of starch is more importance than its quality.

The accumulating information gained from these investments shows very mixed results. Telephones cannot be connected to each other. Many Chinese are reluctant to talk to strangers. Others are bankrupt. In one case, Cerestar thought creatively about how to adapt transportation of its products for its consumers. However, that joint venture's liquid sweeteners, for example glucose, a product used in beverages, posed many problems. a short-term solution for this joint venture is to consider transporting the glucose in small drums to Southern China, where most of the plant's consumers reside. When it arrives in Shanghai in winter, it will be very thick, but it can be warmed up.

Various multinationals' market research demonstrates large potential for the Chinese market. However, the research often fails to account for competitors entering a newly developed market, resulting in excess capacity, price-cutting and a realization that China's market faces strong regional protectionism. The French car maker Peugeot lost money because of an inability to compete with US white-goods maker Whirlpool, a Daimler-Chrysler truck venture and Australian brewer Foster's. For foreign enterprises, China represents the last big frontier. By learning from the experiences of multinationals and keeping up quality standards, China can develop certain advantages, particularly, to local their companies' better access to distribution networks and connections within China's rambling bureaucracy. In fact, the Chinese government's favorite practice with its' domestic enterprises is to 'study, cooperate, and compete with foreign companies in China in order to build economic strength. Beijing promotes hi-tech transfer and overseas training programs offered by foreign multinationals, in order to get its domestics firms up to speed.

Intellectual-Property Rights and Copyright Violations

The global business-risk-consulting enterprises include China with their Asian neighbors India, Indonesia, South Korea and Thailand. However, for intellectual-property violations, many regard China as being in a league of its own. The nation is a major world center of counterfeiting. Copyright violations are conducted by unscrupulous business people and abetted by the employees of the multinationals being "ripped off". Some mainland-based Western pharmaceutical manufacturers put the counterfeit rate at 10 percent or more. Increasingly, as multinationals suffer losses, decisions about whether to make further investments in China may be dropped altogether or put on hold. The counterfeiting issue influences P&G's ability to raise the prices of its product. Counterfeiters can undercut on price. Foreign multinationals like P&G

face with loss of their revenues in China through counterfeiting and loss of their reputations and their export markets. In addition, when counterfeiters sell unsafe or inferior products, they undermine and harm its owner's reputation and undermine loyalty to the brand with customers.

On the rare occasions when counterfeiting cases get court dates, government officials, even local courts and law-enforcement agencies, always protect the counterfeiter. In some cases, local governments control wholesale markets that trade in counterfeit goods. Thus the counterfeiting issue has not stopped Local governments protect counterfeiters as a way to keep tax revenue and jobs in their jurisdictions.

Regulatory Risks and Politics

Political risk and governmental and national stability, constitutes a major factor in the strategic decision-making of multinationals operating in foreign nations. Political risk exists in many parts of Asia including Indo-China, Indonesia, parts of India and the Philippines. Because China has been relatively peaceful, many multinationals have become complacent about its stability. Despite the uncertainty or regulatory risk about which factions and interest groups will make what governmental policies tomorrow remains most tempting market. For example, China's fast-growing telecommunications market presents much of the regulatory risks facing multinationals. China's telecommunications market has seen growth, making China the largest mobile-phone market in the world. The Chinese are already making their influence among technology standards for next-generation mobile phones.

Corruption

China's pervasive culture of corruption poses a major problem for foreign multinationals operating there. Suppliers routinely pay bribes to the buyers for foreign multinationals, who pass the cost to the multinationals in the form of higher prices for inputs.

The economic success of Hong Kong and Taiwan indicate that overseas, Chinese are able to be globally competitive in business behavior. This success was achieved quickly in the competitive home markets of the developed west. Hong Kong's major customers are the USA and Germany. Products include toys, garments, textiles, furniture, electrical goods, ceramics, craftwork, plastics, and components, as well as industrial products. However, the industrial structures of Hong Kong and Taiwan are not the same. Taiwan possesses deep Japanese industrial influence and has a greater military budget.

Both Taiwan and Hong Kong have many small business enterprises. Their characteristics are as follow:

- Concentrate on one product or market with growth by opportunistic diversification.
- A close relationship of ownership, family and control.
- Small size, and simple organizational structure.
- Weak in creating large size market recognition for brands.
- Generally very sensitive to cost and financial efficiency.

The Chinese family enterprise has a strong leadership ability and is able to exercise a very large amount of decision-making power without consultation. This enable rapid change. The organization is comprised with workers who are obedient and loyal. The Chinese families are ethical and trustworthy with each other. The Chinese family business is generally small. Large family enterprises exist but family domination remains. Chinese family firms have centralized power structures, with all decision making within the family. In overseas operations, for Chinese business, the critical sanction against breaking an agreement is loss of face. Chinese are taught to build and protect it. Hong Kong and Taiwan possesses social stability, increasing

wealth, capital availability, technical sophistication, increasing regulation, extensive education and a large stock of creative entrepreneurs. In other Chinese businesses in Pacific Asia, where they are part of a host society in Malaysia, Indonesia, the Philippines or Thailand, they have succeeded in securing a strong position by extensive political cooptation. For a government to allow a laissez-faire policy, in these circumstances, the decentralization of power can be permitted without destabilizing society. The success of such policies is in the Overseas Chinese norms for keeping long-term stable relations.

Summary

Various foreign multinationals depend on joint ventures with local partners to decipher the local terrain. The local partners ideally would provide knowledge of local conditions and business environments. Foreign multinationals experienced unhappiness with joint-venture partner in China with a number of issues ranging from copyright violations to cultural misunderstandings. Foreign multinationals must undertake extensive on market research and buying habits, customer's tastes and competitor's operations to estimate true market potential and profit targets. For trademark protection and copyright, some multinationals overlook registering the multinational's trademark in China, and make sure that patents have been approved, as well as not just applied, before introducing any technology to China. However, for now, China remains a high-risk but high-potential market.

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ENHANCING HOUSE BUYERS' PROTECTION THROUGH DEVELOPMENT OF HOUSING WARRANTY SYSTEM IN TACKLING HOUSING PROBLEMS IN MALAYSIA

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Abstract

The Housing Industry is one of the active industries which contribute towards economic growth of Malaysia. It has become a venue for competition among the developers in order to fulfill the demands from the public and at the same time to gain profits. With so many housing projects around, often we hear many problems related to the projects such as defects, late delivery, abandoned projects, fraud and others which will mainly affect the house buyers. Although the country's housing industry is strongly regulated by the law under the Housing Development (Control and Licensing) Act 1966, the problems still occur which affected huge volumes of house buyers. Therefore, it is the aim of this paper to highlight the issues that may lead towards enhancing the protection for house buyers in Malaysia through the innovation or development of a comprehensive housing warranty system. Firstly, this paper will briefly explain on the available protection in form of laws or regulations which are related to the housing construction together with their objectives or purposes. Later, it will highlight the current issues which may trigger us on the need for more improvement on the weaknesses and also to provide more protection against the housing problems. The importance of knowing the issues will finally lead towards providing a guideline in implementing a comprehensive warranty system to tackle the housing problems so that the industry can really serves its purpose for a more affordable and sustainable homes.

Keywords: Housing Industry, Housing Problems, House Buyers, Protection

Introduction

Housing problems in Malaysia are in various kinds or categories. Late delivery caused by abandoned projects and defects in foundation and structural works are of the major problems within the industry and are commonly suffered by the house buyers. As an example, from the year 1999 until 2005, data from the Ministry of Housing and Local Government of Malaysia (MHLG) combined together with the Consumer Association of Penang and Consumer Association of Federal Territory of Kuala Lumpur and Selangor recorded that defects in structural and physical workmanship have been the highest in number of complaints as compared to other types of claims such as damages, payment, late delivery, interest, deviation of plan, services, fraud, deposit, transfer, infrastructure, violations of Act or Regulations and agreement of sale and purchase (Sufian and Rahman, 2008). Furthermore, statistics provided by the National House Buyers' Association in 2006 have shown that the number of received complaints relating to shoddy workmanship and defects comprises of 7% out of other complaints which consist of strata issuance (30%), property maintenance (24%), abandoned projects (14%), late delivery claims (12%), certificate of fitness (9%) and non-compliance with building plans and infrastructure (2%).

Abandoned projects is another serious problem in the country. It was reported that from the year 2000 until the month of September 2009, there are total of 148 abandoned housing projects throughout Malaysia which involved nearly 50,000 housing units and more than 31,000 house buyers. As at the year 2009, only 61 of those have been revived and only 12 out of it have been completed. Even if the affected percentage seems to be small, it however involves a very high degree in numbers.

This paper hereby intends to stress out the point that despite many efforts by the government to tackle those problems, the problems still exist and the consequences are suffered by the house buyers. The paper firstly discusses on the available protection for the house buyers in Malaysia and later it highlights the problems that lead towards the need for more protection for them. Finally, this paper provides a kind of framework for the related authorities to develop or improve the current and existing implementation of house buyers' protection through innovation and development of a warranty system.

Review on Current Available Protection

1. Regulatory Control

The Malaysian government had in fact introduced several laws and regulations with regards to the monitoring of construction works by the contractors and also to control some post-construction problems which may be faced by the house buyers. At pre-construction level, the government needs to ensure that the developers, contractors or other parties which are involved in the progress of the projects are officially licensed and given the permit to do the construction works. For example, Section 5[1] of the Housing Development (Control and Licensing) Act 1966 requires that the housing developer to be licensed before engaging in any housing development project. In other words, house buyers must not indulge in purchasing houses from unlicensed housing developers.

Furthermore, the construction works which has been approved by the government must follow certain rules and guidelines in terms of the materials quality or in terms of building regulations which have been laid out by the states or district local councils. For example, the developers and contractors must make sure that certain materials must conform to the approval standard imposed by the laws such as ground floor slabs must be of 4 inches thick as stated in

By-Law 59[9] of the Uniform Building By Laws 1984. These laws have been introduced not only for the purpose of ensuring quality control during the construction stages, but it also reflects certain degree of protection for the house buyers in relation to their rights to living and safety.

In the post-construction stage, house buyers' protection is provided in the form of defects guarantee in which the developers and contractors are under the obligation to rectify any defect found based on complaints and reports within certain limit of time known as the defect liability period. This protection is clearly stated under Schedules G, H, I and J of the Housing Development (Control and Licensing) Regulations 1989 which is incorporated within all the standard sale and purchase agreements (SPA) for newly built-houses by the developers. Until now, the duration of the standard defect warranty period for both landed properties and apartment-type houses is at the length of 24 calendar months, the period of which to be commenced from the day the keys were officially being handed over to the buyers.

Regardless of the laws and regulations introduced by the federal government for the purpose of application towards the whole country, there are also laws that only apply to certain states such as the National Land Code (Penang and Malacca Titles) Act 1963, Sarawak Land Code 1957, and Sabah Land Ordinance 1963. Besides that, there are also rules and regulations which have been set by the state through its legislative council so that it is only applicable within the scope of such state. Such rules which are being passed and enforced within the state shall be enforced either by the state land administrators, district officers or the state enforcement body such as the city council. For example, in some housing development projects, the allocation quota for the Malay people may be different between each state. The significance of the land laws and regulations that have been mentioned is that they are also important in relation to the housing development process in terms of its planning, alienation process and land conversion.

2. Platforms for redress

Besides the regulatory control, house buyers may be able to express their dissatisfaction, complaints and problems to various platforms be it the government authority, non governmental authorities or other professional cum non-profit organizations like National House Buyers' Association (HBA), Malaysian Bar Council, Pertubuhan Arkitek Malaysia (PAM), Federation of Malaysian Consumers Association (FOMCA) and many others which exist in most of the states. Additionally, house buyers may also opt to appoint their own lawyers to argue their case in High Court which has jurisdiction to consider unlimited amount of claims. Otherwise, house buyers can represent themselves if they bring their case before the Tribunal for Home Buyers' Claim for a very minimum processing fee of RM10. However, the Tribunal can only entertain claims of not more than RM50,000. In Peninsular Malaysia alone (except the states of Sabah and Sarawak), the Tribunal has recorded an average of around 2,000 cases each year ranging from the month of December 2002 until January 2009. This indicates that there are serious problems within the housing industry which need to be solved and tackled.

3. Insurance coverage on housing

Besides all the laws and regulations that have been imposed by the government in ensuring guarantee and security, other companies and banks may also offer insurance schemes for house buyers in order to protect their houses from certain risks like fire and theft. According to the General Insurance Association of Malaysia, there are generally three types of housing insurance schemes available in Malaysia namely the fire insurance policy, house owners' policy and house holders' policy or content insurance.

The fire insurance policy gives protection to house buyers in relation with material damage or loss of building and house equipments against fire and lightning or damage caused by

explosion of domestic boilers or gas used for domestic purposes. It may also be extended with some additional premiums to cover other aspects such as damage against riot and strike, aircraft damage, bursting or overflowing of water tanks or pipes, earthquakes, volcanic eruption and others.

The second type of insurance is the house owners' policy which comprehensively includes the fire policy with additional loss or damage against theft and loss of rent against building if it is uninhabitable. The third type of insurance is the householders' policy which covers only the content or certain household goods within a house. This policy is said to be suitable for renters because it does not covers the whole building or the possession of the property.

Basically many banks in the country have already introduced and offered those kinds of policies that have been mentioned either through some underwriter companies or by their own selves. Standard Chartered Bank Malaysia for example, offered housing insurance packages through MSIG Insurance (Malaysia) Bhd, whilst Maybank (Malaysia) Bhd. through their subsidiary Mayban General Assurance Berhad. The home insurance policies offered by the banks usually differ with each other in terms of its branding and modification of scope, but basically contain the same principles and structure.

4. Examples of Regulations on Housing

There are numbers of laws and regulations relating to the housing development and construction which have been introduced by the Malaysian government in order to control and monitor the housing construction activities by the developers. The lists are briefly shown and explained as follows:

4.1 Housing Development (Control and Licensing) Act 1966

The Act was firstly introduced in 1969, then it was revised in 1973, and the latest amendment was in the year 2007, which was only applicable to Peninsular Malaysia. The main purposes of this act are to provide certain guidelines for establishing a licensed housing developer company, to list certain duties that a licensed developer needs to adhere to, and also to clarify certain powers that the Minister may invoke in the event of breach of all the requirements and duties. It provides for the detailed procedures on how to apply for the developer's license such as the application and the requirement of certain amount of deposit (Section 5 and section 6A). The duties of a licensed developer are mentioned under part 3 of the act such as to report on any progress of the construction works for every six months until the certificate of completion and compliance has been obtained (Section 7[f]), and the duty to maintain the housing development account (Section 7A). In the event of breach of any of the provision of the act, the Minister may have the power to either revoke or suspend the license of a developer (Section 13). Furthermore, the act also provides for the details on the establishment, functions and powers of the Tribunal for Home Buyer Claims. For example, Section 16C explains about the membership composition within the Tribunal, Section 16L explains on the requirement for commencement of proceedings before the Tribunal, while the jurisdiction of the Tribunal is stated under Section 16M.

The act also contains sub-regulations which provide for more detailed and specific explanations on certain issues such as the guidelines for sale and purchase agreements under the Housing Development (Control and Licensing) Regulations 1989 which has been amended in the year 2008. Meanwhile, the Housing Developers (Control Housing Development Account) Regulations 1991 was introduced mainly to clarify issues relating to the establishment and maintenance of housing development account by the developers, and the Housing Development

(Tribunal for Homebuyer Claims) Regulations was introduced in 2002 with the purpose of providing more detailed about the technical procedures which are to be involved in the Tribunal process.

4.2 Building and Common Property (Maintenance and Management) Act 2007

This act which was applicable only to Peninsular Malaysia and the Federal Territory of Labuan relates to the post construction stage whereby it explains the need for an establishment of a Joint Management Body by the developers and the property owners after the subdivided land or building has been completed. The purpose of having a management body is to ensure that the common properties inside the building is to be maintained so that the property owners can enjoy the use of the properties. In Malaysia, the role of establishing the Joint Management Body is the developer's responsibility whereby they have to convene a meeting among the owners to determine the membership committees as representatives for the owners (Section 4 until Section 6). The body itself has its own duties that need to be obeyed as listed under Section 7. Additionally, Part 4 of the act provides for the developer's requirement to establish a building maintenance account (Section 16) while Part 5 explains the duty of property owners to pay service charges for the maintenance of the common properties (Section 23).

4.3 Strata Titles Act 1985

This act which applicable only to the Peninsula Malaysia was lastly amended in 2007 in order to provide the detailed explanations on the technical processes and procedures to be involved in the subdivision of land or building. For example, the proprietor of the land or building needs to apply for subdivision to enable all owners of the subdivided units which is known as 'parcel' under the land or building to have their own proprietary rights, thus they shall be entitled for a separate document of title. This will lessen the burden of the original proprietor

of the land or building in paying the quit rent because once the land or building has been subdivided, each owner of the individual parcel shall be responsible to pay their own quit rent.

In brief, Part 2 and Part 4 of this act explains about the process in applying for subdivision of land or building (Section 10), while Part 3 explains about the registration of strata titles in the strata register. Part 6 explains about the rights attached to individual parcels or blocks while Part 7 lays out the requirement for an establishment of a management corporation after the land or building has been subdivided. Furthermore, any dispute regarding the process of subdivision shall be directly brought before the Stata Titles Board which is formed under Part 9A of this act (Section 67A).

4.4 Street, Drainage and Building Act 1974

This act serves the purpose of consolidating the laws relating to street, drainage and building in local authority areas in West Malaysia whereby Part 2 of this act covers the provisions relating to streets, Part 3 covers the provisions relating to drains, while Part 5 covers the provisions relating to buildings.

Under Part 2, it provides the maintenance procedures for public streets (Section 4), widening of private streets (Section 14), procedures on putting up lamp posts (Section 26), putting streets' names (Section 29), and penalty offence for obstruction (Section 46).

As regards to drains, the local authority is given the rights to improve, repair or alter the drains as it deems necessary (Section 51 until Section 54). Furthermore, Section 55 provides for the penalty for the offence of making unauthorized drains.

Finally, Part 5 explains the building provisions whereby Section 70 stated that there should be no erection of building unless with the approval from the local authority. Additionally, the local authority may conduct an inspection to ensure that any erection of building is approved

by the local authority (Section 70D). Besides, the authority may instruct any building owners either to repair or demolish building which is considered unfit or unsafe (Section 83 and Section 89). The building provisions also provide the penalty against non-compliance in using combustible materials in walls or roofs (Section 78).

Issues On House Buyers' Protection

1. Limited scope on defect warranty

Defect warranty is a type of mandatory protection given to house buyers in the form of post-construction guarantee according to the Housing Development (Control and Licensing) Regulations 1989. In terms of duration, the length of defect warranty is for the period of 24 months starting from the date of the handing over the property keys or possession of the properties to the buyers. In other words, complaint of defects must be made within the warranty period and the developer or the contractor shall be obliged to repair the defects within 30 days of the complaint being made. Additionally, the said warranty only covers houses which are newly built and which are directly purchased from developers. Therefore, if the purchase involves second-hand houses or subsidiary sale which is known as 'sub-sale', therefore there is no clear provision to provide the defect warranty in the sale and purchase agreement (SPA). The types of sale and purchase contracts or agreements are drafted in a standard way under the Schedules G, H, I and J of the Housing Developers (Control and Licensing) Regulations 1989.

Hence, the format of the SPA in second-hand houses or sub-sale contract is totally at the control and discretion of the seller, so long as not to contradict the main principles of the contract in the Contracts Act 1950. This also indicates that house buyers will not enjoy a standard home warranty for all types of purchases whereby the second or subsequent buyers may not be able to enjoy the standard housing warranty scheme as what has been enjoyed by the first original

buyers. As cited by Ong (1997), Blumenthal (1994) reported that the coverage of home warranties can be limited. The rationale should consider that the second or subsequent buyers to be also entitled for standard warranty as the properties involved have been used and therefore are more open to risks.

2. No clear provision on project completion

Besides defects, abandoned projects are also a serious problem in the housing industry. In fact, housing warranty should not only cover defects but it must also look into other aspects such as completion and home financing. Countries like Korea and Sweden are good examples to follow in terms of completion warranty. In Korea, there are various kinds of guarantee such as guarantee for completion, project financing, rental dwellings and others (Pyo, 2005) whereby in Sweden, the warranty policies are also extended to insurance against non-completion of the building contract due to death, disappearance or insolvency of the builders (Jutehammar, 2005).

Until now, the standard SPA in Malaysia does not incorporate strict rules on completion warranty by the developers, and therefore this will put more burden on the buyers in paying the financial installments if the projects are delayed and, at the worst, abandoned. In other words, there should be some kind of guarantee to be applied in pre-construction stage as well as in post-construction stage (Sibly et al., 2009). For example, there should be a warranty clause that the houses shall be completed within certain timeframe by the developers to avoid unnecessary abandonment whilst house buyers should be given financial warranty that payment of installments shall not be made if the construction stops.

Additionally, the home insurance policies offered by the banks also quite limited in scope. For example, there are policies which include the coverage for projects which are still under construction, but the effect or the purpose of the insurance is to settle the loan on behalf of

the customers' in the event of death or permanent disability. In other words, it still does not cover the costs in the event of non-completion or abandonment of the construction projects.

3. Duration and length of defects warranty

The most common problem suffered by the house buyers regarding defects is that those defects are to be found or discovered after the defect warranty period. As explained earlier, as stated in the Housing Development (Control and Licensing) Act 1966, the defects liability period for the contractors or developers to rectify is within 24 months from the date that the keys were handed over to the buyers. In other words, when the defects were only to be found or emerged after the standard warranty period of 24 months therefore the affected house buyers would have to repair the defects with their own costs and expenses. The question is whether the existing length of defects warranty is sufficient enough to protect the house buyers, especially against latent defects.

It has been suggested that longer period of housing warranty was claimed to be more reliable as compared to the shorter one in which, housing should like other durable products have a long term warranty (Xiao and Proverb, 2002). In the UK for example, warranty for structural defects or latent defects is being offered for up to 10 years (Carter, 2005) whilst in Australia, the warranty period for structural defects is offered at a minimum of 6 years (Mamutil, 2005). Factually, not all warranty schemes will be able to cover for unlimited time warranty, because the warranty providers may not be able to cater for lifetime risk support as they only have limited funds and probably looking for more profits rather than risks. However, Malaysia as a country which were considered safe from earthquakes, hurricanes and volcanoes should at least consider and try to pick up examples from those countries with higher risks of natural disasters but

managed to implement longer home warranties in order to provide appropriate protection to the house buyers.

4. Procedures, effects and powers upon complaints

There are a lot of complaints made against developers in every year for causes such as late delivery, abandoned projects, defects and others which have been mentioned before. However, According to the Ministry of Housing and Local Government, only developers who have breached the enacted laws and regulations such as the Housing Development (Control and Licensing) Act 1966 shall be taken necessary action by the ministry, otherwise if the breach is related to non-regulatory or just contractual breach, the affected parties themselves have to bring the case for trial. It was reported that from 2006 until 31st of March 2009, there are 537 cases have been brought to court for breaching regulations under the Housing Development (Control and Licensing) Act 1966.

House buyers therefore have to really determine whether a complaint relates to a regulatory breach or just a contractual terms breach before bringing up the case to the ministry. In other words, the buyers must invoke the appropriate regulations related to the offences. This should not be the problem for some house buyers whom can afford to hire their own legal advisors and bring the matter before the high court with higher processing fees, but this will not be the case for some others who reflect the lower income groups of people. In the event that the breach is just a contractual breach, the parties may either opt for trial before the Tribunal for Home Buyers Claim for claims not exceeding RM50,000 or to appoint lawyers to bring the matter to open court but with more costs.

The establishment of Tribunal for Home Buyer Claims in 2002 as one of litigation platforms against developers is seemed to have minor effects on the protection of house buyers.

During its early establishment, the limitation to the limit of award by the Tribunal whereby the limit for claiming award was less than RM25,000. If the amount of claim is more than that, the Tribunal will have no power to hear the claim and it will be at the option of the affected house buyers either to proceed or not with legal actions in courts. Of course the house buyers may represent themselves in a Tribunal without any assistance from legal council as compared to the court proceedings. However, with the recent amendments in 2007, the Housing development (Control and Licensing) Act have increased the power of the Tribunal so that it can hear claims up to the amount of RM50,000.

Even with the increased amount, it is still doubtful that most of the claims will be less than RM50,000 by looking at the increasing property values these days. For example, the low cost houses can be said to be priced within the range between RM35,000 to RM45,000 for each unit. Then if the related project fails to continue or has been abandoned, the affected house buyers may have to claim close to double the amount of the price. The look into the financial aspects should also be considered as how much the buyers would pay to the financial institutions in the event the houses are yet to complete. It is however important to note that the procedural application for hearing before the Tribunal still seemed to be a complicated process for a layman whereby many forms will be required to be fulfilled. It is quite a difficult task except with some help from individuals or organizations which have been involved in the said process.

5. Responsibility and accountability of the contractors

The point which is to be raised in this discussion is that whether the existing regulations were really sufficient to raise the responsibility and accountability of the developers. In other words, in some cases of defects, the developers or contractors shall be willing to rectify them according to the regulations. However, in most of the times, the quality of rectification could be

argued. The defects will normally appear again and by the time the defects have reappeared, the defects warranty expires thus the house buyers will not be able to invoke the warranty. Therefore, there is doubt in terms of the quality of the materials being used, or in terms of the seriousness of the contractors undertaking the rectification works. There are some developers who willfully undertook the responsibilities to rectify defects with proper adherence, but there are also reports of those who did not put precautions in rectifying the defects. The responsibilities to act upon complaints or reports were found to be in existence, however the accountability of ensuring quality works is still in question. There are no checking mechanisms to ensure that the repair-job is appropriately completed or guaranteed. Sometimes the rectifications are only being done after several complaints, or when it involves only major defects, whilst there are cases where the repairs were done by non-qualified contractors. In Malaysia, the provision under the Housing Development (Control and Licensing) Regulations 1989 provides that the rectification works must be done within 30 days upon complains. In Korea as an example, the rectification works must be done within 3 days (Pyo, 2005).

In the pre-construction stage, there is a requirement under Section 7[f] of the Housing Development (Control and Licensing) Act 1966 that imposes the developer to submit the details on the construction progress in every 6 months. Many developers would tend to miss out this obligation and finally would lead to some delays in their projects. It is up to the developers themselves to initiate the effort to submit the progress to the higher authority. For house buyers, they will not be bothered with such necessity on behalf of the developers as what is important for them would be the final end of the product which is the house. It is therefore critical not only to impose certain strict regulations in rectifying defects but it must be together with inculcation of

values in terms of accountability amongst the developers or contractors as they are one of the key players and also the end-providers in the housing industry.

Research Design

Before looking into the current practice of home warranty system in various countries, it is important for the literature to focus on the features of the general warranty arising from either product or service warranty because it also acts as an assurance for a product to serve its purpose, or to be free from certain defects. From the literature, four main features were highlighted which are classified into contractual obligation, coverage, duration and the structure. For example, in terms of obligation, the promise or the assurance to provide repair or additional services constitutes legal and contractual obligations or liability for the seller or manufacturer that it will be an offence if it is not adhered to (Murthy and Djamaludin, 2002). Therefore the manufacturer will try to produce quality materials to reduce the liability of providing additional costs for repair or other services.

In terms of coverage, the literature focuses on warranty only towards the extent of its physical coverage or in simple word is the extent of service being provided such as to repair or to replace in the case of defects, malfunctions and non-performance. Emons (1989) stated that the warranty cannot be enforced if the products or goods perform satisfactorily. If the products or goods do not perform satisfactorily, it means that they have failed in their functions and therefore the buyer or customer may invoke the liability against the seller or the manufacturer to either repair or replace the goods concerned (Murthy and Djamaludin, 2002).

Another critical feature of warranty is the duration whereby it is usually limited but there is no prescribed length or duration for warranty as it usually depends on the kind of manufactured product. It has been stated that a warranty is a form of obligation that a seller or a

manufacturer undertakes to repair or replace product within specific time (Srivastava and Mitra, 1998; Karim and Suzuki, 2005). Therefore, the claim for warranty repair or replacement should be done within the specified warranty period (Jack & Schouten, 2000). If the claim is made after the warranty period, therefore the warranty terms may exclude the manufacturer's liability towards the buyers.

The last feature which is discussed in the literature is the structure whereby the warranty may be differently designed in order to suit the subject matter of the warranty, which is the product itself. Buczkowski et. al. (2005) stated that the warranty design should consider certain issues such as the length or the period, quality control, the repair policy and the warranty policy. This means that there are certain criteria that need to be looked at before a warranty package can be finalized as a framework.

In the current practice in Malaysia for example, the form of warranty available is the defect liability period whereby the developers will hold the liability and responsibility to repair any defect which appears and being reported within specific duration of time up to the maximum thirty six months beginning from the handing over of vacant possession of the houses or units. There are no specific warranty schemes in order to cover for pre-construction and pre-completion period. In some other countries like Sweden and Canada, home warranty was introduced and applied for more than 10 years ago whereby the liability period for home latent defects warranty is offered up to a maximum of 10 years. In pre-construction period, the warranty for project completion is up to 2 years. The task of the assessment agencies as warranty providers is to ensure that the quality of houses is maintained throughout the offered warranty period. In Korea for example, there are many types of warranty services being offered for the house buyers whereby interestingly there is even a warranty services which can guarantee the

repayment of the principal and interest of the builders or developers' debt financing or project financing (Pyo, 2005). Interestingly in U.S., the home warranty does not only include constructional or material defect, but it also covers additional post-services such as lawn services and furniture cleaning as part of the warranty package.

From these features combined with some examples of housing warranty implementation in other countries which has been described earlier, a model of a housing warranty system is developed which comprises of some improved practices. This model as illustrated in Figure 1 shows the innovation of the housing warranty system through some criteria of best practices.

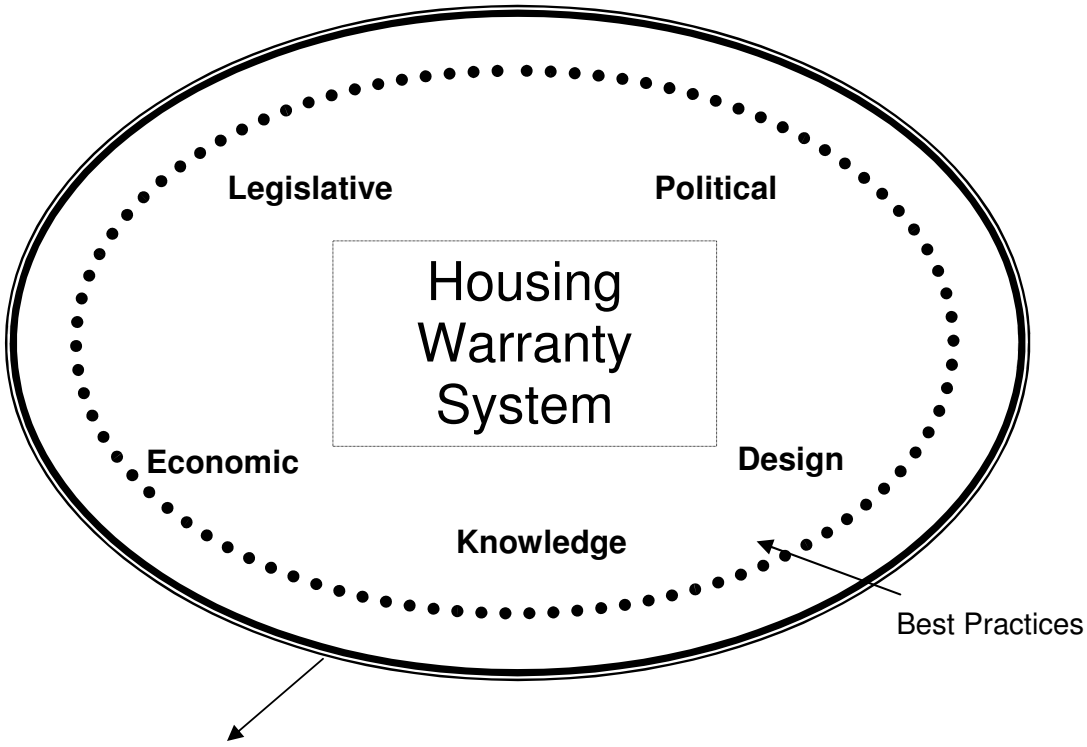

Figure 1. A developed model which identifies the criteria for best practices of housing warranty system which derived from the basic features

A few criteria of best practices were highlighted and classified into five categories such as legislative control, political and economical influences, the knowledge process and the design. The legislative control comprises the scope of enforcement, coverage and duration whereby through enforcement, both buyers and sellers can invoke their liabilities and claims (Murthy and Djamaludin 2002). The enforcement will ensure that the seller is bound to sell quality product or house and at the same time the buyer is to consume the product or house according to its purpose. In the aspect of coverage, a seller may opt to either repair a defective product or to replace it with a new one (Murthy and Djamaludin 2002).

In another dimension, housing warranty is also applicable to either pre-construction stage or post-construction stage according to Sibly *et al.* (2009). At the pre-construction stage, relevant warranty scheme such as completion guarantee has been practiced in countries like Sweden and Korea which provides for guarantee against the non-completion of the building project (Jutehammar 2005; Pyo 2005). In the post-construction stage, many countries have implemented latent defects warranty such as in UK, Japan, Korea and Australia (Sibly *et al.* 2009) in which the period or length of warranty period is for 10 years commencing from the completion date of the buildings.

In terms of duration it was shown that longer warranty period will infer that the product is considered to be more reliable (Chukova and Hayakawa 2005) and there are higher preferences towards longer warranty period compared to the shorter ones (Xiao and Proverbs 2002, Karim and Suzuki 2005).

The political approach is another important factor which can contribute towards a good warranty system whereby government has a very strong influence over the stakeholders. For example, Malaysian government has come up with necessary laws and regulations to control the

activities of the developers and it also introduced the optional "Built Then Sell" concept in 2006 purposely to provide an alternative for house buyers who are interested to buy houses after completion (Yusof *et al.* 2009). Similar approach has been taken by the Korean government whereby it involved and ventured with one of the dominant housing warranty company providers to promote housing guarantee for the purpose of protecting the customers or house buyers from unnecessary problems (Pyo 2005).

In economic approach, the developers especially have to think for the best way to optimize their costs and at the same producing quality and affordable housing accommodation (Bliscke and Murthy 1996; Murthy and Djamaludin 2002). This is considered one of the crucial challenges for them in order to survive the market and also to compete with many arising developer companies.

In terms of design, to form a warranty contract is not that simple as some issues must be considered such as the length, period, quality control and the repair policy (Buczkowski *et al.* 2005). For this purpose, the seller or manufacturer should be innovative in promoting a kind of warranty that could attract the customers such as adding some extra services on top of the existing guarantee of its products. For example, in housing warranty, providing extra maintenance services has been existed and practiced in the USA by a well known company namely the 'American Home Shield (AHS)'. AHS was considered as the oldest and the largest home warranty company in the USA (Gwin and Ong 2001).

The knowledge approach is the way to inculcate the correct information for the house buyers so that they will not be tricked by depending too much information by the sellers or developers themselves without doing own personal research (Yusof *et al.* 2009). The stakeholders must also play their role to help to spread the information on the current housing

system to the house buyers and at the same time, the developers must also equip themselves with new knowledge technology to make them more efficient in producing their workmanship.

Conclusion

Housing industry cannot be free from problems such as defects and abandoned projects. The imposition of regulations as a method of enforcement alone cannot tackle almost all the problems, but with support from the stakeholders within the industry and with proper housing delivery system, there would be major boost in handling or tackling those problems. The ultimate aim for housing is to provide living places which are affordable, and at the same time to provide security and protection to the house buyers against problems that were merely caused by the unscrupulous developers and contractors. It is hoped that the scope of this paper would be able to be opened into future detailed research or discussions on the issues related to the house buyers' protection in the country and perhaps the developed framework shall be able to be adapted and implemented at the same level of housing warranty system as what has been practiced in some other countries like the US, UK, Japan, Korea, Australia and Sweden. The development of the housing warranty system should also be monitored and be revised gradually in order to suit with the arising and expanding of new knowledge and technology.

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OPTIMIZING MULTIPLE QUALITY CHARACTERISTICS BY TAGUCHI METHOD AND TOPSIS ALGORITHM

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Abstract

In the anisotropic vinyl magnet industry, the multiple quality characteristics must be assessed simultaneously due to product and manufacture process complexity. Taguchi method has been employed to improve the performance of products and processes over years. However, most of the applications are only limited to single quality characteristic. This study presented an optimization procedure for multiple quality characteristics by integrating Taguchi's Method with TOPSIS algorithm. By using the approach to optimize multiple quality characteristics, the best combination of parameters could be found easily. A case study was illustrated to confirm the feasibility and effectiveness of the proposed approach that was expected to reduce production costs and to enhance industrial competitiveness.

Keywords: Multiple quality characteristics, Taguchi method, TOPSIS, Optimization

Introduction

With the progress of high-tech industry and the complexity of product structure, so when considering multiple quality characteristics upon the product or process, it is more extremely difficult to determine the best combination of parameters in the manufacturing. In recent years, many scholars gradually focus their study on the issue of multiple quality characteristics. Their research is mainly to identify the most effective way to determine the parameters to substitute what the engineers or operators are dealing with by using their practical experience.

The Taguchi Method

The Taguchi method is also known as the Robust Design approach. The Robust Design is a way which adapts engineering optimization approach to improve qualities. It can be used to improve the product quality and manufacturing process design technologically as well. Its goat is to pursue their stability in quality aspect. The Taguchi method, considering quality characteristics both in the stage of their manufacturing design and in the assessment of their cost-effectiveness, can greatly enhance the product quality outcomes. Tzeng (2003) applies Taguchi method to study the best parameter design in the high-speed CNC milling process. The parameter design is the way the Taguchi method to optimize the design of manufacturing parameters. An orthogonal array is designed to conduct experiments. It can make the noise factor of products less sensitive to interferences, and can reduce product quality variability as well. For example, Zhang, Chen and Kirby (2007), adapts Taguchi parameter design method to minimize the surface roughness in surface grinding of metal cutting.

Optimizing Multiple Quality Characteristics

With the increasing complexity of product design, product quality problems can not be perfectly solved with the optimization on single quality characteristic. The multiple quality

characteristics need to be seriously considered at the stage of optimization. Therefore, many scholars use the traditional Taguchi method to improve the optimal parameters under the existence of multiple quality characteristics. Antony (2000)(2001) modifies the traditional Taguchi loss function to simulate the optimization of process in multi-quality characteristics. Jeyapaul, Shahabudeen and Krishnaiah (2005) also consolidates and inducts the issue of multiple quality characteristics by using the method of fuzzy theory, gray relational analysis, neural networks, and principal component analysis.

Under the multiple quality characteristics, it is a major problem to integrate the measures of multiple quality characteristics. The common approach is through the desirability function. The desirability function was proposed in 1965 by Harrington. Its main idea is to solve the issue through the mathematical conversion by transforming multi-objective problem into single objective problem. Wu (2006) and Chang (2008) use the response surface and neural networks methodology, which combine with the desirability function, to integrate multiple quality characteristics into a single function, and then solve the problem of multiple quality optimizations. Another scholar has put forward after the multi-criteria decision making method such as Technique for Order Preference by Similarity to Ideal Solution, TOPSIS. The TOPSIS is proposed by Hwang & Yoon (1981) to solve the issue of multiple criteria decision. The TOPSIS evaluation method is mainly used in the sort of performance assessment, such as: Pi (2005) combines TOPSIS and Analytic Hierarchy Process (AHP) to rank the performance of suppliers. Gradually, this assessment is also applied to processes that integrate multiple quality characteristics into the overall performance indicators (OPI). Such as, Tong, Wang, Chen and Chen(2004) combines principal component analysis and TOPSIS to simplify the process optimization under multiple quality characteristics. Chang Wang and Liu(2005) has suggested

that Taguchi method & TOPSIS can be integrated into a valuable feasible model for the application of multiple quality characteristics in the electrical discharge machining industry.

However, those analysis methods are too complicated to implement. The Taguchi method is recognized as the experimental method with the R&D and cost efficiency. Therefore, this case study tried to apply the Taguchi method, along with TOPSIS algorithm, to construct the optimal manufacturing parameters to simplify the improvement of product qualities in the anisotropic vinyl magnet industry. And it was expected to reduce its production costs and to enhance industrial competitiveness.

Methods

This case study focused on how the best control factors (input parameters) were simultaneously designed when a process or product was under the existence of multiple quality characteristics. The study integrated the Taguchi experimental design with TOPSIS algorithm to easily simultaneously determine the best combination of factors.

The Taguchi Method

The Taguchi experimental design was largely based on an orthogonal array. The analysis was firstly to select an appropriate orthogonal array, and then to place on the parameters in the standard array at different levels. After accomplished the experiment, following the design of the orthogonal array, each group of the experimental *S/N* ratio could be calculated from the collected experiment data. The *S/N* ratio, according to the individual quality characteristic, would be calculated with one of the equation of the higher the better (*HB*), the lower the better (*LB*) and the nominal the better (*NB*), respectively. The *HB*, *LB*, and *NB* are defined as following:

$$HB : \eta = -10 \log\left(\frac{1}{n}\sum_{i=1}^{n} y_i^{-2}\right)$$

$$LB : \eta = -10\ log\left(\frac{1}{n}\sum_{i=1}^{n} y_i^2\right) \quad (1)$$

$$NB : \eta = -10\ log\left(\frac{1}{n}\sum_{i=1}^{n} (y_i - \mu)^2\right)$$

Where η: the *S/N* ratio calculated from the experimental observations; y_i: the measured value of the observation for i^{th} experiment; μ: The nominal value; n: number of repetitions for each experiment.

The TOPSIS Algorithm

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) algorithm was used in this case study, under the process for multi-quality characteristics, to find the best combination of parameters. With weights for each assessment criteria, the entropy method was used to get their objective weight. The entropy method originally refers to the phenomenon of physics. It is based on the concept proposed by Shannom in 1948. Typically, it is used to measure the uncertainty mathematically. That is, the greater the entropy value, the greater degree of random. The entropy is also adapted to measure the objective attribute weights. The greater the entropy value of the attribute, the more objective the attribute weight implied (Yen and Wang, 2005). The TOPSIS algorithm implemented the following steps:

1. Construct the original data evaluation matrix

To assess m types of control factors with n sorts of appraisal criteria of the quality characteristic, the evaluation needed to construct an original matrix D.

$$D = \lfloor x_{ij} \rfloor_{m\times n} \quad i = 1,2,....,m \quad j = 1,2,....,n \quad (2)$$

Where x_{ij} was the array of i^{th} experimental alternatives with j^{th} assessment criteria without normalized for the original assessed value.

2. Normalize the original matrix

In order to objectively compare among the quality characteristics, it needed to normalize the original matrix. The r_{ij} was the assessed value after normalization. $R = [r_{ij}]_{m \times n}$ was the normalized matrix.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad i = 1,2,..., m \ , \quad j = 1,2,..., n \tag{3}$$

3. Using entropy to calculate objective weight and the weighted matrix

Firstly calculated the entropy value e_j of the assessment criteria for each quality characteristic, and secondly calculated the weight of each evaluated criteria. The e_j was the entropy value for the j^{th} criteria.

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^{m} r_{ij} \ln r_{ij} \quad i = 1,2,..,m \ , \quad j = 1,2,..,n \ . \tag{4}$$

The weights of each evaluated criteria w_j were then calculated:

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n} \left(1 - e_j\right)} \quad i = 1,2,.., m \ , \quad j = 1,2,.., n \tag{5}$$

Suppose the weight of n criterion was $W = (w_1, w_2, ..., w_n)$. Then, in the normalized evaluation matrix $R = [r_{ij}]$, each criterion was multiplied by its weight. It was called the weighted matrix V.

$$v_{ij} = r_{ij} \times w_j , \quad V = \left\lfloor v_{ij} \right\rfloor_{m \times n} i = 1,2,..., m \ , \ j = 1,2,..., n \tag{6}$$

4. Calculate the positive and negative ideal solution (V^+, V^-)

In order to rank the priority of samples with m types of parameters and n sorts of evaluation criteria, it needed to find out the positive ideal solution and negative ideal solution for the relative ranking among the parameters. The positive ideal solution was set to $V^+ = \left\{v_1^+, v_2^+, ..., v_n^+\right\}$, comprised from the optimal value of all the assessment criteria (i.e., benefit

criteria). The negative ideal solution was set to $V^- = \{v_1^-, v_2^-, ..., v_n^-\}$, comprised from the worst values of all evaluation criteria (i.e., cost criteria).

5. Separation measure: respectively calculated the distance from assessed samples to positive and negative ideal solution

According to Euclidean distance equation, the relative separation, between each sample and positive, negative ideal solution, could be obtained and denoted as S_i^+, S_i^- respectively.

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2} \quad i = 1,2,..., m, \quad j = 1,2,..., n \tag{7}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2} \quad i = 1,2,..., m, \quad j = 1,2,..., n \tag{8}$$

6. Relative closeness: calculate the OPI values *(*C_i*)*

Overall performance indicator (OPI) values (C_i) was calculated from the distance between each criteria and the negative ideal solution, S_i^-, which was put as the numerator of fractional number. The greater the S_i^- value, the closer the distance between the criteria and the positive ideal solution. At the same time, it also meant the larger distance between the criteria and negative ideal solution. Therefore, it was better with a larger S_i^- value.

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad i = 1,2,..., m \tag{9}$$

7. Formulate the response table to find the best combination of parameters

After obtaining the common measure, *OPI* value, from TOPSIS operations, it needed to average the *OPI* values for every level of each factor (parameter), and formulate those *OPI*s into a response table. The purpose of the table was to identify the factor level with the largest response value. The factor level would be the best combination of manufacturing parameters in the confirmation test.

$$\overline{T}_k = \frac{1}{n}\sum_{i=1}^{n} C_i \qquad (10)$$

Where $\overline{T}_k$ was the average OPI value of the same level on k^{th} factor.

The Case Study

One of the project's sponsors, Jasdi Magnet Co. LTD. in the central of Taiwan, suggested that eight control factors all with 3 levels, except (A) with 2 levels, be selected to conduct this study. The weight of materials (%) was based on the weight of magnetic powder. The factors included (A)Antioxidants, (B)Synthetic plastics, (C)Stabilizer, (D)Lubricants, (E)Flow auxiliary, (F)Thickening agent, (G)Compounding temperature, and (H)Compounding time. The control factors and their levels were included in Table 1.

Table 1. Control factors and levels

Levels / Factors	1	2	3
A. Antioxidants (%)	A_0 – 0.1	A_0	---
B. Synthetic plastics (%)	B_0 - 7	B_0	B_0 + 8
C. Stabilizer (%)	C_0 - 0.1	C_0	C_0 + 0.1
D. Lubricants (%)	D_0 - 0.2	D_0	D_0 + 0.2
E. Flow auxiliary (%)	E_0 - 0.1	E_0	E_0 + 0.1
F. Thickening agent (%)	F_0 - 0.1	F_0	F_0 + 0.1
G. Compounding temp (□)	G_0 - 20	G_0	G_0 + 20
H. Compounding time (min)	H_0 - 2	H_0	H_0 + 2

According to the suggestion from the technical personnel, the study analyzed the following three quality characteristics:

Residual Induction (RI, Gauss) set to the attribute of *HB*.

Specific Gravity (SG) set to the attribute of *LB*.

Magnetic Attraction Forces (MAF, $KgCm^2$) set to the attribute of *HB*.

1. Deploy the experiment and calculate S/N ratio

According to the number of factors and their levels listed in Table 1, the study would deploy the experiment with an orthogonal array of $L_{18}(2^1x3^7)$. After executing experiments and collecting their data, by using equation (1), the *S/N* ratio of three quality characteristics was calculated and summarized in Table 2.

Table 2. The *S/N* ratio of each quality characterics

No.	A	B	C	D	E	F	G	H	RI	SG	MAF
1	1	1	1	1	1	1	1	1	56.3733	8.3519	16.7770
2	1	1	2	2	2	2	2	2	56.3865	8.6032	14.4855
3	1	1	3	3	3	3	3	3	56.2226	8.4686	16.5215
4	1	2	1	1	2	2	3	3	56.1687	8.3633	16.2583
5	1	2	2	2	3	3	1	1	56.6160	8.4456	17.9525
6	1	2	3	3	1	1	2	2	56.8355	8.6289	17.8419
7	1	3	1	2	1	3	2	3	56.7265	8.5565	17.7298
8	1	3	2	3	2	1	3	1	56.5775	9.2084	17.9525
9	1	3	3	1	3	2	1	2	56.9226	8.6289	18.1697
10	2	1	1	3	3	2	2	1	56.9473	8.4226	18.9878
11	2	1	2	1	1	3	3	2	56.4695	9.0741	18.4856
12	2	1	3	2	2	1	1	3	56.6075	8.8450	18.6900
13	2	2	1	2	3	1	3	2	56.7138	8.6032	18.7904
14	2	2	2	3	1	2	1	3	55.9315	8.4732	15.8478
15	2	2	3	1	2	3	2	1	56.9843	8.6454	18.8897
16	2	3	1	3	2	3	1	2	56.2404	8.7804	19.6454
17	2	3	2	1	3	1	2	3	56.8147	8.6925	18.0618
18	2	3	3	2	1	2	3	1	56.6417	8.6854	19.3697

2. Use TOPSIS to obtain a common indicator, OPI value

The case study conducted the following steps:

Step1: Define the original data matrix and construct its normalized matrix

According to *S/N* ratio equations, the *S/N* ratios, which were the performance value of the original matrix, were calculated as listed in the left part of Table 3. The original data matrix was normalized according to the equation (3) and shown in the middle part of Table 3.

Table 3. The original data matrix, normalized matrix and weighted matrix

No.	Original data matrix			Normalized matrix			Weighted matrix		
	RI	SG	MAF	RI	SG	MAF	RI	SG	MAF
A1	56.3733	8.3519	16.7770	0.2349	0.2278	0.2215	0.4983	0.4831	0.4686
A2	56.3865	8.6032	14.4855	0.2350	0.2347	0.1913	0.4984	0.4977	0.4046
A3	56.2226	8.4686	16.5215	0.2343	0.2310	0.2181	0.4970	0.4899	0.4615
A4	56.1687	8.3633	16.2583	0.2340	0.2281	0.2147	0.4965	0.4838	0.4541
A5	56.6160	8.4456	17.9525	0.2359	0.2304	0.2370	0.5004	0.4886	0.5015
A6	56.8355	8.6289	17.8419	0.2368	0.2354	0.2356	0.5024	0.4992	0.4984
A7	56.7265	8.5565	17.7298	0.2364	0.2334	0.2341	0.5014	0.4950	0.4952
A8	56.5775	9.2084	17.9525	0.2357	0.2512	0.2370	0.5001	0.5327	0.5015
A9	56.9226	8.6289	18.1697	0.2372	0.2354	0.2399	0.5031	0.4992	0.5075
A10	56.9473	8.4226	18.9878	0.2373	0.2298	0.2507	0.5034	0.4872	0.5304
A11	56.4695	9.0741	18.4856	0.2353	0.2475	0.2441	0.4991	0.5249	0.5163
A12	56.6075	8.8450	18.6900	0.2359	0.2413	0.2468	0.5004	0.5117	0.5221
A13	56.7138	8.6032	18.7904	0.2363	0.2347	0.2481	0.5013	0.4977	0.5249
A14	55.9315	8.4732	15.8478	0.2331	0.2311	0.2093	0.4944	0.4902	0.4427
A15	56.9843	8.6454	18.8897	0.2374	0.2358	0.2494	0.5037	0.5001	0.5276
A16	56.2404	8.7804	19.6454	0.2343	0.2395	0.2594	0.4971	0.5079	0.5487
A17	56.8147	8.6925	18.0618	0.2367	0.2371	0.2385	0.5022	0.5028	0.5045
A18	56.6417	8.6854	19.3697	0.2360	0.2369	0.2558	0.5007	0.5024	0.5410

Step2: construct the weighted matrix

Firstly, to eliminate the impact by the subjective views of decision makers, this study, by using the equation (4) and (5), adapted Entropy method to calculate the objective weight for each assessment criteria in the normalized matrix. The objective weight of each assessment criteria was found to be W_j = (0.3297, 0.3352, 0.3352). Using equation (6), then the normalized matrix would be, respectively, multiplied by its weight. The weighted evaluation matrix could be found in the right part of Table 3.

Step3: Calculate the distance from the positive and negative ideal solution for each evaluated sample

The positive and negative ideal solution was respectively found out as $V^+ = \{0.5037, 0.5327, 0.5487\}$ and $V^- = \{0.4944, 0.4831, 0.4046\}$. With equation (7) and (8), the distance from positive and negative ideal solution for the assessment samples was calculated and summarized in the middle part of Table 4.

Table 4. The distance from positive and negative ideal solutions and *OPI* value

No.	The distance		OPI value (C_i)
	S_j^+	S_j^-	
A1	0.0944	0.0641	0.404613
A2	0.1484	0.0151	0.092237
A3	0.0974	0.0573	0.370446
A4	0.1067	0.0496	0.317107
A5	0.0648	0.0972	0.600098
A6	0.0605	0.0954	0.611943
A7	0.0655	0.0917	0.583221
A8	0.0474	0.1089	0.696697
A9	0.0531	0.1045	0.66296

A10	0.049	0.1261	0.720112
A11	0.0336	0.1194	0.780234
A12	0.0341	0.121	0.779965
A13	0.0425	0.1213	0.740785
A14	0.1147	0.0387	0.252311
A15	0.0388	0.1245	0.762374
A16	0.0256	0.1463	0.850942
A17	0.0534	0.1021	0.656701
A18	0.0314	0.1379	0.814711

Step 4: Calculate the value of the overall performance indicators (OPI)

According to equation (9), this study calculated the *OPI* value and ranked them in line, as shown in the right part of Table 4. It is better to have larger value of calculated *OPI*. It is a good choice to be closer to the positive ideal solution and be farer away from the negative ideal solution. As shown in the right part of Table 4, the *OPI* of the 16^{th} experiment was 0.850942, the largest one, which explained that the combined parameter for the experiment was better than others.

Step 5: Build up response table to determine the best combination of parameters

The study used the TOPSIS algorithm to obtain a common measure of *OPI* value, the largest one. In order to find the best combined parameters, it was necessary to make up a response table for every level of each factor with the *OPI* value. The equation (10) was used to calculate their factor effect. The result was summarized in Table 5. Therefore, the optimal combination of factors and their levels would be of $A_2B_3C_3D_2E_3F_3G_3H_1$.

Table 5. The response table

	A	B	C	D	E	F	G	H
Level 1	0.4821	0.5246	0.6028	0.5973	0.5745	0.6485	0.5918	0.6664
Level 2	0.7065	0.5474	0.5130	0.6018	0.5832	0.4766	0.5711	0.6232
Level 3		0.7109	0.6671	0.5837	0.6252	0.6579	0.6200	0.4933

The *S/N* of the research method vs. the current level

	Factors/Levels								S/N ratio		
	A	B	C	D	E	F	G	H	Residual Induction (RI)	Specific Gravity (SG)	Magnetic Attraction Forces (MAF)
The research method	2	3	3	2	3	3	3	1	8.1950	14.0138	13.2128
Current level	1	2	2	2	2	2	2	2	6.6637	0.0756	12.3021

Conclusion

This study proposed a multi-criteria optimization method to achieve the objective. The process has concluded the following results:

By obtaining the optimal parameters of a single quality characteristic, it could only meet its own goals of individual quality characteristics. However, by integrating Taguchi method with TOPSIS algorithm, this study has contributed to establish a model to easily find out the optimal parameters of multiple quality characteristics. The experimental design has provided designers, by avoiding the increase in time and costs, to deal with more quality characteristics or more parameters situation.

As the result shown in the case study, the research method has found out the optimal parameters of $A_2B_3C_3D_2E_3F_3G_3H_1$, whose *S/N* ratios were better than the existing one, $A_2B_2C_2D_2E_2F_2G_2H_2$. Especially, the quality characteristic of the Specific Gravity, which is positively correlated with the usage of the magnetic powder (i.e., the major cost of the product),

was obviously improved up to 184 times. Therefore, we could confirm that the proposed method of study has proven to be fully contributable and helpful. In addition, the method not only could help companies save the cost of experiments, but also could shorten the duration of speeding a new product into mass production, increasing their competitiveness in the industry.

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THE APPLICATION OF BALANCED SCORECARD TO PERFORMANCE EVALUATION FOR ENGINEERING EDUCATIONAL SYSTEMS

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Abstract

This study investigates the management and performance of engineering educational systems and attempts to establish a performance evaluation model for engineering educational systems. By using the performance evaluation model, schools can make a better strategy to develop better engineering educational systems and to train better engineering students. The concept of balanced scorecard is used to construct a performance evaluation model for engineering educational systems. The balanced scorecard has been used in business successfully. This study collects suitable performance evaluation configurations and indices by literature reviews and interviews to department heads in engineering educational systems in Taiwan. According to the four components of the balanced scorecard, a more objective performance evaluation model for engineering educational systems is developed in this study.

Key Words: balanced scorecard, performance evaluation, educational strategy, engineering education

Introduction

In the past decade, engineering education has faced intensive pressures for changes. These challenges have resulted from a confluence of factors, including quantum leaps in

computer and communications technology, structural changes in business organizations and processes (e.g., downsizing, reengineering and virtual corporations), and major shifts in student body demographics (e.g., increased proportions of adults seeking retraining or continuing education).

The fundamental nature of these forces for change suggests that responding to them also would require a fundamental rethinking of programs and approaches. The change process needs to be well designed and executed. The vastness of the strategic management literature suggests that many other models for managing change exist that also merit consideration. Performance evaluation is an essential component of whatever change process is adopted. It can provide motivation and direction, give feedback on the effectiveness of plans and their execution, and help in strategy formulation and revision. The purpose of this article is to suggest the balanced scorecard as a tool for enhancing the success of engineering education systems.

The Balanced Scorecard

The balance scorecard is an integrated set of performance measures comprising both current performance indicators and drivers of future performance, and financial as well as non-financial measures. For managers of organizations, the function of the balanced scorecard is to provide a holistic view of what is happening both inside and outside the organization. The balanced scorecard's key characteristic is that the included measures are linked to the entity's mission and strategy, and are explicitly designed to inform and motivate continuous efforts toward their attainment (Hoffecker, 1994; Kaplan & Norton, 1992, 1993, 1996a, 1996b, Kurtzman, 1997; Maisel, 1992). As such, the balanced scorecard is an integral part of the strategic planning process, and not just a system for tracking performance after the fact.

An effective balanced scorecard generally includes a mix of outcome measures and performance drivers. Using a manufacturing setting for illustrative purposes, examples of the former are high quality and speed, while defect rates and cycle times are examples of the latter. The latter measures communicate how the desired outcomes are to be achieved based on assumed causal relationships among objectives and measures. In this way, the balanced scorecard articulates a theory, or model, of the organization's causal chain of performance drivers and outcomes. Furthermore, an effective balanced scorecard embodies a balance between diagnostic measures and strategic measures. The former helps to monitor whether the organization remains "in control" and whether immediate intervention is required. In contrast, strategic measures are designed to evaluate success in achieving strategic goals. Thus, diagnostic measures capture the necessary "hygiene factors" that enable the organization to operate normally, while strategic measures help to ensure that short-term concerns are not overemphasized at the expense of the entity's strategic goals.

At the organizational level, developing the balanced scorecard involves identifying several key components of operations, establishing goals for these and then selecting measures to track progress toward these goals. The number and nature of components can be expected to vary depending on the nature and strategy of the organization, though the following four components are typical:

(1) *Customer perspective:* How do customers see us? This component track how well the organization is meeting the expectations of its customers.

(2) *Internal business perspective:* At shat must we excel? This component focuses on the internal processes that the entity must perform well if it is to meet customers' expectations.

(3) *Innovation and learning perspective:* Can we continue to improve and create value? This

component focuses on the infrastructure that the entity must build and sustain in order to ensure and enhance its ability to satisfy customers' expectations.

(4) Financial perspective: How do we look to providers of financial resources? This component tracks how well the organization is translating its operational results into financial well being.

Thus far, discussions and reported applications of the balanced scorecard have been concentrated in the for-profit sector. The lack of reported balanced scorecard applications in educational institutions, especially in the instructional functions, may be taken to imply a lack of applicability. Indeed, educational institutions do have features that can make implementation of the balanced scorecard (and the strategic planning process of which it is part) more difficult than in for-profit entities. For example, whereas for-profit entities typically can use huge bonuses or other forms of compensation to reward performance, educational institutions rarely have such resources or latitude. When combined with the sanctity accorded to "academic freedom," this can limit the ability to promote change and/or continuous improvement.

Specifically related to the balanced scorecard, one also could debate who, exactly, are the "customers" of a university. A case can be made for including students, employers, parents of students, alumni, non-alumni donors, research funding organizations, governments, the community and taxpayers. One also could argue for inclusion of the faculty and staff. With the potential for such diverse views, gaining consensus on the definition of "customers" can be challenging, yet necessary, if an effective balanced scorecard is to be constructed.

But it also is possible that the dearth of reported balanced scorecard applications in the educational sector simply reflects a lack of awareness or understanding. In any cases, as long as engineering programs will attempt change and improvement, exploring ways to improve this

process would be worthwhile. It is in this spirit that we present this discussion of the balanced scorecard. Our belief in the balanced scorecard's potential applicability is based on two main factors. First, at least in the nature of operations, educational institutions are service organizations like banks and insurance companies, which have adopted the balanced scorecards with favorable reported results. More important, the survey and interview responses of some engineering-related department heads, who should be familiar with the educational environment, generally affirm that the balanced scorecard can be beneficial to their programs.

Comparison Between The Balanced Scorecard And Existing Evaluation Methods

Comparing the balanced scorecard to the performance evaluation approaches which underpin external ratings of academic programs can further elucidate its unique features. Among the most widely publicized of such ratings are those in the media, such as Business Week and U.S. News and World Report. These focus primarily on entire programs or institutions, or only list the top-rated programs. In contrast, other services, such as The Gourman Report (Gourman, 1993) and Educational Ranking Annual (Hattendorf, 1996), provide ratings of specific disciplines.

Like the balanced scorecard, all of these external rating approaches use multiple criteria. The Gourman Report (Gourman, 1993) uses a linear combination of 18 (differentially) weighted criteria to derive its ratings (e.g., total programs offered, faculty qualifications and productivity, quality of administration, computer facilities, research funding). In addition to issues of measurement (e.g., how to measure the quality of administration), the Report also cautions readers that because disciplines vary in their educational methodology, the significance given each criterion should vary from one discipline to another. It also emphasizes the limitations of combining complex data into a deceptively convenient numerical rating (Gourman, 1993).

The Educational Ranking Annual (Hattendorf, 1996) even more explicitly recognizes the limitations of any one ranking methodology. It states that while educational rankings are usually based on complex measures (e.g., academic reputation, citation analysis, peer evaluations or perceptions, distinguished alumni, admissions selectivity, tuition, faculty salaries, library and computer facilities), none of these precisely reflects the institution's educational quality (Hattendorf, 1996). Rather than selecting one ranking approach, the Annual provides separate ranking based on four groups of measures: (1) reputation rankings derived from the opinions of college and university presidents, dean, department chairpersons, senior scholars and others; (2) citation analysis; (3) faculty productivity, measured by the number of publications; (4) statistical ranking derived from such information as endowment, library facilities and admissions selectivity.

Thus, existing ranking approaches do consider multiple facets of educational programs, many of which would seem appropriate even if an alternative approach (such as the balanced scorecard) were used. But unlike the balanced scorecard, these approaches do not select the various measures, nor do they organize them, based on a holistic or integrated system of performance drivers and diagnostic indicators. They also do not relate these measures to each institution's unique mission and circumstances. Because of these features, their usefulness for guiding individual programs toward continuous improvement and change would seem open to question.

Survey Findings and Applications

To investigate the potential applicability and benefits of the balanced scorecard to the performance evaluation of engineering education systems, we conducted a survey of several

heads of engineering-related departments in Taiwan. In the surveying process, we asked those department heads the following twelve questions.

(1) Do you think that the balanced scorecard communicates an engineering department's goal and objectives better than the traditional mission and goals statements? In what ways is it better? Worse?

(2) How important do you think it is to balance an engineering department's goal and objectives? To what extent and in what ways do you think the balanced scorecard helps or hinders this balancing?

(3) To what extent do you think that the four components in the balanced scorecard encompass the essential goals and objectives for an engineering department? If you think that there are major omitted goals and objectives, under what labels would you classify such goals and measures?

(4) To what extent do you believe that the four components are interlocked so that the success of the second (internal operations) and third components (learning and innovation) will lead to success with the first (customer satisfaction) and the fourth (financial) components?

(5) Do the goals and measures presented by us include the key leading indicators for success in an engineering program so that departments will know at an early stage that they are on the right track to where they want to go?

(6) Do you think that the performance measures in the balanced scorecard can be measured with affordable costs?

(7) How easily do you think the measures in the balanced scorecard can be undermined in the implementation phase to reduce the effectiveness of the balanced scorecard system?

(8) Do you believe that there are downsides to using diverse multiple performance indicators? Could you elaborate?

(9) Do you think that some of the measures in the balanced scorecard may severely contradict each other? If so, what do you think can be done to overcome this problem?

(10) How much change is necessary in your department before a balanced scorecard approach can be implemented? Could you elaborate on the nature of these needed changes?

(11) Compared to your department's current performance evaluation system, do you think that there is a lot to be gained if a balanced scorecard is successfully implemented? What would be the major types of benefits to your department?

(12) Overall, do you think that the gain will outweigh the costs if an engineering department were to implement the balanced scorecard?

Based on the survey, we suggest a performance evaluation model for the engineering education system according to the four components of the balanced scorecard.

Customer Perspective

(1) Percentage of students with job offer at graduation

(2) Number of companies recruiting on campus

(3) Graduates recruited by Big 100 companies in Taiwan

(4) Average starting salaries of graduates

(5) Alumni evaluation

(6) Graduating student survey

(7) Accreditation

(8) Recruiter evaluation

(9) Professional exam-passing rate

(10) External ranking or ratings in the press

(11) Percentage of enrollment out of applications

(12) Student evaluation of advising

(13) Student satisfaction survey

(14) Offering frequency of required courses

Internal Business Perspective

(1) Distribution of grades awarded

(2) Exit exam or student competency evaluation

(3) Prerequisite enforcement rate

(4) Number of internships available

(5) Number of companies involved

(6) Student evaluation

(7) faculty-to-student ratio

(8) Educational expenses per student

(9) Average class or laboratory size for majors

(10) Average class or laboratory size compared to other institutions

(11) Number of faculty in the specialized area

(12) Number of other schools offering the same program

Innovation and Learning Perspective

(1) Number of faculty presentations at conferences

(2) Number of faculty publications

(3) Number of seminars attended by faculty

(4) Travel budget for conference attendance

(5) Number of courses incorporating new technology

(6) Number of teaching innovation projects

(7) Number of teaching workshops attended by faculty

(8) Number of curriculum revisions in last five years

(9) Number of new courses offered in last five years

(10) Number of firms involved in joint activities

(11) Number of joint activities

Financial Perspective

(1) Annual giving to the department

(2) Amount of permanent endowment

(3) Amount of external grants

(4) Enrollment trend

(5) Level of student enrollment

(6) Funding per student

In considering whether to adopt the balanced scorecard approach, it is important to note some key challenges in its application:

(1) The balanced scorecard embodies an implicit or explicit model of the organization - what are the key outcomes and outcome drivers, and how do these variables interrelate at a point in time as well as across time? As the department heads observed, careful construction and evaluation of this model is essential if the balanced scorecard is to provide guidance and feedback toward the desired outcomes.

(2) Developing and implementing the balanced scorecard can be very time-consuming. An effective design and implementation process should include translating the vision and gaining consensus; communicating the objectives, setting goals and linking strategies; setting targets, allocating resources and establishing milestones; and feedback and learning. Experiences from the for-profit sector suggest that completing this process can take up to two years or more (Kaplan & Norton, 1996a, 1996b).

(3) To the extent of measures that the scorecard includes which require subjective judgment, there may be concerns about measurement bias, reliability and susceptibility to manipulation.

However, these concerns are not unique to the balanced scorecard approach. Deriving a mission statement and translating that into goals and actions also implies a model of the organization, in addition to requiring substantial time commitments. The current movement toward using both financial and non-financial performance measures also makes issues of measurement accuracy and reliability unavoidable. In responding to these challenges, engineering educators are not operating in a vacuum. Some department heads assist in providing access to an extensive literature on measuring and modeling student learning outcomes. They also provide valuable guidance to extant knowledge about a wide range of curriculum, educational technology, student and faculty issues.

Conclusions

Engineering educators and programs increasingly are seeking effective responses to the challenges of a rapidly changing technological, economic and social environment. Regardless of the change process adopted, performance measurement is essential for providing motivation and direction, and for giving feedback on the effectiveness of plans and their execution. The balanced scorecard approach, which has been adopted by many for-profit organizations, merits

consideration as a means to stimulate, focus and sustain continuous improvement effort in engineering programs. As an integral part of the strategy-formulation process, developing a balanced scorecard can improve communication and increase focus on the key success variables. And as a system of performance evaluation, it can provide timely feedback on the organization's as well as its constituents' success in attaining its goals.

The engineering-related department heads that we surveyed indicated that, like other management tools, the balanced scorecard has both strengths and weakness. But on the whole, they were quite positive about its potential benefits to engineering programs. These department heads also suggested components, goals and measure that can form an effective balanced scorecard for an engineering program. While each program has to design its own scorecard consistent with its mission and circumstances, these suggestions can be a useful demonstration of the room for creativity in this process.

Ultimately, in evaluating the balanced scorecard and other means of supporting change and improvement, it is important to recognize that all approaches have strengths and weaknesses. The key question is not which method is perfect. Rather, it is which has the greatest excess of benefits over costs, including those arising out of its imperfections. The answer to this question necessarily depends on each institution's situation and aspiration. This paper's discussion of the balanced scorecard, along with the insights from departmental chairs, can add to the tools for initiating, guiding and sustaining continuous improvement in engineering education system.

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TELECOM UPGRADED SERVICES ADOPTION MODEL USING THE USE - DIFFUSION THEORY: THE STUDY OF CHINA'S TELECOMMUNICATIONS MARKET

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Abstract

The consumption cycle consists of the whole process of consumption from the selection of alternatives at the beginning, extending to ownership and consumption of the products, and even making the final evaluation of the products. This process can be divided into “before” and “after” purchase, two - stage behavior. The concept of the use - diffusion model extends ideas to use behavior which is after adoption, and proposed two measures of its dimensions for products used by consumers after use - diffusion mechanism, namely “use frequency” and “use diversity”. Studies on behavior of post - purchase including actual use or consumption, the evaluation of product use, to understand what value consumers care about. Demand and value generated before purchase and the value received after the actual purchase will differ from time to time, so the actual value is the experience that the consumer perception of the real using the product. Regarding the complex of consumer technology products, the spread track and time scale must be able to extend by using the degree of development. Therefore, this study systematically discussed use - diffusion through the examples of China's telecommunications market. The architecture of the use diffusion in product upgrading and functional innovation can help to improve management research and market segmentation and product development.

Keywords: Consumption cycle, use - diffusion model, telecommunications

Introduction

The consumption cycle is the whole process of consumption from considering the selection of alternatives at the beginning, extending to own and to consume the products, and even making the final evaluation for the products. Moreover, based on the post - evaluation to make decision for a new round of the selection of products consideration and thus go into the next round of consumption cycle. This process can be divided into “before” and “after” purchase, two - stage behavior. Gardialet. (1994) explored these two phases. He found the products where the meaning of place, a standard of comparison, and evaluation of the results and emotional responses the consumers were interested, are slightly different. At the same time, they also believed that it was biased for the research of pre - purchase behavior much more than post - purchase. Robertson and Gatignon (1986) mentioned it cannot be only concerned about product adoption in the research of proliferation of product and product innovation. The degree of using technology is also described as an important variable of innovation diffusion. Ram and Jung (1989) and Ridgway and Price (1994) began to serve “the use of new products” as a variable in the study of technology diffusion. Recently, scholars have pointed out that using only the "adoptive” diffusion model cannot account for the whole of diffusion theory. The process of the diffusion on “using" also requires attention and validation (Anderson and Ortinau, 1988; Golder and Tellis, 1998; Lewis and Seibold, 1993; Robertson and Gatignon, 1986).

"The prospective new service" is another focus of this study. The so - called quasi - new concept is a non - brand - new product. The prospection is closed to upgrade from old products. With the advancement of technology, there are a lot of products or services, especially in the technology industry, so - called "update" or "upgrade" products or services emerged. This is not very innovative from scratch, but coupled with the already existing products and new

technologies, the emergence of new products, still has few changes in essence. To determine whether consumers will accept new services or changes of the standard use of quasi - new service, consumers will have begun to use or too frequently use the original product or service for a long time, after there has been a sense of familiarity, for the prospective emergence of new products or services, whether to accept and then converted into new products or quasi - services would be considered. In recent years, technology has been completely changed in the traditional thinking of the operation, the life of the surrounding network services, media services, community interaction, service experience, etc., for the technological elements join in, which bring in new business models and appearance. In the case of consumer acceptance of high technology and related product, the past operation and business model faced changes and new wave of challenges. I heard the launching of 3G yesterday, 3.5G has been already spread today, ipad2 has spotted for a few days, ipad3 has been strongly concerned. In this impact, it is difficult to applying of technology to upgrade traditional areas of public life. When enterprises are eager to find a larger market, to attract more consumers to use, with the popular trend nowadays, grasp the needs of the consumer expectations which become the truly fundamental path to success.

According to the case of development 3G overseas, the 3G users are almost all coming from the original 2G users. In the mobile telecommunications industry, 3G is a quasi - new service business, it's the same as 1G and 2G, which are based on the mobile phone voice services, but due to development in technology, 3G improved bandwidth and speed, and it added more data services than 2G diversification which is the 2G upgrade version. Therefore, this study attempts to explore the "quasi - new", and to identify the potential factors and results impact on consumer acceptance of new products or services, and expects to give different inspirations to industry and seize the future opportunities.

In recent years, the Chinese market has attracted much worldwide attention, and China's mobile communication industry reform and reorganization to improve service quality, improved marketing efforts to maintain rapid and healthy development momentum. According to China's Ministry of Statistics, at the end of April 2011, China's mobile phone users has exceeded with 900 million, accounting for 17% worldwide users, of which nearly 70 million 3G users , and about 300 million Internet users use the mobile as their main Internet means. Such a huge market leads China to become a communications giant which attract the world's attention. Although China launched 3G services very late, in addition to the completion of this investment, consumer spending power and maturity, operators operational capacity considerations, as the world's largest amount of mobile communications devices user, China was defined as "the first year of 3G in China" in 2009 industry, such a competitive oligopoly market, telecoms operators by means of a smooth transition to 2G users to 3G valued by the industry's issues, in particular, extends into the market from 2G to 3G, competition in the market created a new situation. Therefore, this study focused on China's telecommunications market to verify the prospective adoption of new service models, which has a better reflect to its theoretical and practical significance.

Theory and Two - Step Model Description

In this study, the concept of logic to the whole, is through the actual use of application, discuss the level of the awareness and acceptance of new concept of the next generation of prospective new products or services by consumers. For prospective new service, which is upgrading the pre - existing, especially for the most significant technology products, such as 2G to 3G, iphone to ipod touch to ipad, even to ipad 2, etc., and the users who buy these products and services are almost divided into two categories: the original user (here we refer to as a

generation older users) and the newly added user (we call the second generation of new users). A generation old users often belong to "impulse positive" groups who make new things more curious, expect to have a try, which affect their loyal spirit in future; the second generation of new users often are "wait and see the reality "ethnic group, who used to see whether the evaluation has requirement, whether is really easy to use and cost - effective, they will join the ranks if it satisfied them. And for enterprises, in their development of next - generation product or service, what factors can attract consumers, make consumers become loyal customers, or affect the consumer's acceptance for a revolutionary product or service, perhaps, the function is a little worse than the previous generation, but the price is much higher than the previous generation of "quasi - new product or service."。

Empirical Model 1: Use - Diffusion Analysis for the 2G Mobile Users

Innovation diffusion theory was originally proposed by the Rogers in 1962 as the person from the first contact for information about innovative products to the final new product is called the process of innovation adoption. He pointed out that consumers find out many significant advantages when they were informed about a new product or service, even if they know it is very difficult, but they still try to accept it (Rogers, 1962). Later, scholars have also emerged an extension of innovation diffusion research advocates and usage items in the user's view, because of the new product can be used as part of response to the fact that diffusion of new products. Using the diffusion model is an extension of the concept of using diffusion models, technological innovation diffusion rate also depends on the user experience of the development of new knowledge or new modes of capacity, particularly consumer technology products, not only make products are generally accepted, but let the frequency of use of the product improved, even considering the use of other related or complementary products (Anderson and Ortinau, 1988;

Golder and Tellis, 1998; Lewis and Seibold, 1993; Robertson and Gatignon, 1986). The studies of Hamblin et al. (1979) showed for the product in some cases, the use phase than the stage to better reflect market demand, using authenticity, but also better able to predict or explain the long - term demand curve. Gardial et al. (1994) have proven that consumers' perceived value will be different when purchase and in using or after using. When purchasing, consumers place more emphasis on product attributes; while in use or after use, consumers are always focus on results. Consumers will have the desired when they have the purchase of the action, may be to imagine what products they want ; after use, they will actually experience the value.

The purpose of this study of using diffusion focuses on "Using behavior". There are many factors to influence customer perceptions through the use of behavior directly. Holbrook (1980) and Woodruff (1997) believe that the user would get some experience after they used the product, and then express their overall experience evaluation, thus, to produce or experience some value, in order to reach the goal which exist at prior to use or before purchasing, and the value of these experiences will affect the future of behavioral intentions directly, which may affect future behavior. Two dimensions of behavior and the aforementioned which mentioned about using the "frequency" and "use diversity" can generate links. Product use frequency or use of diversification may be in accordance with each person's needs, objectives or goals, and different from the way to reach the results, also the individual's environment or context can form the difference using behavior (Ram and Jung, 1990). When these differences emerge, they will let the user do a variety of alternatives, to emerge the formation of preferences, and value the benefits or perception of their experiences in the process. Thus, each person's behavior may not quite be the same as each other, and their access to the experience or perceived value will be also different.

Continuation of a number of scholars, the behavior of measuring the use of product may have two dimensions: "frequency" and "use of diversity." These two dimensions were really suitable for using in the durability products, especially science and technology innovation products. This study considers that use of frequency represents the depth of using; the use of diverse represents the using width. There are four characteristics and differences between them which can be classified: "frequency" may be a significant driver in the consumer's task requirements, "Using diversity" depends on product characteristics, the diversification provided by the diversity of situations and use; "frequency" may be as immediately after purchase land elevations, and the "use of diversity" increase may depend on whether the consumer can quickly gain access to products with different characteristics necessary knowledge and skills; "frequency of use may be eligible daily needs, "Using diversity" may meet the diverse needs of exploration; for adding "diversity" in the market for the product development has a positive effect, which may attract consumers have different usage requirements, and increasing product proliferation possibilities (Gatignon and Robertson, 1985). The two dimensions in this study will focus on "use diversity" than "frequency", because the "use of diversity" represents a more complex behavior and involves a higher level of cognitive ability. Further, different antecedent variables may affect the use of frequency and diversity, so they should be separated.

1. Determinants of the spread of use 2G

(1) Technology dimension

Technology precision - It contains the inherent characteristics of the technology, the features and performance is easy to use. In general, the users who use of more advanced system can show a higher diversity use, at the same time, we believe that those familiar with high technology users will spend more time in technology, which can lead to higher utilization. As the

function of the mobile phone become more stable and practical under the progress in science and technology, and are willing to take the time to understand the new features of mobile phones, and therefore the use rate and various functions of mobile phones has increased. New value - added services and systems with advanced mobile phone can express its function. So we draw the following assumptions:

H1: High - tech precision will lead to high diversity and high frequency use rate.

The use of complementary technologies

The use of any technology must consider other technologies. According to Rogers's ideas (1995), the existence of tech - clustering affects the innovative use of the frequency. La Rose and Hoag (1996) has used the concept of technology clusters technology cluster phenomenon will affect the organizations using new things, the conclusion found that the use of the Internet, there are a number of companies have used other companies related to telecommunications or computer equipment, the impact of technology there is no cluster question was confirmed, the use of complementary technology to the organization will use the influence of new things which can be proved.

Vitalari, Venkatesh, and Gronhaug (1985) has designed and tested some of the same type of technology, which have similar characteristics and competing or complementary. If the acceptable of superior performance of a new technology is easy, it will replace the existing technology. Complementary technology to create a synergistic effect, which increases all the technology within the cluster use. Now many mobile phone have various features, to some extent replace the cameras, game consoles, pagers and other functions, but also easy to carry. In addition, with the reduction of fixed - line subscribers, fixed - mobile substitution is a gradual

trend. Complementary technology to create synergies, to take advantage of different ways to master the technology. Therefore, the use of this product with similar features new technology, the more that this needs higher in the diversity use should be higher, use frequency should also higher. This study proposes:

H2: The use of complementary technologies lead to high use of specific technologies and high - frequency diversity

(2) Personal dimension

Use of innovative specialty - The consumers who has Innovative high personality are usually the first to try some new products, services or things, they have the tendencies to try different things with the experimental, the reaction of these innovative can decide whether the new products or services is success (Schiffman and Kunak, 2000), especially that technology innovation in products, which lead consumers to changes their habit for using a different product, it has become an important indicator of profitability.

Hirschman (1980) also advocates to use of innovative products, and proposed "inherent novelty seeking" is to use one of the diversity of the antecedent variables. Ram and Jung (1990) further carry on research for the durability of products, the result shows that involvement and the use of innovative characteristics are related with the diversity use, frequency or both of them in different products. In 1994 Ridgway and Price first proposed a new way consumers use products affected by the new use of sensitivity and attractiveness, as well as new ways to use the product creativity. Treat the innovation as the central personality traits, including the use, using and the sharing of innovation. The use of innovative which refers to use the product or the creative ability of using products by new ways. Since then, scholars of consumers begin using the innovative performance which base on the Ridgway and Price (1994) research.

When Shih and Venkatesh (2004) was using computer do verification on variables of using innovative personality traits at home, he suggested that if consumers has innovative, it means that they had the tend to try different things. So, innovation will be associated with the diversity use. Hu Wanling (2006) did positive demonstration for car users who use mobile digital TV, work out that consumers do special behavior in driving to obtain the use of innovative, thus affecting the use frequency.

Summary: the results of the literature and empirical research, can infer the positive correlation between innovative characteristics and diversity use frequency. Therefore, based on previous theoretical and empirical research, we assume:

H3: The higher of using the innovative specialty, leading to the higher of the diversity use and use frequency.

Frustration of technology - Technology's mission is to bring a better life for mankind, but we often accuse some products will waste our time, makes us feel confused, or even to isolate us (Champion, 1998). In other words, the complex technology may often make users feel disappointed or frustrated, possibly because of the performance of its technology does not function, or cannot meet user expectations (Lupton and Miller, 1992; Mick and Fournier, 1998). Mick and Fournier (1998) made the concept of "Paradoxes of Technology", the existence of these contradictions will affect consumer perceptions, purchasing, and ways to use technology products. Mukherjee and Hoyer (2001) also pointed out that the main reason for the frustration of learning, including additional costs, and difficult to understand and so on. When a user feels disappointment or frustration or not the same as expected when using of technology products, the user may reduce the use frequency and diversity use.

There is also a assumptions about the degree of frustration with the technology. Davis (1989) and Mick and Fournier (1998) pointed out that even if consumers are faced with setbacks in the use of the product or find it difficult, because the product may also be able to provide specific utility and sustainable use. Therefore, we believe that:

H4: *a) Use of high technology frustration will lead to a lower frequency and diversity use.*
b) The technology does not affect the level of frustration with diversity or use frequency.

Previous experience - Study in psychology, Bentler and Speackart (1979), Ajzen and Fishbein (1980), and Bagozzi (1981) have researched for the "experience" of attitude, intention, behavior conducted empirical, and found the experience of attitude, intention, behavior has a significant impact on results. The user's knowledge comes from their experiences; these experiences provide the user to understand the new technology which can be applied to the environment and how to apply its skills. The studies of Alba and Hutchinson (1985), Kiesler et al. (1997, 2001), and Norman (1999) showed that the complexity of the technology will be reflected in the diffusion model of user knowledge play a key role. Therefore, the user must always update their knowledge in order to achieve a more advanced level. For a mobile phone user, the previously used mobile phone experience will help them better understand and easy to use mobile phones with new technology.

Hill and Jones (2004) mentioned that a group of technology enthusiasts, innovators, and receptive to new things, and such consumer products with the technical knowledge and ability with vision. Hahn and Colleagues (1994) pointed out that the positive impact of "the direct product experience" has become the precondition for users to repeat use it. Therefore, when the user gain more experience with the technology, we can develop more features, and feel their

dependence on technology and continue to use. Meanwhile, the user's experience makes them become more familiar with technology and the different possibilities, which are positively, affected the frequency and diversity use. Therefore, we have the following assumptions:

H5: The more experience of accumulated product, the more possible to use high frequency and high diversity.

(3) Social dimension

External communication - More emphasis on external communication and the importance of communication between people, language or non - language, to do the whole process of information by purpose. In the process of passing, people exchange their feelings, thoughts, and knowledge, so it is a meaningful social interaction. Dodson and Muller (1978) put forward that oral communication play an important role in the diffusion process. Robinson (1991) thinks communication is the transfer process of knowledge and technology. Mohr and Spekman (1994) believed that communication behavior, including: information sharing, communication quality, and communication in three. Kiesler et al. (2001) considered that when users can discuss issues with other people (especially the more knowledgeable user with discussion), the information can be quickly exchanged to enhance the user's beliefs and behavior will help to overcome the practical difficulties of technology. In contrast, when the user cannot solve the problem by him, they will feel frustrated, then do not spend time in this product, or even abandon the use. Moreover, in the social environment, the impact is not only the existence of communication, the amount of interaction and communication - intensive but also play an important role. Although the focus of communication is the use of behavior, but the use frequency on his role is limited, because people do the same thing repeated when more do not want to communicate; When users want to try different techniques, they will need to go with communicate with others or for help.

External technologies - The more times of using technology (e.g., offices, schools) also increased the diversity use, or various forms of connection with other tools, such as mobile phones and laptop connections, mobile phones connect with each other, phone and TV connections , can therefore increase the diversity use.

Media exposure - The effect to the consumers which made by the social environment is too larger than personal attitudes sometimes. In the study of consumer behavior literature, many authors of social influence is described as a marketing stimulus, such as advertising, print media and staff promotions. The main feature of media is the information influence, which make audio - visual mass media and long years of contact, communication, and thus influence or change their habits and attitudes.

Heider (1958) considered that consumers' attitude toward advertising "would affect their attitude towards the product, it reached the balance between the cognitive and emotional. When consumers reach the inner equilibrium, it will affect the attitude of the product purchase decision. With the level of product knowledge of consumers, due to primary or external sources of information (such as advertising) the impact of the existence, it has different internal process, and increase product usage (Bettman, Sujan and Mita, 1987; Herr, 1989).Nelson (1974) believed that advertising makes the consumer product features, quality, price and other knowledge have increased dramatically. Shih and Venkatesh (2004) believes that the products or services related to science and technology high visibility in the media, and technology will stimulate user's involvement, and increase utilization, but also stimulate the use of various technologies. For the above three, we have the following assumptions:

H6: External communication will lead to a higher intensity diversity use.

H7: In combination with other techniques will lead to higher diversity use

H8: More targeted media exposure will lead to higher diversity use and frequency use.

2. Different types of 2G mobile users

Spread in accordance with the "Use diversity" and "frequency" two dimensions summarized four types: "heavy use" refers to the innovative use of the surface behavior in the two institutions have a significant degree; "specific use" is focused on increasing use frequency, this behavior is essentially using the innovation as a specific tool (Tinnell, 1985); "comprehensive use" of the use of behavior on behalf of multiple use category is more important than the use frequency, is based on the behavior of trial and error; Finally, "limited use" tends to use low diversity and low use frequency. If users can find valuable potential applications, the product will be classified as a minor role, or even disadoption (Lindolf, 1992).

The four categories proposed here are based on researching related to use of its characteristics to distinguish the user's four forms, with face validity. It is noteworthy that four users at any given time segment is completely mutually exclusive (each user is only attributable to a single category). However, in this time sort out of the users may change over time, it may also be due to changes in demand and other situational factors, and let the user from the current segment to another segment at, for example, a user may be strong as time goes on, the use of behavior becomes habitual and turn into a specific user. In the marketing environment, where the mobile behavior of these segments are relatively rare, unless there is psychological research that people will experience lifestyle changes, will be separated from now at the turn into another. In addition to using diffusion type, we can identify different types of users under the demographic characteristics, research in this area has a very definite practical value, any operator

can be identified by these demographic characteristics can be targeted to promote the new services.

3. Perception of evaluation after using for 2G mobile users

Consumer use, disposal of goods will affect consumers' action, experience, emotions, feelings, attitudes, and even affect the next phase of behavior (Schiffman and Kunak, 2000). Indeed, consumers use the product before the product's main impression from the transmission; and once using a product, the actual experience, should also be formed from the consumer product evaluation, as the main source of attitude. These perceptions will be an important indicator of consumption in future.

(1) The importance of the perception of science and technology for users.

Perception of the importance of science and technology, including the need for awareness and influence technology, the user may compare of the current behavior and past behavior, compare between the own purpose or goal and the use of the results, or compare the expected and the actual position of the other, format of a kinds of experience evaluation. The more times people used which directly lead to the perception in daily life about the technological influence. On the one hand, a high use of technology and make use of the diversity of people living in the technology which has become inseparable part of the user, and control the user's daily operations. On the other hand, with few times using of technology and diversity use, it will not have the same perception of influence, because the use of the frequency and diversity of users is not completed.

(2) The perception of knowledge and skills for using

Alba and Hutchinson (1987) thought when consumer added to a certain degree of familiarity to product, the knowledge of products will be increased, it is natural to select the

previously chosen brand, which is the so - called “automaticity”, referring the consumer to minimum of investment and not in conscious control of the situation continues the process of implementation (Alba and Hutchinson, 1987), so familiarity with the apparently spontaneous, but such an effect on consumers faced with tremendous time pressures will be particularly evident (Alba and Hutchinson, 1987). In addition, Bettman and Park's studies (1980) also found that consumers are more familiar with the product than the product comparison is not so familiar to consumers, the product evaluation and selection process more dependent on the brand name of the clues. Therefore, for the different current knowledge of consumers, the product selection process will vary.

(3) User's perception about financial investment

Users of financial investment is required to pay the cost of money, that is so - called “price”. Prices will affect the level of consumer satisfaction in the service sector (Voss, Parasuraman, and Grewal, 1988; Parasuraman, Zeithaml, and Berry, 1991). So we can see that the price will affect the hearts of consumers for the product or service quality and value perception, and further affect subsequent behavioral intentions. Perceived price is the most important factor to decide the consumers to buy services or products, the actual monetary price of experience. From the consumer point of view, the price that the consumer must give up or sacrifice in order to get products or services (Zeithaml, 1988; Bei and Chiao, 2006). Zeithaml (1988) pointed out that consumers do not always know or remember the actual price, it is significant that through his mind identified to the price of a truly meaningful, this is easy to stay in the memory of the experience is perceived price. When consumers purchase products or services, the perceived price of the performance or subjective perception is the perceived price (Jacoby and Olson, 1977).

Research of the acceptance of the price refers that the minds of consumers can accept every price; there will be a acceptable price range. When consumers see prices in their acceptable range, it will tend to accept the product. After using, if quality is below their expectations, they will think the price is too high and not want continue to purchase; on the other hand, if the quality is higher than expected, then consumers will think the price is cheap and will continue to use and even expand the scope of use.

Gourvelle and Soman (2002) pointed out that consumer has different pricing strategy because of the different carriers, thereby it affect their willingness to use after purchase. Wansink's studies (1994) also pointed out that the operators must transfer their target about how to increase the buy rate of the product. China's current competition mobile operators, users, or the most mind price, so the more consumers are willing to use consumer - related products, the more products will be sold, feel of a product or service less the possibility of spending the new money would feel the cost and continue to use.

(4) The perception of costs information for users

Perceived cost of information, including assessment of costs, learning costs, and establishment costs. Blattberg and Deighton (1996) thought that consumers must purchase the core product according to he supplements the amount. Klemperer (1995) pointed out that, because manufacturers often play as to provide a complete manufacturers' role, so that consumers save time and effort in a place to buy needed supplies. Mobile operators provide services and products even like this. Consumers will evaluate the business for mobile operators to join the project and choose their own mobile operator. Thus, users of business, the more understanding of business information, the lower the perceived risk. This is not only a different product, it also bear a variety of features, price or convenience of the risk. And the kinds of

products that consumers use are more than the need to spend more effort to compare the new products or new features; they must set more new products or new features, in order to learn how to use a large number of new products or new features with More Bets.

(5) The perception of the emotional loss of Users

Interpersonal aspects of emotional perception of losses, including the relationship with the brand, which is related to loss of mental and emotional level. Benefit Relationships refers that consumers give up both suppliers and service for the establishment of the resulting sense of identity arising from the emotional loss. The loss of Brand relationship shows existing suppliers and consumers to abandon the brand identity to achieve emotional loss (Porter, 1985; Aaker, 1992; Burnham, 2003). McCracken (1986) pointed out that once for suppliers to increase interaction, which will create more multiple relationships. With the increase in human interaction, customers and suppliers' personal brand recognition will increase, the result is that the relationships between service providers and the relevance of the brand relationship will be enhanced, it is the emotional impact of the effect. Bames et al. (2004) also pointed out that humans have stuck phenomenon for learning or behavior habits, such as the U.S. beer market is not easy addition of new sights taste the taste of the consumer habits die hard, the old brand is also a factor and even people.

In this study, it does not consider the relationship with the mobile operators, while the single - 2G mobile communications for discussion, so here is a more user binds to the 2G communication of emotional phenomena.

Empirical Model 2: The Effect Analysis of Upgraded Technology Adoption via Use - Diffusion

Acceptance of technology in the last study by the widely used theory of rational behavior, theory of planned behavior and Davis (1989) proposed Technology Acceptance Model. These

theories are suitable from the user point of view of users of new technology products and features to accept the case, the research and practical applications after they have a good explanatory power and predictive ability.

TAM thought that there are two factors affecting consumer's acceptance of information technology, which helps to do things better with "perceived usefulness" and that is very easy to use "perceived ease of use." Attitude about using the perceived usefulness and perceived ease of use is joint decision. Taylor and Todd then presented a decomposition theory of planned behavior model, which is the integration of TAM with other theoretical studies of a milestone, in which attitude is decomposed into perceived usefulness, perceived ease of use and compatibility, perceived usefulness and perceived easy to from the use of TAM, compatibility refers to the potential users of new technologies and values, previous experience and current needs of the match.

Rogers's innovation diffusion theory and TAM were similar. He raised from the process point of view of the individual five - stage model of innovation diffusion, innovative features that will affect the rate of consumer adoption of innovations. The innovative features of the five factors which affect the pace of innovation are: relative advantage, compatibility, complexity, Observability, you can try sex. Because studies have only shown that the innovation diffusion theory of comparative advantage, complexity, compatibility to accept a significant impact on motivation, and the comparative advantage is similar to TAM's perceived usefulness, complexity, and the TAM's perceived use ease, this study The model integrates innovation diffusion only existing compatibility.

H9: Perceived usefulness significantly affect the attitude of the new technology

H10: Perceived ease of use will significantly affect the attitude of the new technology

H11: Compatibility will significantly affect the attitude of the new technology

TAM model studies have shown that attitude on behavioral intention of use will have an impact, thereby affecting the actual behavior. When consumers believe that the services received for their work or daily life to help, they will form a positive attitude to product service, thereby further affecting their behavioral intentions and actual use. And Fishbein and Ajzen's theory (1975) of reasoned action to explain and predict the behavior of decision - making process, that the individuals reaction is engaged in behavioral intention of an act of will and conscious planning, the best indicator is always to predict behavior. The Interest of consumers arises from these two factors: personal factors, temporary response "to the behavior of attitude", the other is to reflect the social impact of "subjective norm." Subjective norm taken by the individual behavior is the perceived social pressure awareness, it can be said that personal feelings of the more important other people or groups that should or should not take the pressure of a particular act. Suppose if the individual's attitude more positive, and the greater the perceived social pressure around them, taking a stronger intention to actual behavior. The research hypothesis is as follows:

H12: the attitude of the new technology will significantly affect the intended use of 3G mobile communications

H13: subjective norms significantly affect the intended use of 3G mobile communications

H14: 3G mobile communications intended use will significantly affect the actual behavior of 3G mobile communications

The theory of reasoned action proposed is based on the theory of planned behavior, with an extra factor, that is, perceived behavioral control, perceived behavioral control that will affect

the behavioral intention and influence behavior. The theory in information systems, investment decisions and other areas to be widely used. Perceived behavioral control refers to the behavior of individuals feel the ease of completion of behavioral intention has a significant impact, is to determine the use of behavior as an important factor. In this study, the emphasis is the use of behavior after adoption, in addition to the difficulty feeling of the complete behavior, there is the perception of the overall use of the process evaluation. Therefore, refer to the following assumptions:

H15: the more 2G mobile users perceive the importance of high technology, the higher 3G mobile communications intend to use

H16: the more 2G mobile users use knowledge, skills and high sense, the higher the intention to use 3G mobile communications

H17: 2 G mobile users perceive the high financial investment, the 3G mobile communications will reduce the intended use

H18: the higher2G mobile users perceived cost of information, the intended use of 3Gmobile communications will be reduced

H19: 2G mobile users perceive the loss of high emotion, the intention to reduce use of 3G mobile communications

Based on the above assumptions, this study proposes a two - stage impact of the adoption of the model, as shown below.

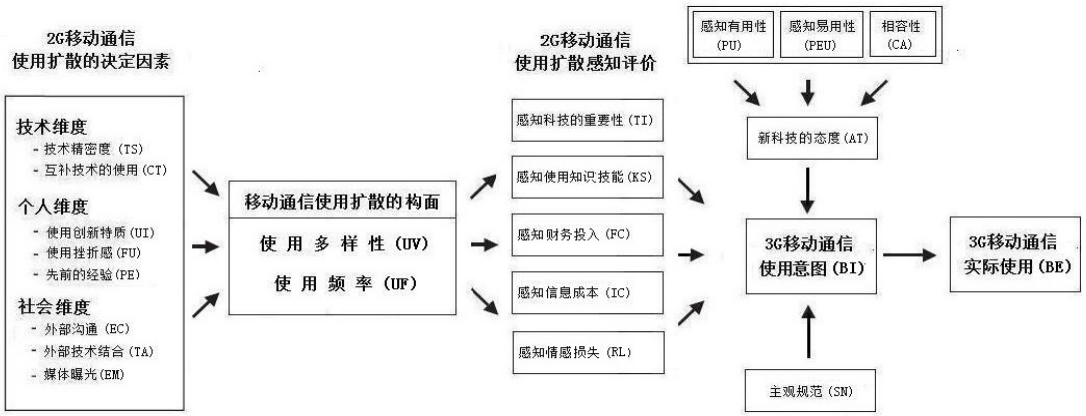

Figure 1. The structure of research model

Research Methodology

The main use of online data collection and street intercept survey combined manner, in this way, we have received 523 copies of questionnaires, which were 508 valid questionnaires. Two empirical models from the method followed the one above methods and procedures, but here we need to explain the particular research methods. The questionnaire survey conducted in the first step, we designed a round that is required for investigation questionnaire, which in theory, the data content can still be used to validate the empirical model 2, but taking into account the legal validity of the challenge model, we again invite 189 users for the survey, the survey is with the mobile operator's help, targeted to understand their attitudes, purchase of 3G services and the actual behavior, the survey received a total of 197 questionnaires. In addition to the last round of qualifying questionnaire integration, it forms a total of 705 questionnaires used to study. The variables and measurement are shown as follow.

Two Dependent Variable of Use - Diffusion: Use Frequency and Use Diversity

According to the Taiwan Institute for Information Industry E - commerce in 2003 with Japan, South Korea, Hong Kong, Finland and Greece, the six countries reached an agreement to a "Worldwide Mobile Internet Survey (2004)", with the frequency use of part of the country which are perceived by consumers. The average daily use time is taken as a standard measure. In this study, the monthly average mobile phone consumer bill, that average monthly bill amount recorded of this subject is taken as a criterion.

Diversity use means the types of function and service provided by the mobile phone features and mobile operators. Checked by the respondents in this study had used the project, plus the total number of items checked, that is, using a variety of. With the proliferation of measure is aimed at mobile phone users for mobile phone services provided by voice, mobile

data services such as product usage and use diversity as a measure of dimensions. This study used variables, most took the simple approach, but there are a few points requiring special instructions, and technical precision in the diversity use, etc., we have taken the relative proportions of the method, a total of n A service function, and the subjects chosen $m(m < n)$ A, then m/n As a new measure of variables included in the calculation of the final model.

Table 1. Using the statistical spread of two dimensions

Variable Name	Definition	Measure	Mean	Standard deviation
Use Frequency (UF)	Average monthly mobile phone users to use the bill amount	1 - 7 numeric	2.93	1.236
Use Diversity (UV)	How many users use the mobile phone features and mobile services provided by operators	Measure of the relative proportions	0.41	0.118

Determinants Affecting The Spread of Use

In this study, the scale according to the relevant literature for sorting out the behavior of mobile communications with a questionnaire item asked, as a reference for the scale of study, mainly to increase the questionnaire's validity. Then for the object and purpose of this study to be

Table 2. Factors affecting use of statistical tables spread

Variable	Definition	Measure	Mean	Standard deviation
Technology dimension				
Technical precision (TS)	2G mobile operators and mobile phones with features	Measure of the relative proportions	0.63	0.317
Complementary use of technology (CT)	Mobile phone users in the total amount of the relevant technology	Measure of the relative proportions	0.57	0.445

Personal dimension				
The innovative character (UI)	Users innovative features	6 - point Likert scale	3.212	1.077
With frustration (UF)	Consumers consider or when using mobile communication technology, the fear, anxiety or feeling of hope	6 - point Likert scale	2.392	0.889
Previous experience (PE)	Network users from the beginning to the present time experienced by	Numeric	8.137	5.516
Social dimension				
External communication (EC)	Users to communicate with the outside world the extent of	6 - point Likert scale	3.108	1.027
Combination of external technology (TA)	Users to use mobile communication technology of continuity	6 - point Likert scale	2.318	0.771
Media Information Contact (EM)	For mobile users access to media information related to the degree	6 - point Likert scale	4.476	0.825

modified, which becomes suitable for the study questionnaire. After several pre - test, get 47 valid questionnaires, for a simple statistical analysis, the question is asked or ask adjusted items, the final form of the final large - scale survey questionnaire.

Outcome Variables of the Spread of Use

Through factor analysis, the results of our test results the following table of variables, basically in line with the standard statistical test, but the model I to, we use the average of the ways to measure the variables of each item to ask.

Table 3. The reliability and validity of outcome variables

Variable	Definition	Cronbach α	Variance extracted estimates (VEE)	average λ
Perception of the importance of science and technology (TI)	Mobile communications technology for the user's influence and importance	0.879	0.632	0.723

Sense to use knowledge and skills (KS)	Users on the level of knowledge about mobile communications	0.810	0.785	0.747
Perception of financial inputs (FC)	Rates for users of mobile phones	- - - - - -	- - - - - -	- - - - -
Perceived information costs (IC)	Users time and effort involved in conversion expenses	0.763	0.779	0.704
Perception of emotional loss (RL)	Users involved in the acquisition of psychological and emotional	0.821	0.720	0.776

Variables of Upgraded Services/Products Adoption

In this study, internal consistency coefficients for all questionnaire scales for reliability analysis. According to accepted academic standards, we set the standard for test indicators are as follows: α values greater than 0.7.

Table 4. Adopted variable reliability and validity

Variable	Definition	Cronbach α	Variance extracted estimates (VEE)	average λ
Perceived usefulness (PU)	Means that users feel using the new technology can improve the efficiency	0.849	0.712	0.813
Perceived ease of use (PEU)	Means that users feel the new technology is easy to understand, learn and operations	0.830	0.655	0.827
Compatibility (CA)	Refers to the user of new technology and personal values and needs of the existing degree of cooperation of deeds	0.799	0.701	0.811
Perception of the importance of	Mobile communications technology for the user's	0.763	0.779	0.793

science and technology (TI)	influence and importance			
Sense to use knowledge and skills (KS)	Users on the level of knowledge about mobile communications	0.901	0.718	0.826
Perception of financial inputs (FC)	Rates for users of mobile phones	- - - - -	- - - - - -	- - - - - - -
Perceived information costs (IC)	Users time and effort involved in conversion expenses	0.823	0.659	0.831
Perception of emotional loss (RL)	Users involved in the acquisition of psychological and emotional	0.807	0.726	0.718
With attitude (AT)	Means that users of 3G mobile communications positive or negative evaluation	0.814	0.743	0.732
Subjective norm (SN)	Others refer to the user to consciously use the 3G mobile communication for its recognition given by the extent of their willingness to follow the views of others	0.745	0.723	0.736
Intended use (BI)	Refers to the use of 3G mobile users will strength of the subjective	- - - - - -	- - - - - -	- - - - -
Actual use (BE)	Refers to the actual use of 3G mobile communication behavior	- - - - - -	- - - - - -	- - - - -

Analysis and Results

When asked about key parts of reliability and validity of analysis and statistical analysis tool which is used SPSS17 analysis software, it is a linear structural equation analysis using LISREL 8.8. In this study, measurement models for each dimension of the confirmatory factor analysis, and testing the various dimensions of reliability and validity; the use of structural models to test the relationship with the relevant path and the theoretical model proposed in this study.

Sample Descriptive Statistics

This study did variables means, standard deviation and percentage statistics from the subject's demographic variables, geographic variables and behavior variables to describe the structure of the sample. The following table is a sample survey of the demographic characteristics of distribution. The sample in gender distribution, male to female ratio of 58.6%: 41.4%. In age classification, it is mainly between the ages of 18 - 35, accounting for 80% of the entire sample. On the education level, it is mainly university - educated. On monthly income, nearly 60% of the subject is more than3,000 yuan.

Table 5. Statistics of the basic sample

	Frequency	Percentage (%)
Gender		
Male	297	58.6
Female	211	41.4
Age		
18	5	0.9
18 - 25 years old	179	35.3
26 - 35	137	46.7
36 - 45 years old	67	13.1
45 years old	20	4.0
Education		
Junior high school and below	10	1.8
High School	76	15.0
College / Undergraduate	410	80.8
Graduate and above	12	2.4
Monthly Income		
1,000 yuan	108	21.3
1000 - 3000 yuan	107	21.2
3001 - 5000 yuan	214	42.1
5001 - 8000 yuan	62	12.3
More than 8,000 yuan	17	3.1

The Reliability and Validity of Variable Scale

Using of exploratory factor analysis and α analysis, and doing questions item analysis, for the items within each dimension cannot be revised to delete the upgrade. When do analysis on exploratory factor, repair and delete question items of which value factor is lower to maintain the simplicity of dimensions on the one hand, on the other hand we can also verify the child constructs the convergent validity. And then ask for the item which has been refined after the dimensions of the construct between the exploratory factor analyses to further confirm the dimensions of the difference between construct validity. As shown in Tables 3 and 4.

Confirmatory Factor Analysis (CFA)

Through exploratory factor analysis (EFA) and α, it will continue to perform confirmatory factor analysis, in addition to re - evaluate the potential scale items and ask the variable factor validity, and preliminary testing of potential variables of theoretical concepts.

Regression Analysis

Based on statistical analysis of research methodology, it verifies the dependent variable to explain the extent of variation of independent variables.

$$
\begin{aligned}
&UV\ \ (UF\ \ ) = \alpha^{\ i} \\
&+ \beta_1^1 TS\ \ + \beta_2^i CT\ \ + \beta_3^i UI\ \ + \beta_4^i FU\ \ + \beta_5^i PE\ \ + \beta_6^i EC\ \ + \beta_7^i TA\ \ + \beta_8^i EM \\
&+ \lambda^i UF\ \ (UV\ \ ) \\
&+ \gamma_1^i Income\ \ + \gamma_2^i Age\ \ + \gamma_3^i AGender\ \ + \gamma_4^i Edu \\
&+ \varepsilon_i (i = 1,2)
\end{aligned}
$$

It can be seen from the regression results, F values are significant, so the return is valid, it can be seen from the results, the degree of individuals demographic characteristics seems to impact on the use of diffusion is normal, it is not important than other variables.

Table 6. The results of least squares regression analysis

	Use diversity		Use frequency	
	Coefficients	Standard error	Coefficients	Standard error
Intercept	4.382***	1.157	0.941**	2.463
TS	0.089	0.967	0.112	0.232
CT	0.318**	1.665	0.450**	0.176
UI	0.741***	0.146	0.081	0.164
FU	- 0.144*	0.114	- 0.016	0.265
PE	0.161*	0.027	0.148*	0.058
EC	0.178*	0.254	0.163*	0.191
TA	0.167*	0.056	- 0.234*	0.590
EM	2.328***	0.435	1.960**	0.620
Income	0.201*	0.117	1.876**	0.883
Age	0.083	2.009	0.045	0.613
Gender	0.081	0.265	0.008	0.010
Edu	0.154	0.351	0.282*	0.127
UF	- 0.103	0.089	- - - - - -	- - - - - -
UV	- - - - - -	- - - - - -	0.937**	0.229
R^2	0.289		0.214	
Adjusted R^2	0.266		0.207	
F Value	33.870***		24.147***	

* P <0.1; ** p <0.05; *** p <0.01

From the table we can see, there are several factors of diversity use as following: the use of complementary technologies, the use of innovative characteristics, the use of frustration, previous experience, external communication, external technologies, media exposure, personal monthly income, a significant (R^2 = 0.289). There are several factors affecting the use frequency, complementary technology use, previous experience, foreign stocks communication, external technologies, media exposure, personal monthly income, education, and the diversity use, are significant (R^2 = 0.214).

The following table assumes the verification results.

Table 7. Empirical model 1 — the results of a study of hypothesis testing

H1	Use high - tech precision will lead to high diversity and high frequency	Does not support
H2	The use of complementary technologies lead to high use of specific technologies and high - frequency diversity	Support
H3	The higher the use of innovative characteristics, resulting in higher diversity use and use frequency	Partial support
H4a	The technology uses high frustration will lead to a lower frequency and diversity use	Partial support
H4b	The frustration level of technology diversity does not affect the use or use frequency	Partial support
H5	The cumulative experience of the product led to more use of high frequency and high diversity	Support
H6	External communication will lead to higher intensity diversity use.	Support
H7	Combined with other technologies will lead to higher diversity use	Support
H8	The more targeted media exposure will lead to higher diversity use and use frequency	Support

Divided Types Based on People Who Use the Diffusion

In order to deepen the use of proliferation further, we take the mean value as the division point, which will be used and at high and low diversity and divided into two levels, thus forming four using diffusion model, heavy users, Comprehensive, specific users and limited users. We also calculated the proportion of the population of these four models, we can see, users are still limited in China accounted for the largest share, but slowly began to differentiate.

Then it can be seen from different demographic characteristics of the population, four types of people in some differences in demographic characteristics, but overall, the differences were not significant. Therefore, it may not be suitable for discussion from the demographic approach to the classification of different users. In particular, this study only be measured from the use frequency and the diversity use, it is difficult to have a very significant difference.

Table 8. The four user types using diffusion

		Use frequency	
		High	Low
Use diversity	High	Heavy users (25.7%)	Comprehensive (15.8%)
	Low	Specific users (21.3%)	Limited users (37.2%)

Table 9. Four kinds of demographic characteristics of users

	Heavy user	Comprehensive user	Specific user	Limited user
Gender				
Male	65.8%	53.3%	45.8%	58.2%
Female	34.2%	46.7%	54.2%	41.8%
Age				
18	15.9%	21.8%	11.2%	14.7%
18 - 25 years old	23.7%	38.1%	23.7%	41.2%
26 - 35	39.6%	21.4%	36.5%	12.7%
36 - 45 years old	18.7%	15.6%	25.9%	27.5%
45 years old	2.1%	3.1%	2.7%	3.9%
Education				
Junior high school and below	2.5%	2.9%	1.9%	1.7
High School	12.7%	10.5%	15.8%	15.3
College / Undergraduate	78.5%	82.2%	77.2%	80.4
Graduate and above	6.3%	4.4%	5.1%	2.6
Monthly Income				
1,000 yuan	16.3%	23.4%	15.4%	29.9%
1000 - 3000 yuan	17.8%	21.7%	24.6%	16.9%
3001 - 5000 yuan	44.7%	36.7%	41.1%	39.6%
5001 - 8000 yuan	14.8%	10.3%	16.0%	12.7%
More than 8,000 yuan	6.4%	7.9%	2.9%	0.9%

The user types, in addition to more specific user account for the proportion of women, the other three user types are more male ratio; heavy users and specific users are concentrated in the 26 - 35 years old, and extensive user and limited users are concentrated in the 18 - 25 years of age; heavy users more than education for the Institute or a little more than other users; heavy

users monthly income in 3001 - 5000 yuan accounted for the largest users of low and limited income users (1,000 yuan) is the largest among all users.

Multiple Comparison Test

Multiple comparison test is to verify the "perceived importance", "perceived use of knowledge and skills", "perceived financial loss", "perceived cost of information" and "perception of the emotional loss" in four different use of the spread of the existence of differences between groups. Study found that four kinds of users to use mobile communications services in the evaluation after the perception that there are significant differences.

Table 10. Four kinds of user types in the use of mobile communication service perception evaluation

	F value	Heavy use	Specific use	Comprehensive use	Limited use
Perception of the importance of IT	80.35***	3.54	2.84	2.99	2.09
Perceived knowledge and skills to use	91.37***	3.37	2.65	3.01	2.35
Perceived financial cost	14.67***	2.64	2.34	2.13	2.09
Perceived cost of information	23.60***	2.63	2.87	2.54	2.07
Perception of emotional loss	100.98***	3.11	1.84	2.89	2.67

*** P <0.01

The importance users of mobile phones on of the heavy users, followed by specific users and comprehensive users, is higher than the limited users. The use of mobile communication skills to heavy users is the highest, followed by extensive users, specific users and limited users. It can be seen frequent use of mobile phones were not able to make full use of mobile phones.

Conversion from the use of 3G, the heavy users of the perceived financial cost is the highest, followed by a specific user, Comprehensive, and limited users.

If the conversion use3G, the cost of a particular user's perception of information is the highest, followed by severe users, Comprehensive and limited users. This result may be due to a specific user who is not very clear what the 3Gis, for them, although many mobile phone use, but they may only use the limited functionality, so they need to spend more time and effort to learning and assessment of 3G.

For the conversion, perceive the emotional loss of heavy users is the highest, followed by extensive user, limited user, and a specific user. This result may be due to frequent use by heavy users and the use of multi - function, so in the immature 3G, the more reluctant convert; and function of specific users less likely to usually just call or send text messages, for conversion to 3G comparison's sake do not care.

Diffusion model with different people have different perceptions for the evaluation of existing services, creating awareness of its conversion services, thus affecting their aim to adopt new services.

Structural Equation Analysis

This study used structural equation to analyze the relationship between the variables, including the overall Goodness of Fit of the relationship between variables and the strength of the relationship between variables display. In this study, LISREL8.2 analysis, the result is X2 = 89.73, df = 36, GFI = 0.882, CFI = 0.885, PNFI = 0.467. Concrete path analysis is shown in Figure 2.

Validation for the hypothesis, the results of the potential relationship between the variables as follows. Spread of use in 2G perception evaluation, all shown to have a significant

impact on use intentions. The conversion cost, the use of intention to significant negative impacts, in order to perceive the greatest impact on the financial cost, perceived cost of information, followed by minimal loss of emotional perception. In addition, for the attitude of the new technology, the compatibility and perceived usefulness are the most influent variables. In the intention to accept the 3G, it seems the attitude has become a very important decision factors.

Figure 2. Path Analysis

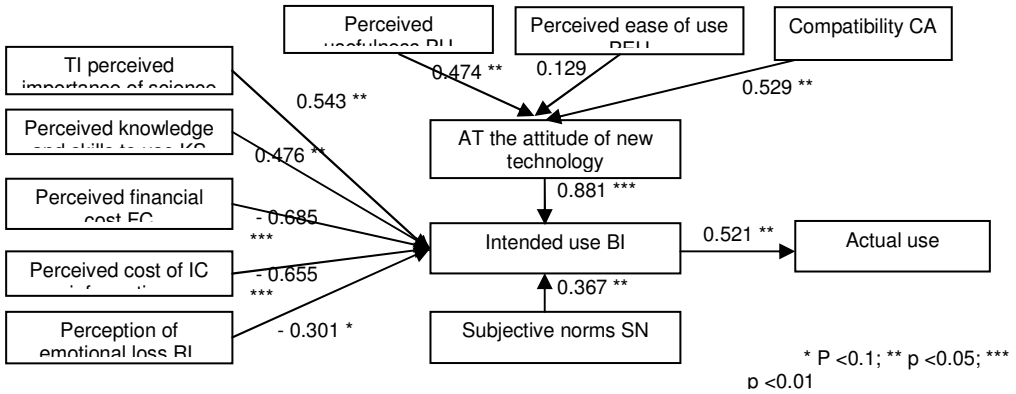

Table 11. Model 2 of empirical - the results of hypothesis testing

H9	Perceived usefulness significantly affect the attitude of the new technology	Support
H10	Perceived ease of use will significantly affect the attitude of the new technology	Does not support
H11	Compatibility will significantly affect the attitude of the new technology	Support
H12	The attitude of the new technology will significantly affect the intention to use 3G mobile communication	Support
H13	Subjective norms significantly affect the intended use of 3G mobile communications	Support
H14	Intended use of 3G mobile communications will dramatically affect the behavior of the actual use of 3G mobile communications	Support
H15	2G mobile users perceive the importance of high technology, the 3G mobile communications intended use will be higher	Support
H16	2G mobile users to use the knowledge, skills and high sense, the intended use of 3G mobile communications will be higher	Support

H17	2G mobile users perceive the high financial investment, the 3G mobile communications will reduce the intended use	Support
H18	2G Mobile users perceived high cost of information, the intended use of 3G mobile communications will reduce the	Support
H19	2G mobile users perceive the loss of high emotion, the 3G mobile communications will reduce the intended use	Support

We have those who truly want to buy 3G services analyzed, that is, those with a 3G phone or 3G service's perspective, the correlation coefficient of 0.521, although there is less than 0.8, this may be because: in the current China, the use of 3G phones with the use of hybrid between the effect of 3G services, and general users are still waiting to see the condition. However, statistical significance test results showed that between the adoption of acts of will and the adoption of a significant positive correlation, so that the marketing studies between attitudes and behavior are in significant contact.

According to the perceived spread of assessment that are intended for use with highly significant correlation, this study can be inferred whether using 2G would affect the intended spread use of 3G. The consumers showed a higher degree of diffusion (heavy users, Comprehensive),the acceptance of 3G will transform the higher dimensions in the use of diffusion, it seems that the diversity of the intended use of influence is greater than the usage.

Perceived usefulness and compatibility of new technologies and attitudes show a significant positive, indicating consumers compatibility with the 3G system operator whether to launch more 3G services 3G will affect consumer attitudes, thereby affecting whether the use of intent to accept 3G.

Perceived importance and perceived use of technology knowledge and skills both showing significantly the situation that associated with the intended use, both of which also is the theory of planned behavior mentioned in the perceived behavioral control variable of the two mentioned above. Therefore it can be proved that in the theory of planned behavior, attitude,

subjective norm, perceived behavioral control all these three would affect the adoption of new technology. The aim of this study, consumer adoption of new services coincides with previous studies.

For the prospective adoption of new services, there is an important aspect is the conversion cost. The three perceived switching costs among the perceived impact of the financial costs the most, followed by information costs, and minimal loss of emotion. Thus we can see, converting prospective customers new services, the most important thing is the price. If the mobile operators on the charges that consumers switch to 3G more affordable, then many people would be willing to accept the 3G. Of course, if the user is currently in use with the business can be the best. This operator will be able to know which aspects of the tariff for the adjustment.

Discussion

The first part of this study is mainly based on using the diffusion model, take use frequency and diversity use as measured standard, which can be further classified and understand the user types, to provide more complete information about consumer behavior, especially for the use of results after the use of depth. Therefore, this study used diffusion model to explore the types of mobile users and use the results of its determinants.

Discussion of the Determinants by Use Diversity and Use Frequency

For the diversity use factors, obtained from the analysis, when the more intensive users of external communication, with more sophisticated mobile phones, the more the use of complementary technologies, the more significant personal characteristics of innovation, the more experience, more The use of low frustration, the more regular contact with media information, more often combined with external technologies, facilitate the diversity use increases.

For use frequency of factors, obtained from the analysis, when the more intensive users of external communication, the more the use of complementary technologies, the more regular contact with media information, the more previous experience, the more often combined with external technologies to help in the use of mobile communication users in an increase in frequency.

In addition, the perspective on demographic variables, personal monthly income and the use of frequency diversity has a significant relationship; and education level for the use frequency is also a significant relationship. Representatives of income will affect mobile phone use, and higher education will be more frequent use of mobile phones.

On the diversity use in terms of frequency and use, but also a significant relationship between the two. Diversity use has a positive relationship between use frequency, that is, the more users use the feature, the user can make more frequent use of mobile phones. Therefore, operators can introduce more useful mobile services to boost the use frequency increase.

Discussion of User Typology

In this study, utilization and use of biodiversity, the user points severe users, specific users, extensive user, limited user and the type of analysis for the users, heavy users and highly variable in the model related, followed by a particular user, be Comprehensive. In addition, to further understand the various user types in the distribution of demographic variables, this study test, found in some of their differences on demographic characteristics, but overall, the differences were not significant.

In addition, according to Ram and Jung (1990), and Ridgeway and Price (1994) is the diversity use and use frequency of the association. In actual measurement, use frequency may contain a multi - use single - use behavior and conduct, therefore, use the higher diversity may

lead to an even higher use frequency. Thus, this study suggests that the four user types, arranged according to level of use of diffusion, the user should be severe, extensive users, specific users, limited users.

Discussion of Use - Diffusion Outcome

Heavy users than other types of mobile communication users feel the importance of daily life have a greater impact, effective use of mobile communications. Thus, the development of mobile communication users must feel its necessity, essential to daily life, and in the use and satisfaction have a greater sense of accomplishment, and its diversity use and relative use frequency will increase, from severe users.

The concept of switching costs in a particular perception of the user information on the cost of significantly more sensitive. This result may be due to a specific user is not very clear why the 3G thing, for them, although many mobile phone use, but they may only use the limited functionality it fixed, so they need to spend more time and effort to learning and assessment of 3G. In the perception of emotion, the higher the level of use of diffusion, the loss will be higher perceived emotional; that, 2G users to use the higher level, the higher the satisfaction of the 2G and 3G systems do not want to convert. In the perception of financial inputs, the higher the frequency, the higher the perception of financial inputs, that is, the user is already in the application of 2G, but with not many functions in the current 3G services is still unable to meet the needs of users do not willing to be able to use 3G services and to pay costs to the detriment of the interests of the use of 2G.

The study advocates the use of frequencies for mobile communications using diversity measure with the use of behavior is true, should be used to track the record is the best fit would

be closer to the real surface, and other demographic variables descriptive statistics, in order to truly reflect the different consumer use, as the market segment of reference information.

Discussion for Adoption of Upgraded Services

The second part of this study is to specify the current 2G users to 3G and then accept or converted to use the empirical results. Relationship between the original variables assumed structure, supported in part, on the other hand it also did not get some support, due to various types of conversion factors under the impact of antecedents and consequences of the effect of a difference, assuming that the variable structure change.

1. Emotional impact of loss on the intended use the lowest 3G

In the first part of the study indicated that the higher diversity use, the more dependent on a sense of 2G and 3G emotional perception of losses on the conversion higher. But when the prospective new service or potential new products appear, the user's attention was diverted. Potential new products or services is that not only retains the original stuff, but also up with a lot of features, so that consumers perceive a high degree of emotional costs on the low side, and on behalf of a strengthened and business space. This is reasonable behavior.

2. Financial inputs to accept the intended use of 3G the most significant impact

In fact, mobile operators were fierce competition with each other, most likely cut from the price point of the program, the so - called market price of the new programs, particularly to reduce the customer's barriers to entry, to arouse the user to accept new business, obviously people have perception of differences. Financial inputs from the perception point of view of the relationship between the intended use, two variables have a significant negative relationship, that is, the higher the perception of financial investment, the lower the intention to accept 3G. Although some of the current tariff scheme reduced the surface looks like difference between 2G

and 3G, that is, to enjoy the same price the original 2G services, 3G services can now enjoy more. But the fact is to explore its contents, but it is joined to enjoy the 3G business, basic business and had greatly reduced the share of 2G services. 3G is not yet stable in the current situation and development of the business has not been practical, in disguise of consumers of financial investment probably to little avail.

3. If take the user types as a factor to have whether to accept or 3G to be analyzed, said the use of different types of users have different views on the intent: heavy users into 3G highest intentions; specific user minimum.

4. Consumers cannot be stuck using the diffusion factor

From China Mobile's point of view, the perception of viewing the information in this study does mean low cost, on behalf of 3G subjects were feeling from the heterogeneity of functional operation is not large. Therefore, consumers have become accustomed to using the mobile operators offer a variety of services, and even inertia, so the difference to upgrade to the 3G experience is not large, making the use of diffusion of information is not easy to form the switching costs.

Besides the use of consumer records to analyze the consumer provided by 3G operators to use the heterogeneity of the product situation. From 2G to 3G, the most obvious difference is the limited services, most notably in the high - speed Internet access and video telephony. Other opportunities for 3G services is too small to be used, although the 3G may provide a considerable degree of innovation and highlights, but consumers will make the use of such heterogeneity cannot easily be perceived, if it is because you want to switch to more value - added services 3G, the current situation, should also be a few people, it does not constitute the need for conversion, most will remain in the 2G wait and see.

Management Implications

With empirical results of this study, the operators have to retain heavy users and improve the use of a specific user skills, to develop Comprehensive in the market. The results showed that a limited user with a wide range of factors in determining the level of knowledge the user does not have significant differences, but heavy users with a particular user on the determinants of cognitive significantly different; the same time, in order to improve the user's use of diffusion effect, mobile operators can continue to introduce 3G mobile phones and value - added services, driven by the functional diversity by using an interactive drawing growing frequency, but cannot ignore the value of providing value - added services, or stride blindly invest in market development value added services, increase the use frequency of no real help. Should be re - added services for mobile communications product detail orientation, different target markets in order to enhance the value perception of value - added services. Service function allows users to identify the effect brought about, in order to avoid service users do not feel the effect of using the feature, and lost the use of interest; In addition, empirical results show that users consider accepting the three 3G mobile communication factors rates, adding new business and system compatibility. For mobile operators, how to make a real difference to meet consumer demand functions, and can be widely used, is the operators need to think about.

Prospects for Future Research

In this study, there is still a lot of constraints on researching, for example, the system cannot be sampled, the sample is difficult to infer the appropriate degree, what’s more, the sample size is not enough, resulting in the case is not accurate which contains a variety cases of users, it is also a great pity. For the scale design, the process of amending the translation can be

easily differ. In addition, the number of variables measure is inconsistent, it may cause bias on the accuracy.

In future research, because there are so many facts affect the use frequency, there are also many perceived results, it is recommended to extend more value - added services on mobile communication dimensions, a more complete and accurate study are needed, in addition, the prospective new products and services changed with each passing day, using the diffusion theory which can be used for a variety of products and services to further validate a more complete use of concrete, which can improve its model.

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RESEARCH OF THE CUSTOMER RECOMMENDED SERVICE MODEL

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Abstract

In this research, we use two different theoretical models for customized modular product design to establish the relationship of product evaluation between the status of consumer demands and the features of the product. Furthermore, by using different theories and the database of the product modules that built through the inputs of the experts we build the criteria for recommending the most suitable product by its modulated functions or components. Then, such mechanism is used to provide customer recommendation system for two different companies with their modulated products. The company can use the system to recommend suitable modulated product according to the needs of different customers. The customer can also use the system to search the desired products by inputting the requirement information.

The model build by the customized modular product design in this research, product design model I: we use fuzzy information axiom as the evaluation and decision principle of the product design model. Product design model I: the Analytical Hierarchy Process, Fuzzy Set Theory, Back-Propagation neural network, and Gray Relational Analysis are also used for the evaluation and decision principle of the product design model. With the maturity of current network technologies and e-commerce practices, a suitable recommendation service system to guide customer's needs is needed for marketing. The manufacturers can use this system to extract the information of the needs for their customers as well as the choices of the products the made. Such information should provide valuable inputs for the sales and future improvement of the product to the company.

Keywords: Customization, Modular Product, Fuzzy Information Axiom, Analytical Hierarchy Process

Introduction

In commodity markets, customers or consumers can purchase products with different functional levels according to the conditions of their demands. How different consumer groups purchase products is a perspective enterprises use to plan the standardization of customized products. This approach ensures that enterprises not only attain higher sales amounts and profit space, but it will also be a key factor in industrial development of the electronic generation. This is especially true in the Internet age; this option can be at a customer's "fingertips" to help them obtain good results. In particular, consumers face complex purchasing decisions. Defining how to help consumers buy products, based on specific recommendations for producers and consumers, is a major area under refinement.

Each customer's degree of demand for a product is different. If every demand is viewed as equal in importance, objectivity and the desired outcome cannot be reached. Furthermore, there are various degrees of fuzzy relations between demand and product functional modules, so there needs to be an appropriate theory or rule that can solve the relation mode.

Therefore, in the product design process, we need to help consumers select the "right" goods. In past research, greater emphasis was on the design of products from the standpoint of product information decision-makers. The information could be easily accessed and handled. However, customers' expectations are typically different from the designed products. For customer-centric information research, the classification of the customer groups and the operations of customer relationship management practices are usually emphasized. As for the complex relationships between customers and companies, policy decision-makers traditionally use a single algorithm to solve a single policy or evaluation. Rarely, they will focus on the

complexity of the issues, finding an appropriate algorithm for different degrees of the demand and provide a better solution for every step.

Consumer habits often use adjectives to describe the demand for the product level, but the semantics of expression is full of a considerable degree of fuzzy logic and uncertainty. After Zadeh (1965) presented a fuzzy theory concerning how to open the order into a number of linguistic expressions of the first kind, research related to fuzzy theory could mushroom to promote the success of the domain. Moreover, if the true intent and product demand function zooms, a considerable degree of fuzzy association exists, which requires appropriate theoretical principles to solve the relational model. Today, product consumption by the customer is more than subjective self-awareness. In particular, consumption is strongly attached to a customer's own vision and values. Characterized by the product's uniqueness and practicality of the purchase are two important indicators of reference. The products with these characteristics have a long product life cycle and they experience greater demand creation or customization. The resulting changes in product design are developed by considering the design intent.

The purpose of this study is as follows:

(1) Two different theoretical models are provided for a customized module design.

(2) Between the evaluations, consumer demand, product characteristics, and functional association are built up.

(3) Two different case modules are presented to create a consumer business referral services system.

Product designs recently researched for this article relate to scholars with a variety of theories to evaluate the product or purchase product decisions. Such scholars include Kulak (2005), Kulak Durmusoglu & Tufekc (2005), Kulak & Kahraman (2005a, 2005b), Diyar &

Kulak (2007), Durmusoglu & Kulak (2008). Scholars use the Fuzzy Information Axiom and Fuzzy Theory, as well as the Gray Theory ,Analytic Hierarchy Process(AHP) to explore the concept of multi-attribute products designed to support decision-making systems. Tsai & Hsiao (2004, 2005), Tsai, Hsiao & Hung (2006), and Tsai & Chou (2007) use a genetic algorithm, AHP, the Gray Theory, and the Fuzzy Theory with customers to explore the multi-functional product evaluation and selection. They also use computer-aided design.

Hsiao & Huang (2002) attempted the use of computer-aided design and neural networks to assist in product shape design consulting decisions. The scholars, Sun, Kalenchuk, Xue & Gu (2000), attempted to combine the Fuzzy Neural Network Theory(FNNT) as the case for the conceptual design for product-related evaluation and decisions.

Using fuzzy axiomatic design principles of information to design the best product is a simple and efficient method, and only the expression of consumer demand semantics can be used to quantify the fuzzy theory. It has been assembled for modular use. This product is easy to use in design principles to search for the best consumer products.

What if the characteristics of functional elements are not yet completed? If this is the case, the customized combination of modules can be obtained using the AHP to rank the importance of customer needs in order to get a back-propagation neural network to obtain the characteristic function of the importance and the gray relational analysis. This obtains the best combination of features for the modular product features.

Product designs feature many key factors to be considered for academic research and theory. Customized modules are designed to consider the following key items:

(1) Customer needs

(2) Functional characteristics (of the module)

(3) Database

(4) Evaluation and decision theory

(5) Optimum product search

Linking these five key factors will greatly influence the results of product design, as well as the product designers and product features. The customer needs identify for the module, so a lot of thought goes into the custom module products library database, and such style must also be sold to customers for the range of products. The final evaluation and decision theory are selected by the designer to achieve the end goal.

Research Methods

The theoretical bases for the use of this research are briefly described as follows.

AHP

This research uses the theoretical analytic of analytic hierarchy process to set up the class weight of customer requirements. Each customer uses a scale of 1–9 (see Table 1) to compare the "importance degree" of the demands according to their "demand degree." If there are n items of basic demands, after the comparison from the customers, an n×n square matrix may be seen ($A_{n\times n}$).

$$A = \begin{array}{c} \begin{matrix} N_1 & N_2 & \cdots & N_n \end{matrix} \\ \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \end{array} \begin{matrix} N_1 \\ N_2 \\ \vdots \\ N_n \end{matrix} \quad \text{---------- (1)}$$

In order to ensure consistency while conducting the paired comparison, a consistency test is performed. The Consistency Ratio (CR) is used to check whether the matrix was a consistent matrix. If $CR \leq 0.1$, the paired comparison matrix features a high level of consistency.

Therefore, one can obtain the eigenvector (**w**) of matrix A from the following formula:

$(A - \lambda I)\mathbf{w} = 0$---------- (2)

I is an n×n unit matrix. λ is an eigenvalue of matrix A. Take the largest eigenvalue λ_{max} with the corresponding eigenvector, which will represent the "importance assessment" of customer demand.

Table 1. Comparison rate of customers' basic needs

a_{ij}	comparison rate of i-demand and j-demand
1	i-demand and j-demand are equal important
3	i-demand is a bit important than j-demand
5	i-demand is more important than j-demand
7	i-demand is much more important than j-demand
9	i-demand is extremely more important than j-demand
2468	Intermediate values of the adjacent scale

Fuzzy Theory – Triangular Fuzzy Number (TFN)

A TFN is a special case of trapezoidal fuzzy numbers. Function $\tilde{t} = (t_1,t_2,t_3)$ is used to represent the distribution graph of the membership. As shown in Figure 1, real number t_1, t_2, and t_3 represent the reflection value of the x-axis in the three vertices of the triangle graph.

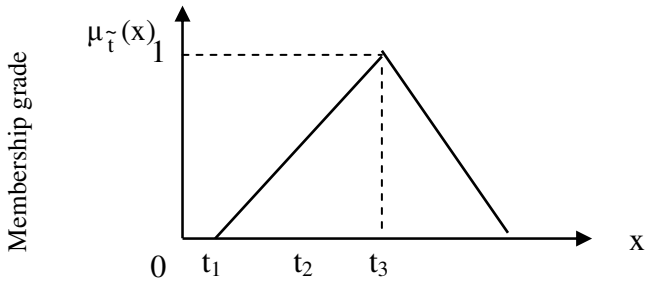

Figure 1. TFN $\tilde{t}$

T

herefore, the TFN can be shown as:

$$\mu_{\tilde{t}}(x)=\begin{cases}0, & x<t_1\\ \dfrac{x-t_1}{t_2-t_1}, & t_1\le x\le t_2\\ \dfrac{x-t_3}{t_2-t_3}, & t_2\le x\le t_3\\ 0, & x>t_3\end{cases} \quad \text{---------- (3)}$$

Back-Propagation Neural Network (BPNN)

Neural networks imitate human nervous conveyor systems, and the BPNN, like emulates a supervised learning neural network. As shown in Figure 2, the network structure can be divided into an input layer, a hidden layer, and an output layer. The theorem uses the non-linear reflecting relation of input and output; amending the error value step-by-step. This is used to calculate the appropriate network weights value and bias so that it can achieve the result of the output reflection in the range of tolerance error.

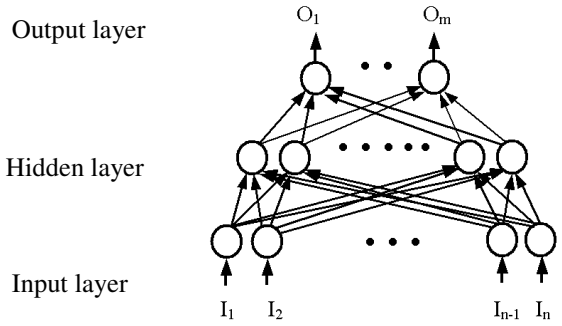

Figure 2. BPNN

The Gray Theory (GT)

In the gray system control theory, or GT, the grayscale of color is an index of the awareness level of the system. The color black indicates that nothing is known about a system's internal structural parameters and characteristics. The color white represents known information that is complete and has been fully understood for the system. The color gray, which lies in

between black and white, represents that the system is composed of partially known information and partially unknown information. The GT is aimed at system uncertainty and incomplete information. Once the level of uncertainty and incomplete information is determined, then correlation analysis and model building are conducted, which relate to the system to assist in further prediction and decision-making.

This research uses the gray relational analysis in the GT to analyze the relation level between the main factors and other factors in the system. Through the calculation of the gray relation degree, the correlation between the two sequences is obtained.

If there is an object sequence $X_1 = (x_1(1), x_1(2), ..., x_1(n))$, and one wants to calculate the individual gray correlation γ between this and the other sequence $X_j = (x_j(1), x_j(2), ..., x_j(n))$, it can be calculated in the following formula:

$$\gamma(X_1, X_j) = \frac{1}{n-1}\sum_{k=1}^{n-1}\left(\frac{\min\limits_{j}\min\limits_{k}\Delta_{1j} + \rho\max\limits_{j}\max\limits_{k}\Delta_{1j}}{\left|x_1(k) - x_j(k)\right| + \rho\max\limits_{j}\max\limits_{k}\Delta_{1j}}\right) \quad \text{---------- (4)}$$

ρ is a resolution factor, usually the value is 0.5; $\Delta_{1j} = \left|x_1(k) - x_j(k)\right|$.

Fuzzy Information Axiom (FIA)

Suh (1990, 1995, 1997, 2001) from the Massachusetts Institute of Technology (MIT), further developed QFD (Quality Function Deployment) and proposed the Axiomatic Design (AD). The main purpose of this axiom is to produce a simple design. Suh defined the information content as I, and it is calculated using the formula I (Information Content) = log (design range/common range). A small "I" implies a large common range, which means that as the common range becomes larger, it is easier for the product of this design parameter to be successful. This success signals the ability to meet its corresponding functional requirement. In

this case, the system range refers to the manufacturing capability of manufacturers; the design range is the designer's requirements, while the common range is the overlapping part of the system range and the design range. Therefore, when the common range is larger, there is a higher possibility for manufacturers to produce a product according to the designer's concept, thus increasing the chance of success. This concept can be seen in Figure 3.

The second axiom of the AD is the information axiom, which states that among those designs that satisfy the independence axiom, the one with the smallest information content is the best design. The definition of information content (I_j), expressed in terms of the TFNs, is as follows:

$$I_j = \log_2(1/p_j) \quad \text{---------- (5)}$$

Where p_j is the ratio of the area of the common range to the area of the system range for the jth design requirement, which is also the probability of the system range meeting the design requirement.

$$p_j = \left[\frac{CommonRange}{SystemRange} \right] \quad \text{---------- (6)}$$

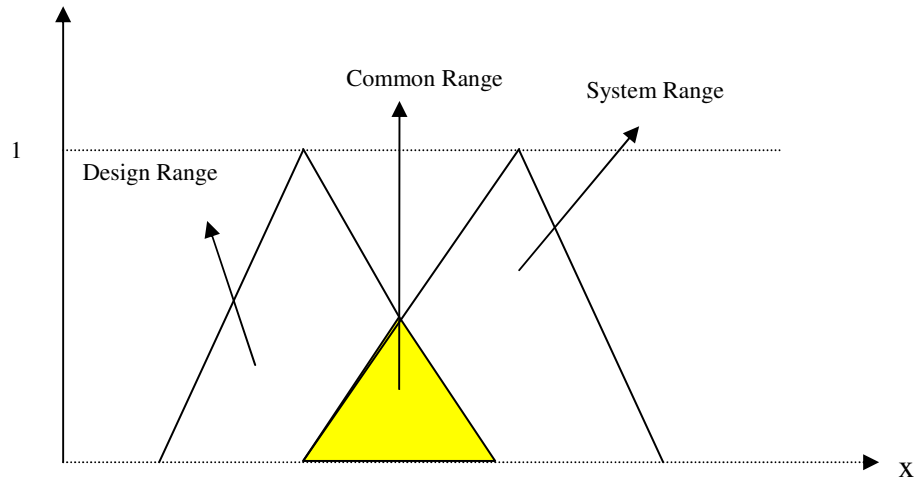

Figure 3. Triangular fuzzy relationship between the system range, design range, and common range

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$$p_j = \left[\frac{CommonRange}{SystemRange}\right] \quad \text{---------- (6)}$$

As shown in Figure 2, the overlap of the "design range" set by the designer and the “system range” of the system capacity is the acceptable common range; the larger the common range, the higher the success rate will be.

Assuming that a product has m number of design requirements, the summation of all the design requirements is such that:

Total Information Content (I_{total}) is defined below:

$$I_{total} = \sum_{j=1}^{m} I_j \quad \text{---------- (7)}$$

Customized Modular Product Design Model.

For product research in the module design process, this article will be divided into two different theoretical models:

Model I: We use the FIA as the evaluation and decision principle of the product design model.

Model II: The AHP, Fuzzy Set Theory, BPNN, and Gray Relational Analysis are also used for the evaluation and decision principle of the product design.

Construction of the FIA model

The model theory of the FIA is the evaluation criteria considered when evaluating the concept of the Taguchi method to conduct modular product design. Its research methods and design process are described as follows.

Using the concepts of the TFNs and the Taguchi method, the following were established:

(1) TFNs for the requirement levels

(2) The relationship between the evaluation of functional requirement options and product features, in order to establish rules to relate the evaluations of customers and designers.

For a designer, the functional requirements not only contain the main, obvious customer product parameters, but they also contain customers' potential needs. The functional requirements of customers are often hard to express explicitly, so fuzzy numbers are used to determine customer needs, as expressed using the seven levels listed in Table 2.

Table 2. TFNs showing seven requirement levels

Vocabulary	Denotation	TFNs
A Very low	VL	(0,0,1)
B Low	L	(0,1,3)
C Medium low	ML	(1,3,5)
D Medium	M	(3,5,7)
E Medium high	MH	(5,7,9)
F High	H	(7 ,9,10)
G Very high	VH	(9,10,10)

The computation formula for the selection of the best product is explained as follows:

(1) Assuming the customers' functional requirements to calculate the median of customers'

functional requirements.

If there are n basic customer needs, they are translated into seven levels of triangular fuzzy numbers and the median of customer needs is calculated and normalized to obtain the customer needs in the hierarchical order **w** ($w_1, w_2, \ldots, w_n$), as shown in Formula (8).

$$\sum_{i=1}^{n} w_i = 1 \text{ ---------- (8)}$$

(2) Computation of the requirement level for a product feature

As shown in Table 4, the TFNs for the relationship matrix of customer needs and product features assessed by experts are $\tilde{A}$

$$\tilde{A} = \left[\tilde{a}_{ij}\right] \text{ ---------- (9)}$$

where i and j denote i-th customer need and j-th product feature.

The product of the relationships between the normalized customer requirement levels, weighted customer needs, and product features will give rise to a j-th TFN for product feature $\tilde{b}_j$.

$$\tilde{b}_j = \sum_{i=1}^{n} w_i \times \left[\tilde{a}_{ij}\right] \text{ ---------- (10)}$$

(3) Computation of information content I_j

Based on the results in step 2, using the design range and system range of the actual product shown in Figure 2, the information content I_j of the j-th product feature is determined:

$$I_j = \log_2(1/p_j) \text{ ---------- (11)}$$

(4) Establishment of rules for the selection of the best product

According to the fuzzy reasoning principles of feature requirements established in Table 4, the median of various product features is calculated, and the normalized weight of the j-th product

feature is w_j^{nd} , whereby $\sum_{j=1}^{m} w^{nd}{}_j = 1$

(5) Finally, all the information content obtained is sequentially multiplied by the standardized level to obtain the grand total value for product information content E_{min} ; its formula is as follows:

$$E_{\min} = \sum_{j=1}^{m} \left(I_j \times w_j^{nd.} \right) \text{---------- (12)}$$

(6) Establishment of the ideal product purchasing interface for customers

The above algorithms are programmed to establish the ideal product purchasing programming interface. Consumers can use this interface to select their personal needs and the system will suggest the most suitable merchandise, or use this interface to preview the recommended products.

Construction of Fuzzy AHP, BPNN, and GT models

This research is based on the algorithms built by the AHP, the fuzzy set theory, and the BPNN to help customers or consumers calculate the membership grade of each functional module level according to their own preference of the demand condition.

(1). Establishment of an evaluation rule for the functional modules

This stage is intended to build up the relation and evaluation mode between "customer demand" and "functional module" in the following three steps.

Step 1. Ranking and development of customer demand

If there are n items of a basic customer demand, after conducting the paired comparison, one can use Formula (2) to calculate the eigenvector **w** (w_1, w_2, w_n) of the customer demand. Next, it is normalized, and the class sequences w^* ($w_1^*, w_2^*, \ldots, w_n^*$) are obtained for customer

demand and fuzzy the sequences into five-order TFNs individually. Table 3 represents the table and graph of the TFNs of five lexical grades.

Table 3. TFNs showing five requirement levels

Lexical Category	TFNs
A Fairly Unimportant/Lower	(0,0,3)
B Unimportant/Low	(1,3,5)
C General/Normal	(3,5,7)
D Important/High	(5,7,9)
E Fairly Important/Higher	(7,10,10)

Step 2. Establish the relevance of "customer demand" and "functional module"

In accordance with different customer demands, one identifies the functional module, with a greater satisfaction, as an important goal of this step. Therefore, the relevance between "customer demand" and "functional module" must be established. Suppose there are n items of customer demand and m items of the functional components category. One can now set up a correlation level matrix $R_{n\times m}$.

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{bmatrix}$$

Therefore, one can imitate the method in Step 1, where the fuzzy r_{ij} is in five grades of TFNs. The correlation level between "customer demand" and "functional module" is shown in Table 3.

Step 3. Evaluation of fuzzy lexical functional module

According to the importance degree of the lexical group (fairly important, important, normal, unimportant, fairly unimportant) and the correlation lexical group (high positive correlation, correlation), which is defined by the first two steps, one can follow the fuzzy logic

structure “if…then” to evaluate the demand level (fairly high, high, normal, low, fairly lower) of the modular function. From the interaction into pairs of the 5 “importance level lexical," and 5 "correlation level lexical,” 25 fuzzy inference rules can be obtained.

For instance, if the ith demand level of a customer is “fairly important” and the functional module of jth that fulfills the demand correlation of ith is “highly relevant,” then that functional module will respond to the correlation demand in “fairly high” form. The statement above can be simplified with fuzzy logic as follows:

IF “Customer demand – fairly important” and “correlation – highly relevant”

THEN “Functional module demand – fairly high”

The 25 fuzzy logic inferences are shown in Table 4.

Table 4. Correlation for customer demands and functional modules

Customer Needs	Relationship Between Customer Needs and Product Features						
	VH	H	MH	M	ML	L	VL
VH	VH	VH	H	M	L	VL	VL
H	VH	H	H	M	L	L	VL
MH	H	H	MH	M	ML	L	L
M	H	MH	MH	M	ML	ML	L
ML	MH	MH	M	M	M	ML	ML
L	MH	M	M	M	M	M	ML
VL	M	M	M	M	M	M	M

Establishment of the fuzzy algorithm of a neural network

As shown in Figure 2, a BPNN can be divided into: input layer, hidden layer, and output layer. In this research, we count 10 values of the 5 fuzzy levels of “customer demand” and “correlation” in the IF condition, and put them as the node values of the neural network input

layer. Additionally, the five levels of "functional module demand" are put in the THEN condition as the output layer node. Therefore, the example of Step 3 can fuzzy the result of the input condition and output condition as:

INPUT: 1 0 0 0 0 1 0 0 0 0

OUTPUT: 1 0 0 0 0

The 25 fuzzy logic conditions, which are structured by the aforementioned, can be provided as neural network learning rules, and calculated by MATLAB software, to obtain the weighted value and bias of the neural network. The network that completes the training can help a customer get a basic demand that corresponds to the output sequence P ($p_{ij}(1)$, $p_{ij}(2)$, $p_{ij}(3)$, $p_{ij}(4)$, $p_{ij}(5)$) of each functional module according to a customer's personal demand. This sequence can be shown as a line chart function f(x) and one can get the focus position p_{ij}^{*} in the line chart function of the ith demand and jth functional module.

$$p_{ij}^{*} = \frac{\int_0^1 f(x)xdx}{\int_0^1 f(x)dx} \text{ ---------- (13)}$$

Hence, one can take each functional module demand as the standard, weighted average demand level (eigenvector) for each functional module. Then, the sum of demand membership in each functional component can be obtained by Formula (14).

$$P_j^{*} = (\sum_{i=1}^{n} p_{ij}^{*} \cdot w_i^{*}) / \sum_i w_i^{*} \text{ ---------- (14)}$$

Use of the GT decision model

The membership that is obtained by Formula (14) can be seen as an object sequence $P^{G}(p_1, p_2, \cdots, p_m)$. However, while the functional modules are in the free combination, some conflicts might occur between different functional style options. If the functional module can be reasonably assumed into pairs, or the manufacturers have set the matching methods at z

combinations, one can see those combinations as z reference sequences $P_k^R(p_1, p_2, \cdots, p_m)$, and k = 1, 2,…,z. Different gray correlations of reference sequences and object sequences through Formula (4) can be attained. The maximum value γ_{max}, the sequence, which corresponds to γ_{max}, is the best product functional module style suggestion according to each customer's personal demand.

Research Case

In this paper, our case enterprises include two companies in Chiayi: (1) a sales-based notebook computer company, and (2) a production and sales-based baby stroller manufacturing company. These two companies will be used for the actual calculation of a modular product design model and model II, and the establishment of referral services system interface module products; these two companies can use this referral service system based on customer needs to have the most suitable module products for their customers. Each company can use the results, combined to promote these modules. Furthermore, the results can be placed on the company Web sites for consumers, in accordance with their needs, to assist their search for the most suitable modules.

Example 1

The basic customer needs are jointly developed by two experienced and professional computer sales staff, two laptop product planners, and one of Research and Development (R&D) staff member. Based on the basic customer requirements for the important features, the experts and consultants of this study selected seven Preferred Features (PF), namely: Central Processing Unit (CPU), Random Access Memory (RAM), Screen Size, Hard Disk Capacity, Display Card, Price, and Color (see Table 5).

Table 5. Designer's selection of customers' functional requirements and preferred product features

	Customer Needs	No.	Product Features
CN1	Word Processing	PF1	CPU
CN2	Professional Graphics	PF 2	RAM
CN3	Numerical Computation	PF 3	Screen Size
CN4	Portability	PF 4	Hard Disk Capacity
CN5	Price	PF 5	Display Card
CN6	Color	PF 6	Price
		PF 7	Color

Feigo would like to buy a laptop, but he knows nothing about computer hardware. In this study, the FIA algorithms are used to help him search for the ideal market laptop based on his actual needs, which are listed in Table 8.

Table 6. Feigo's requirements for computers and the requirement levels

Serial Number	Functional Requirements for Computer	Feigo's Requirement Level
CN1	Word Processing	H
CN2	Professional Graphics	VL
CN3	Numerical Computation	M
CN4	Portability	MH
CN5	Price	Below TWD 30,000 ML
CN6	Color	White

The notebook computer product purchasing interface is produced (see Figure 4).

A smaller information content indicates that the laptop is closer to the customer's requirements. Feigo's top three computers are NB21, NB41, and NB50. Looking at the laptop ranked first in the table, its price and color have satisfied Feigo's requirements, the screen size is comparable to his requirements, and it has a higher CPU and hard disk capacity. The customer has a greater need and priority for word processing and numerical computation; therefore, since

the laptops that ranked second and third may have smaller screens, and their CPU and hard disk capacity are much smaller, they are placed below NB21.

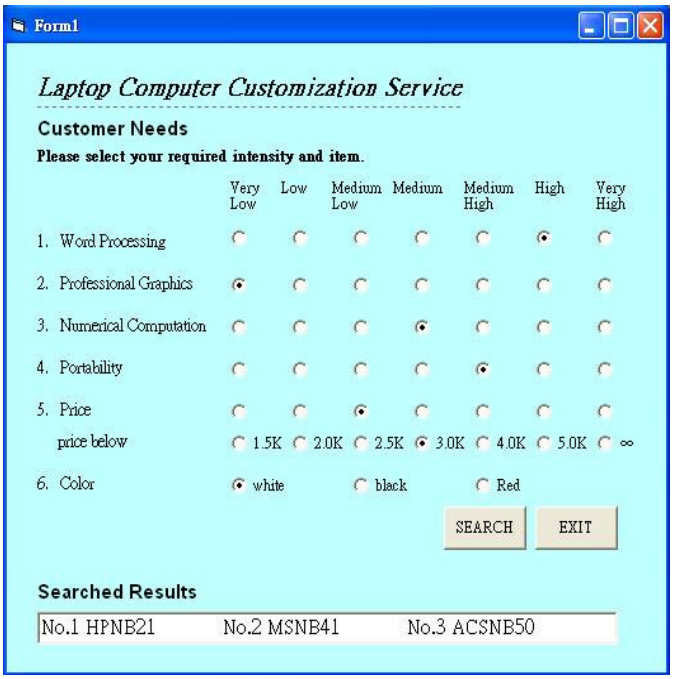

Figure 4. Notebook computer product purchasing interface

Example 2

The setting of each baby stroller functional type classification is shown as Table 6. Each functional type has its own modular style. The modular style that has the same function can follow the low-to-high of the product positioning, equally divided between the value [0, 1]. In Table 7, the value in that column shows the relationship between customer demands and functional modules.

Table 7. Category of modular function for baby strollers

Item	*Product Features*	*Alternatives*	*Membership Grade*
F_1	*Folding Operation*	*One-Hand Operation + Joint Pull*	*1*
		Hook Pull + Joint Pull	*0.5*

		Joint Pull	*0*
F_2	*Self-Standing after Folding*	*Included*	*1*
		Not Included	*0*
F_3	*Reversible Handle*	*Included*	*1*
		Not Included	*0*
F_4	*Accessories in Front o Seat*	*Tray + Toy Bar*	*1*
		Tray	*0.5*
F_5	*Seat Back Adjustabilit*	*Bumper*	*0*
		Multi-Position	*1*
		Two Positions	*0*
F_6	*Foot Rest*	*Adjustable*	*1*
		Fixed	*0*
F_7	*Wheel*	*Pivoted (6 Wheels or 8 Wheels)*	*1*
		Fixed Direction (4 Wheels)	*0*
F_8	*Suspension*	*Cantilever-Type*	*1*
		Simple-Type	*0.5*
		Non	*0*

(1) The setting of customer demand

The set of six basic customer demands according to the product features is depicted in Table 8. These demands are: (1) sitting comfort for baby, (2) collapsibility, (3) portability, (4) operational usage, (5) additional components (toys, space), and (6) lower price.

Table 8. Setting demand for baby strollers

Item	Content of Demand
N_1	Sitting Comfort for Baby
N_2	Collapsibility
N_3	Portability
N_4	Operational Usage
N_5	Additional Components (Toys, Tray)
N_6	Lower Price

(2) Finally, the baby stroller product purchasing interface is provided (see Figure 5).

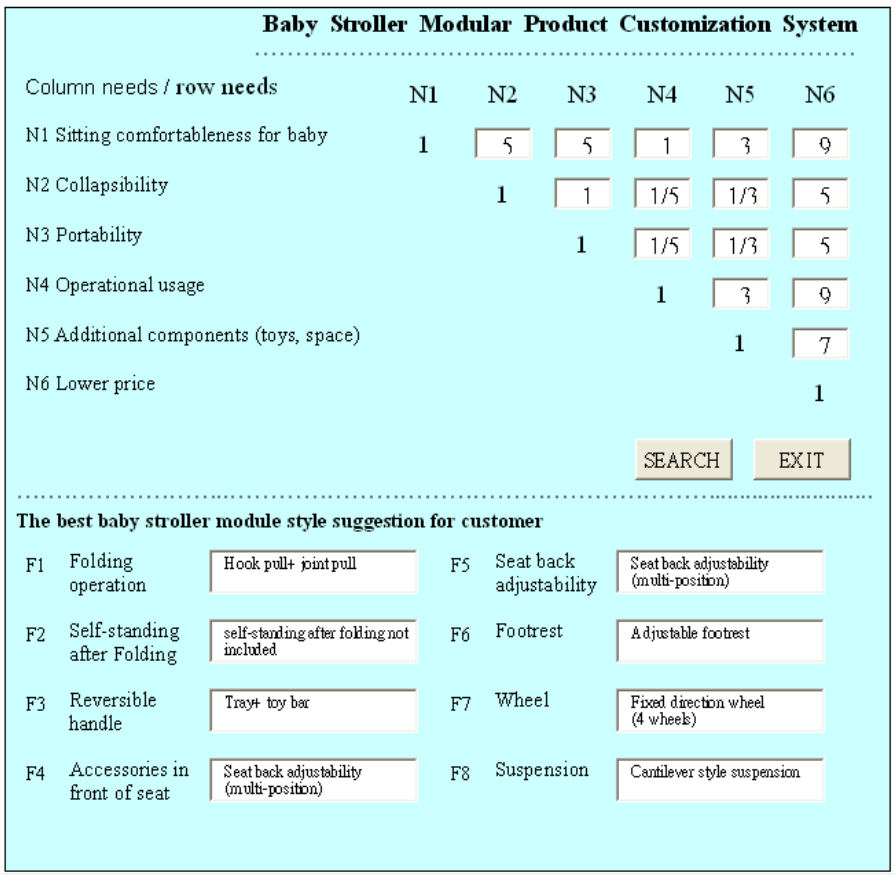

Figure 5. Baby stroller product purchasing interface

For this reason, the best baby stroller module style suggestion for customer A is: (1) hook pull + joint pull, (2) self-standing after folding not included, (3) reversible handle, (4) tray + toy bar, (5) seat back adjustability (multi-position), (6) adjustable foot rest, (7) fixed direction wheel (4 wheels), and (8) cantilever-style suspension.

Conclusions and Discussion

This paper discusses customized module design, model-building, and customer assistance in two case enterprises. These efforts are discussed to establish a service system and to make customers a variety of products where they can select a suitable product. The contribution of this paper is as follows.

(1) In the customized module design, two established design patterns, starting with the preferences of the customer's needs, attend to consumer purchase behavior, which may be

waived by the designers for the lack of subjective guidance.

(2) In the product design process, some scholars design the FIA to evaluate the product, then consider this increase in customer expectations of the product quality characteristic factor in market practices, thereby enhancing consumer product satisfaction.

(3) In the product design process, after establishing an expert evaluation of the database modules, consumers can buy more products based on similar module choices.

(4) Once this module product design model is established, then versatile enterprises can use this model to establish the company's consumer referral service system to provide consumer buying preferences of the different modules of their products.

(5) A company can apply what is in this paper to provide the service system recommendation to consumers who fall within the interface of the obtained results, with the actual consumer purchasing decisions in the market comparison. The different results may help a company's marketing and product development strategies. They may need to be strengthened in part (e.g., determine if advertising spending is adequate; identify if the introduction of the modules is appropriate to customer needs, etc.).

(6) The case study companies (a computer company and manufacturer of baby strollers) are actual operations. Experienced sales staff and product R&D planning personnel may conduct staff evaluations of functional characteristics and may find the results of this study to be very helpful. This industry cooperation model will serve as a model for forward work.

In a customer-oriented era, being able to quickly assess and respond to changing consumer demands and service requirements are the only ways to be successful in business. In the pursuit of an exemplary modern society, the quality of a product or a system's design strengths and weaknesses directly affect market competitiveness.

Consumer demands for products and different levels of semantics are not yet clear, and in the face of relatively unfamiliar (or functionally more complex) requirements, there are often bewildering choices. One does not know how to choose the appropriate function module; therefore, reliance upon product experts' designs is imperative.

This custom-built modular product design has two patterns. Design pattern I is the axiomatic evaluation of fuzzy information and decision-making rules. Design mode II involves the level of analysis, fuzzy theory, neural network and gray relational analysis employed as evaluation and decision-making rules.

The customized module design framework is an established calculus, starting from the setting of customer needs, identifying the important functional characteristics of modular products and components, to the evaluation of the relationship between the two. The establishment of the database modules, evaluation, and use of theoretical models make the decision to choose the best products, and the establishment of the universal module products and enterprises can then be selected based on the desired mode. Additionally, there is a basis for a calculation process to build a product recommendation service system.

Blurring the customer needs for a reasonable and rigorous theory is a mapping of the transition to the product characteristics. The logic of the research framework is reasonable, objective, and accurate, and it can operate on the practical application of business practices in the design process, enterprise research, and development. Sales personnel can provide assistance, engaging in various discussions in which both sides should be inspired by this process to have a resulting industry-university cooperation.

With today's Internet, e-commerce technology has matured, so some believe that for many manufacturers, the urgent need is to properly guide customer needs to a recommendation

service system. Companies can then service systems, business, and manufacturers to obtain customer needs and the site can select the relative information. This information can be obtained from company sales and R&D, which may ultimately be of great help to consumers.

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AN IMPLEMENTATION OF TARGET TRACKING BY NEW GA-BASED α-β-γ-δ FILTER WITH ITS PARAMETERS OPTIMIZED BY THE TAGUCHI METHOD

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Abstract

An application of a new fourth-order target tracker α-β-γ-δ filter using a Genetic Algorithm (GA) whose parameters are optimized by the Taguchi Method for numerical simulation in target tracking is addressed in this paper. The current third-order α-β-γ filter system is explored in target tracking for many years. The filter can predict the target's next position and velocity based on the current and past of positions and velocities. A fourth-order target tracker of α-β-γ-δ filter can be explored in order to further predict the acceleration and improve the tracking accuracy. Demonstrably, the new α-β-γ-δ filter shows a significantly improved tracking accuracy over the conventional α-β-γ filter. Not unexpectedly, however, the new α-β-γ-δ filter takes more computation time in the optimization process. The developed GA-based α-β-γ-δ filter has been proposed to overcome this weakness [1]. As extended, the Taguchi method is applied to find the optimal set of GA parameters that leads to get more tracking accuracy, meanwhile, for more application in reality, the trajectory as snake track simulated by the GA-based α-β-γ-δ filter is compared with the other GA-based α-β-γ filter to illustrate the efficiency of the filter in this study.

Keywords: target tracker; Genetic Algorithm; the α-β-γ-δ filter; the α-β-γ filter; the GA-based α-β-γ-δ filter

Introduction

In recent years, many researchers have around the study and application of the various models of the target tracking process. Target tracking is used widely in many applications of military and civilian fields, e.g., airplane and missile interception, air-traffic handling and so on. The target tracking problems are manipulated by optimal design of filter with many mathematical models. The dynamic model and the discrete-time data are used to describe and predict the kinematics of a dynamic object. Since the mid 1950's, as described in Sklansky [2], a sampled data target tracking algorithms was used in the radar system. Thereafter, numerous optimal target-tracking algorithms have been explored [3, 4] and the relatively simple second- and third-order filter trackers [5, 6] were developed to deal with this problem. The optimal design of the third-order α-β-γ filter was presented by Tenne and Singh [7]. In perspective, the third-order filter is able to predict the target's next position and velocity based on the current and past positions and velocities. To further predict the acceleration and improve the tracking accuracy, we have used an additional state variable called *jerk*, a time derivative of acceleration. In the meanwhile, a practical technique for optimal simulation via GA is used to reduce the computation time because of the addition of *jerk*, however, increases greatly the computation time for the optimal filter parameters (i.e., α, β, and γ). GA is one of parameter estimation techniques based on artificial intelligence have been successively proposed in recent years. As a numerical optimization method, GA can be an efficient optimization for finding the optimal parameters (i.e., α, β, γ and δ) as the final output values. The applicability of GA has been widely developed [8, 9, 10].

In Wu et al. [1], the developed GA-based α-β-γ-δ filter was presented not only the optimal set of filter parameters to minimize position tracking errors but could also reduce the computation time. Furthermore, the optimal set of GA parameters is found via Taguchi method

to get more tracking accuracy, meanwhile, for more application in reality, the trajectory as snake track is simulated in this paper; the associated tracking errors of the two filter systems (i.e. GA-based α-β-γ and GA-based α-β-γ-δ filters) are compared. The simulated results by use of the two filters are included for comparison to illustrate the modeling efficiency.

Basic Equations

The following basic equations for the object's position and velocity of the modeling target tracking and α-β-γ filter are extracted from Tenne and Singh [7], Kalata [11], and Wu et al. [1]:

2.1 The third-order α-β-γ filter target tracker:

$$D_f(k+1) = \Phi D_s(k) \tag{1}$$

$$D_f = \begin{bmatrix} d_f & \dot{d}_f & \ddot{d}_f \end{bmatrix}^T,\ D_s = \begin{bmatrix} d_s & \dot{d}_s & \ddot{d}_s \end{bmatrix}^T \tag{2}$$

$$\Phi = \begin{bmatrix} 1 & T & \frac{1}{2}T^2 \\ 0 & 1 & T \end{bmatrix} \tag{3}$$

where

T : the time step or the time increment,

d : the position,

$\dot{d}$: the velocity

$\ddot{d}$: the acceleration;

The subscripts f and s denote the predicted and smoothed state values, respectively.

$$D_s(k) = \mathrm{M}(k) + K(y_e(k) - HD_f(k)) \tag{4}$$

Where

$$D_s = \begin{bmatrix} d_s & \dot{d}_s & \ddot{d}_s \end{bmatrix}^T\ D_f = \begin{bmatrix} d_f & \dot{d}_f & \ddot{d}_f \end{bmatrix}^T \tag{5}$$

$$\mathrm{M}(k) = \left[d_f(K) \quad \dot{d}_f(K) \quad \ddot{d}_f(K) \right]^T \tag{6}$$

$$K = \left[\alpha \quad \frac{\beta}{T} \quad \frac{\lambda}{2} T^2 \right]^T \tag{7}$$

$$y_e(k) = HD(k) + V(k) \quad H = \left[1 \quad 0 \quad 0 \quad 0 \right] \tag{8}$$

where subscript *e* denotes the exact value,

From equations (1) to (8), by the Z-Transform, the ratio (d_f/d_e) is solved and the transfer function in the z-domain is given by:

$$G(z) = \frac{d_f}{d_e} = \frac{\alpha + (-2\alpha - \beta + \frac{1}{4}\gamma)z + (\alpha + \beta + \frac{1}{4}\gamma)Z^2}{Z^3 + (\alpha + \beta + \frac{1}{4}\gamma - 3)Z^2 + (-2\alpha - \beta + \frac{1}{4}\gamma + 3)z + \alpha - 1} \tag{9}$$

The α, β, and γ parameters is yielded by the Jury's stability test [12] on the constraints for the α-β-γ filter, as shown below. This test is also used to find the stability domain for the characteristic polynomial (CP) of equation (3).

$$0 < \alpha < 2 \tag{10}$$

$$0 < \beta < 4 - 2\alpha \tag{11}$$

$$0 < \gamma < \frac{4\alpha\beta}{2 - \alpha} \tag{12}$$

2.2 The fourth-order α-β-γ-δ filter target tracker:

For improving the tracking accuracy, the equations of the fourth-order α-β-γ-δ filter target tracker being for predicting the acceleration are given by:

$$D_f(k+1) = \Phi D_s(k) \tag{13}$$

where

$$D_f = \left[d_f \quad \dot{d}_f \quad \ddot{d}_f \quad \dddot{d}_f \right]^T, D_s = \left[d_s \quad \dot{d}_s \quad \ddot{d}_s \quad \dddot{d}_s \right]^T \tag{14}$$

$$\Phi = \begin{bmatrix} 1 & T & \frac{1}{2}T^2 & \frac{1}{6}T^3 \\ 0 & 1 & T & \frac{1}{2}T^2 \\ 0 & 0 & 1 & T \\ & & & \end{bmatrix} \quad (15)$$

$$D_s(k) = \mathrm{M}(k) + K(y_e(k) - HD_f(k)) \quad (16)$$

Where

$$D_s = \begin{bmatrix} d_s & \dot{d}_s & \ddot{d}_s & \dddot{d}_s \end{bmatrix}^T \quad (17)$$

$$\mathrm{M}(k) = \begin{bmatrix} d_f(k) & \dot{d}_f(k) & \ddot{d}_s(k) & \dddot{d}_s(k-1) \end{bmatrix}^T \quad (18)$$

$$K = \begin{bmatrix} \alpha & \frac{\beta}{T} & \frac{\lambda}{2}T^2 & \frac{\delta}{6}T^3 \end{bmatrix}^T, \quad (19)$$

$$y_e(k) = HD(k) + V(k), H = \begin{bmatrix} 1 & 0 & 0 & 0 \end{bmatrix} \quad (20)$$

$$D_f = \begin{bmatrix} d_f & \dot{d}_f & \ddot{d}_f & \dddot{d}_f \end{bmatrix}^T \quad (21)$$

The transfer function in the z-domain is given by:

$$G(z) = \frac{d_f}{d_e} = \frac{(\alpha + \beta + \frac{\gamma}{4} + \frac{\delta}{36})Z^3 + (-3\alpha - 2\beta + \frac{\delta}{9})Z^2 + (3\alpha + \beta - \frac{1}{4}\gamma + \frac{\delta}{36})Z - \alpha}{Z^4 + (\alpha + \beta + \frac{\gamma}{4} + \frac{\delta}{36} - 4)Z^3 + (-3\alpha - 2\beta + \frac{\delta}{9} + 6)Z^2 + (3\alpha + \beta - \frac{\gamma}{4} + \frac{\delta}{36} - 4)Z + (1 - \alpha)} \quad (22)$$

The α, β, γ, and δ parameters will be as follows

$$0 < \alpha < 2 \quad (23)$$

$$0 < \beta < \frac{13}{6}(4 - 2\alpha) \quad (24)$$

$$0 < \gamma < \frac{4\alpha\beta}{2 - \alpha} \quad (25)$$

$$0 < \delta < 24(2 - \alpha) \quad (26)$$

Genetic Algorithm

As Evolutionary Programming and Evolutionary Strategies, GA is one of the Evolution Algorithms. The beginning of GA was traced back to the early 1950s and was formally introduced in 1970s by John Holland at university of Michigan, United States. He utilized the principles of biological evolution in nature-natural selection and survival of the fittest to find the best solutions in optimization procedures. The ideals of GA are derived from the principle of "natural selection" and "survival of the fittest" in the world of nature, imitating competitions among creatures which show that the survivors are who can propagate their next generations.

Then, it is applied to the optimal design that will randomly generate abundant compositions. Thus, a GA, after an iterative process of selections, eventually the most optimal result can be generated in the operations.

Taguchi Methods

Taguchi methods are a statistical process that perturbs a parameter for studying its influence on the overall output. Taguchi methods' strength exhibits their ability to extract relatively large amounts of information from limited experiments that are compared to full experiments. The basic tools used to obtain the information are orthogonal arrays and linear graphs. An orthogonal array contains the number of experimental runs, the number of levels of each input factor or parameter, and the number of columns in the array. In an orthogonal array, every input factor is placed in one of the columns. A linear graph contains the relationship of input factor interactions. Taguchi method has created a transformation of the repetition data to another value, which is a measure of the variation present. This transformation is the signal-to-noise (S/N) ratio [13, 14]. By examining the S/N ratios, the significant factors can be identified.

When performing Taguchi method analysis, the S/N ratio for each experiment run is computed and recorded. The S/N ratio is an indication of significance. There are three commonly used types of S/N ratios: the-larger-the-better, the-nominal-the-better, and the-small-the-better, depending on the type of design objective. In this study, our design objective function is the-small-the-better.

This study is intended to find the optimal parameter combination of GA parameters: Population, Generation, Crossover, and Mutation via Taguchi method, and to use them to be optimal design of tracking accuracy. Each parameter is tested with three levels, see table 1. The L_9 orthogonal array is chosen for the approach. The tracking errors are compared for each type of error with and without Taguchi method.

Numerical Simulation

As demonstrated in Wu [1], we begin with the problem formulation. Let H be the continuously differentiable matrix-valued function defined for $H \in S$,

where $S = \left\{ H \in \Re^4 \mid 0 \le H_i \le H_{\max}, H_{\max} < \infty, i = 1,2,3,4 \right\}$.

The minimized $H^* = [\alpha^*, \beta^*, \gamma^*, \delta^*] \in S$ is found in the optimization process. The performance index of the mean squared error (L_2) or the maximum absolute error ($L_{\max}$) is also minimized. The optimization process is expressed as follows.

$$L_2 = \frac{\sqrt{\sum_{i=1}^{n} (d_f(i) - d_e(i))^2}}{n} \tag{27}$$

or

$$L_{\max} = \max \mid d_f(i) - d_e(i) \mid, i = 1,2,\ldots,n \tag{28}$$

$$n = \frac{t_{\max} - t_{start}}{T} \tag{29}$$

The numerical values of α, β, γ, and δ are restricted within the ranges defined by equations (23) - (26) and T expresses the different time steps.

For dealing with the above optimization process of the problem, the process of GA algorithm with specified constraints is described in the following steps:

Step 1. Coding, the Binary Coding Population is used in this paper.

Step 2. Initialization, by the random sequence, a general initial population of $H_0 = [H_1, H_2, \ldots, H_N]$ with size N is generated by randomly initializing. In our numerical simulation example, the N is 50. The size of chromosomes is 50 in every generation. Each chromosome includes 30 genes for three parameters (α, β, γ) or 40 genes for four parameters (α, β, γ, δ). It means that the resolution should be $1/2^{10}$; each three-dimensional solution vector $H_i \in S$, with $i = 1,2,\ldots,50$ subject to the constraints defined by equations (10)-(12) of α-β-γ filter and for the equations (21)-(24) of the α-β-γ-δ filter.

Step 3. Estimate the fitness function $f_i = f(H_i)$ for every H_i, $i = 1,2,\ldots,50$, where

$$f(H_i) = \frac{\sqrt{\sum_{i=1}^{n} (d_f(i) - d_e(i))^2}}{n}, \tag{30}$$

$$H_i = [\alpha, \beta, \gamma, \delta] \in S \tag{31}$$

or

$$f(H_i) = \max | d_f(i) - d_e(i) |, i = 1,2,\ldots,50 \tag{32}$$

A fitness function of string H_i, $f(H_i)$ is related to the objective function is given by

$$H(H_i) = \frac{1}{1 + f(H_i)} \tag{33}$$

Step4. Estimate the fitness score for each H_i from the *n*-th generation H_n, and then find the best string H_i^* of H_n such that $h(H_i^*) = \max_{H_i \in H^n}\{h(H_i)\}$. Then set the best strings in H_n as H_i^{e}.

Step 5. Selection, create offspring using genetic operators by initially employing roulette wheel selection, then crossover, and finally mutation on the strings H_i of the mating pool and obtain a population H_i^t.

Step 6. Compare the fitness function of each H_i^t with H_i^{e}. If $h(H_i^{\mathrm{t}}) < h(H_i^{\mathrm{e}})$, then replace the string of H_i^{t} by H_i^{e}, and put it into the new generation. Otherwise, put H_i^{t} into the new generation.

Step 7. Repeat steps 4-6 iteratively until the value of $f(H_i^*)$ is converged.

Step 8. Set H^* by H_i^* and decode the chromosome H^* (represented by a binary string) having the maximum fitness value of objective function into its corresponding values of α^*, β^*, γ^*, and δ^*.

Step 9. Stop the algorithm.

It is desirable to compare the position tracking errors of the GA-α-β-γ filter and GA- α-β-γ-δ filter via a numerical simulation process. Consider, for example, a case where the fighter avoids attacking by missile. The trajectory is supposed as snake track. Supposing the track of target is linear and acceleration motion, our initial conditions are $a_x(0) = 0\mathrm{m/s}^2$, $a_y(0) = 0\mathrm{m/s}^2$, $v_x = 300\mathrm{m/s}$, $v_y = 0\mathrm{m/s}$, $x(0) = 10000\mathrm{m}$, $y(0) = 10000\mathrm{m}$. The target tracking motion equations are as follows.

(1). During 30~60s, $a_x = 5\ \mathrm{m/s}^2$, $a_y = 5\mathrm{m/s}^2$.

(2). During 60~90s, $a_x = 5\ \mathrm{m/s}^2$, $a_y = -10\mathrm{m/s}^2$.

(3). During 90~120s, $a_x = 5\ \mathrm{m/s}^2$, $a_y = 10\mathrm{m/s}^2$.

(4). During 120~150s, $a_x = 5$ m/s^2, $a_y = -10$m/s^2.

(5). During 150~180s, $a_x = 5$ m/s^2, $a_y = 10$m/s^2.

(6). During 180~210s, $a_x = 5$ m/s^2, $a_y = -10$m/s^2.

(7). After210s, linear constant speed motion, $a_x = 20$ m/s^2, $a_y = 20$m/s^2.

Simulation of the object's position was performed with each of the two trackers and the associated errors were determined. The upper and lower limits for α, β, γ and δ are determined by meeting the constraints given by equations (10)-(12) for the α-β-γ filter and by equations (23)-(26) for the α-β-γ-δ filter. In the simulation process, the increment for each simulated parameter value was set to be 0.1.

In numerical simulation, with t_{start} =0 and t_{max} =220 , the error with each filter was calculated at different time steps, i.e. $T = 0.4, 0.2, 0.1, 0.05$; these time steps play very important roles in the tracking. Figures 1, 2, 3 , and 4 show a position tracking plot at $T = 0.4$ and 0.05 with the GA-based α-β-γ-δ. It means the acceleration changes with time and shows the change of the state variable, jerk. It is noted that the simulation error in acceleration is related to the second order derivative with respect to time.

Tables 2 and 3 summarize the tracking errors on L_2 and $L_{\max}$, respectively, from the employment of the two filters. As seen, the GA-α-β-γ-δ filter outperforms the GA-α-β-γ filter at every time step. Evidently, a fourth-order target tracker of α-β-γ-δ filter shows a significantly improved tracking accuracy over the α-β-γ filter. Table 4 and 5 summarize the tracking errors on L_2 and L_{max}, respectively. The data indicates that the GA-based α-β-γ-δ filter tracker with Taguchi method outperforms the GA-based α-β-γ-δ filter tracker without Taguchi method for every given time step. It shows that two heuristic methods can be combined together for improving tracking accuracy.

Conclusion

The new fourth-order GA-based α-β-γ-δ filter is explored and compared with the GA-based third-order α-β-γ filter for the tracking efficiency. The results clearly indicate that the former exhibits a significant improvement in tracking accuracy compared to the latter again. It shows the fourth-order α-β-γ-δ filter is a highly accurate and efficient as a tracker especially when the moving target exhibits a large variation in its speed (acceleration), because it predicts the target trajectory in a pure data-driven system. The other result shows that two heuristic methods, such as GA and Taguchi method, can be combined together for improving tracking accuracy. Furthermore, the new fourth-order filter could be explored in many applications in future.

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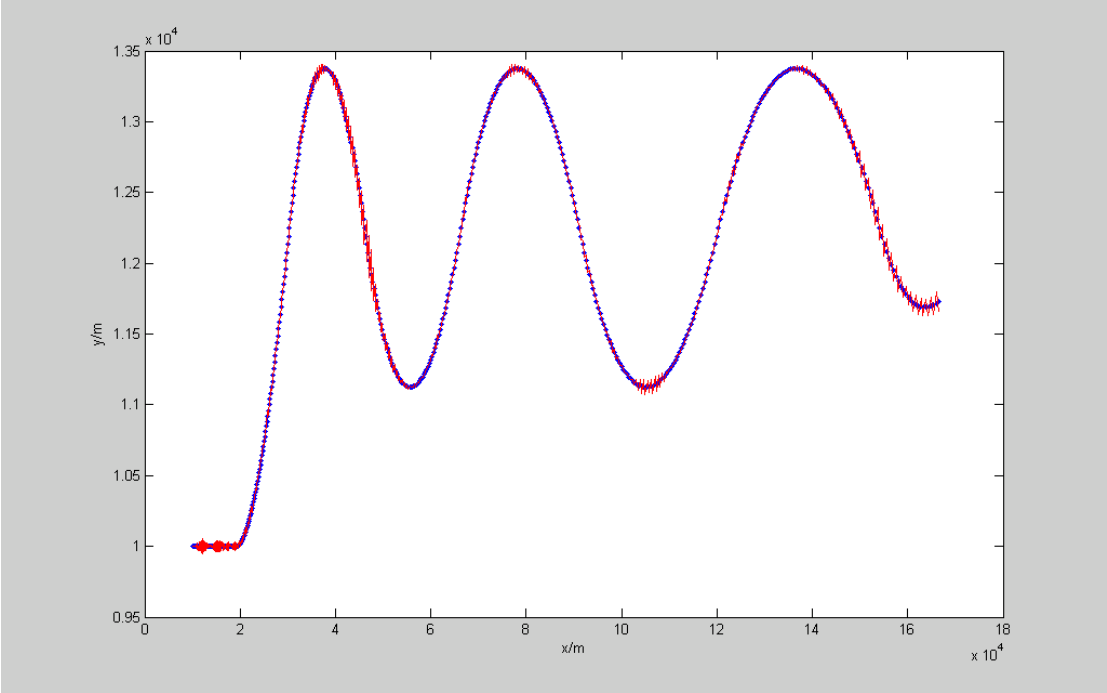

Figure 1. A Tracking Plot at T=0.4 (L2)with the GA-based α-β-γ-δ filter (-:d_e, -: d_f)

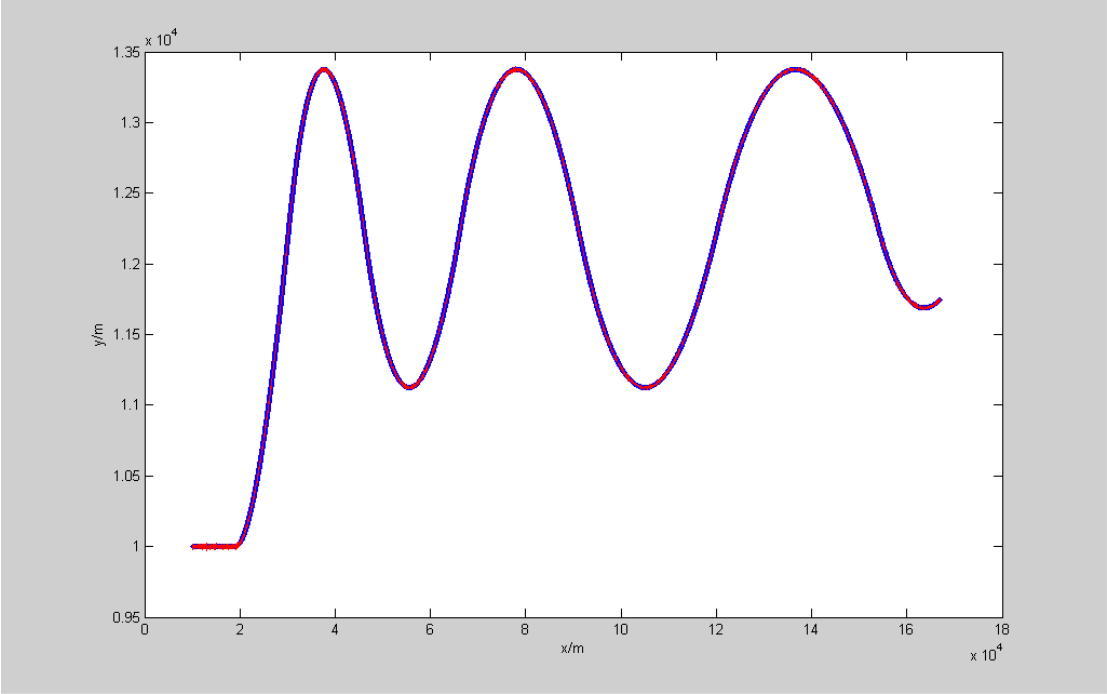

Figure 2. A Tracking Plot at T=0.05 (L2) with the GA-based α-β-γ-δ filter (-:d_e, -: d_f)

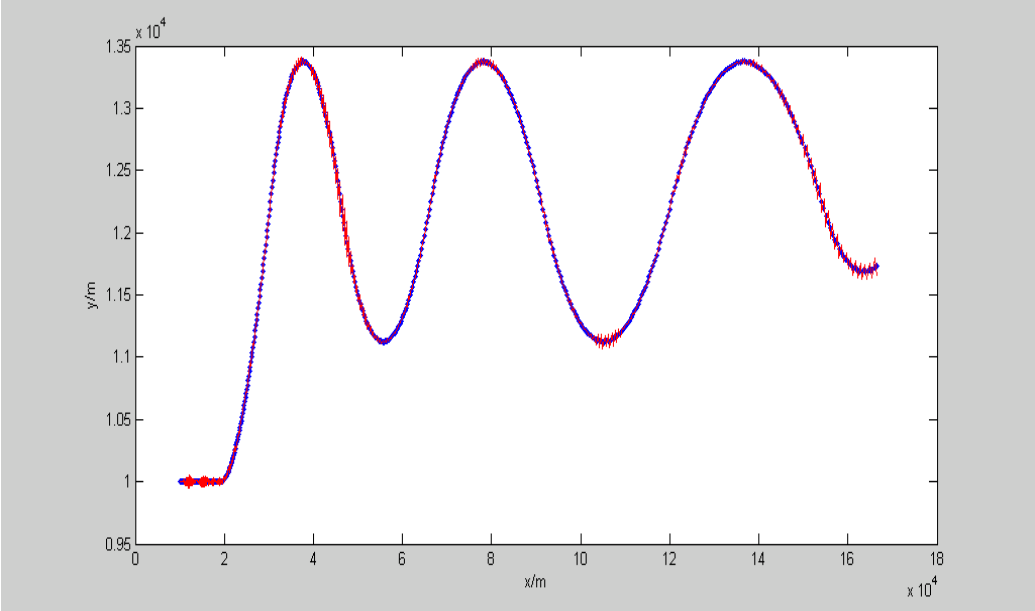

Figure 3. A Tracking Plot at T=0.4 (Lm)with the GA-based α-β-γ-δ filter (-:d_e, -: d_f)

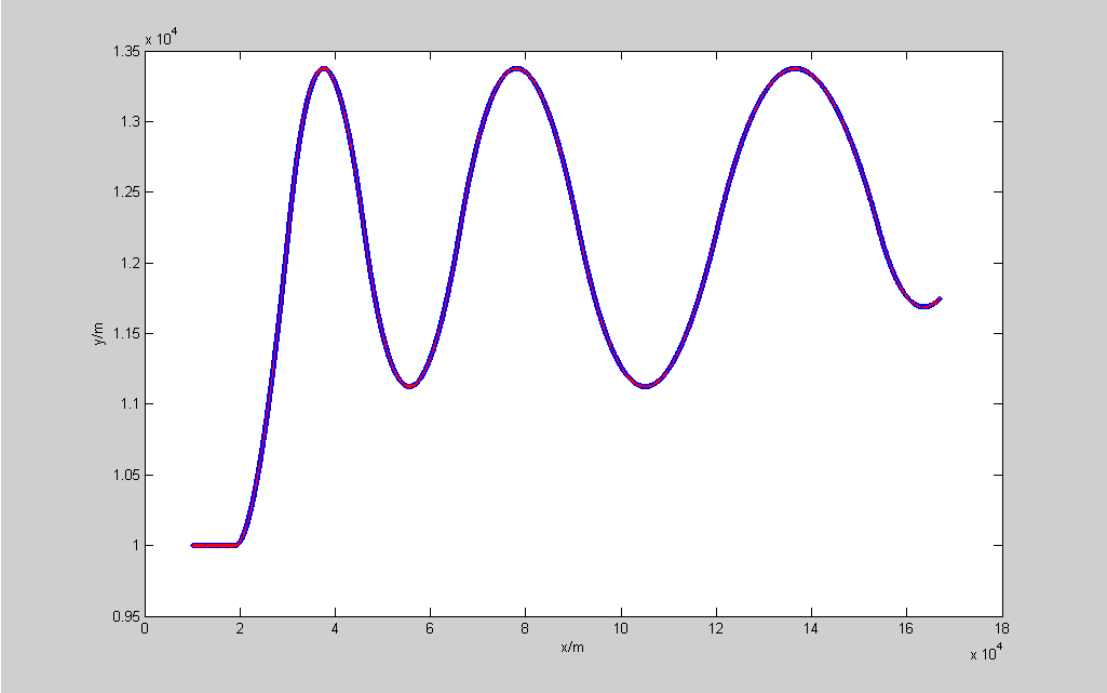

Figure 4. A Tracking Plot at T=0.05 (Lm) with the GA-based α-β-γ-δ filter (-:d_e, -: d_f)

Table 1. The three levels of GA parameters

Parameters	Level 1	Level 2	Level 3
Population	50	100	150
Generation	20	30	50
Crossover	0.7	0.8	0.9
Mutation	0.1	0.2	0.3

Table 2. Tracking Error Comparisons on L_2 among Two Filters

Time Step	GA-based-α-β-γ filter (1)	GA-based-α-β-γ-δ filter (2)	Accuracy Improvement [(1)-(2)]/(1)%
T=0.4	α=0.93,β=2.11, γ=3.22 L_2=0.01158	α=0.65,β=2.69,γ=1.89,δ=0.50 L_2=0.01051	9.24%
T=0.2	α=0.75,β=2.45, γ=2.76 L_2=0.00136	α=0.69,β=2.56,γ=1.81,δ=0.44 L_2=0.00123	9.56%
T=0.1	α=1.03,β=1.88, γ=2.83 L_2=1.5936e-004	α=1.00,β=1.99,γ=3.64,δ=3.50 L_2=1.4220e-004	10.77%
T=0.05	α=1.42,β=1.08, γ=2.54 L_2=2.2432e-005	α=1.07,β=1.66,γ=4.45,δ=5.12 L_2=1.8742e-005	16.45%

Table 3. Tracking Error Comparisons on L_{max} among Two Filters

Time Step	GA-based-α-β-γ filter (1)	GA-based-α-β-γ-δ filter (2)	Accuracy Improvement [(1)-(2)]/(1)%
T=0.4	α=0.45,β=2.82, γ=3.18 L_{max}=2.75985	α=0.88,β=2.16,γ=0.75,δ=2.75 L_{max} =2.43101	11.91%
T=0.2	α=0.43,β=2.85, γ=2.81 L_{max} =0.70707	α=0.38,β=3.00,γ=2.88,δ=4.60 L_{max} =0.56569	19.99%
T=0.1	α=1.31,β=0.74, γ=2.89 L_{max} =0.18680	α=0.55,β=2.86,γ=1.58,δ=4.29 L_{max} =0.17678	19.84%
T=0.05	α=0.42,β=3.07, γ=3.14 L_{max} =0.04019	α=0.63,β=2.10,γ=0.79,δ=2.65 L_{max} =0.03027	24.68%

Table 4. Tracking Error Comparisons of L_2 on GA-based α-β-γ-δ filter w/o Taguchi method

Time step	GA α-β-γ-δ filter without Taguchi method (1)	GA α-β-γ-δ filter with Taguchi method (2)	Accuracy improvement ((1)-(2))/(1)%
0.4	α=0.94,β=2.04,γ=1.57,δ=0.14 L_2=0.01107	α=0.65,β=2.69,γ=1.89,δ=0.50 L_2=0.01051	5.05%
0.2	α=0.68,β=2.35,γ=1.83,δ=2.33 L_2=0.00131	α=0.69,β=2.56,γ=1.81,δ=0.44 L_2=0.00123	6.10%
0.1	α=0.74,β=2.48,γ=3.63,δ=4.38 L_2=1.5041e-004	α=1.00,β=1.99,γ=3.64,δ=3.50 L_2=1.4220e-004	5.46%
0.05	α=0.73,β=2.51,γ=1.93,δ=3.32 L_2=2.0156e-005	α=1.07,β=1.66,γ=4.45,δ=5.12 L_2=1.8742e-005	7.02%

Table 5. Tracking Error Comparisons of L_{max} on GA-based α-β-γ-δ filter w/o Taguchi method

Time step	GA α-β-γ-δ filter without Taguchi method (1)	GA α-β-γ-δ filter with Taguchi method (2)	Accuracy improvement ((1)-(2))/(1)%
0.4	α=0.48,β=2.95,γ=0.32,δ=4.17 L_{max} =2.61979	α=0.88,β=2.16,γ=0.75,δ=2.75 L_{max} =2.43101	6.94%
0.2	α=1.25,β=1.40,γ=1.58,δ=2.03 L_{max} =0.60711	α=0.38,β=3.00,γ=2.88,δ=4.60 L_{max} =0.56569	6.82%
0.1	α=0.55,β=2.01,γ=1.27,δ=3.90 L_{max} =0.18719	α=0.55,β=2.86,γ=1.58,δ=4.29 L_{max} =0.17678	5.56%
0.05	α=0.45,β=2.79,γ=1.95,δ=5.90 L_{max} =0.03241	α=0.63,β=2.10,γ=0.79,δ=2.65 L_{max} =0.03027	6.60%