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Persistence in Innovation and Innovative Behavior in Unstable Environments

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Abstract

Analyzing the persistence of the innovative activities can improve the understanding of firm dynamics, forecast the effectiveness of different policy actions, reinforce innovation cycles and promote sustainable and responsible innovation ecosystems. Innovation persistence was empirically analyzed for innovation leaders or even followers; still the literature fails to provide evidence for moderate innovators. The present article appraises the innovative strategy of firms operating in this context and their attitudes towards persistence, controlling for firm characteristics such as size, sector, R&D expenditures and human capital intensity. To do so, a balanced panel was built, encompassing three waves of the Portuguese Community Innovation Survey (CIS), (2004 to 2010) including 1099 firms from different areas. The estimation of the random effects probit model, evidenced that persistence hypothesis fails to be corroborated, evidencing no time dependent innovation strategies. Such result suggests that innovation policy programs do not have long-lasting effect on innovative behavior of firms and it is unlikely that incumbent past innovators be the drivers of creative accumulation and future innovation. There is, however, some evidence that new, smaller, innovators might lead the creative wave. In this vein, there might be a rational to encourage public policies targeting start-up firms and new market entrants when innovation is the main primary funding goal.

Keywords: CIS, dynamic random effects probit, moderate innovators, persistence in innovation

1. Introduction

The rapid erosion of value in goods and services caused by highly perishable technologies have been driven the increasing competition in internal and external markets (Bower and Christensen 1995; Vecchiato, 2017). Innovation, conceived as the transformation of ideas, information and knowledge to improved competitiveness and sustained competitive advantage, is a central in firm survival (Karlsson and Tavassoli, 2016).

As a driver of firm performance, innovation and its persistence can help explain sustained competitive advantage and lasting inter firm performance differences (Cefis and Ciccarelli, 2005; Hecker and Ganter, 2014). Innovation persistence relates “the feedbacks, accumulation, and lock-in effects that arise from innovations and put the firm in a better position to seek new innovations, with the consequent increase in the odds of continuing to achieve these” (Suárez, 2014: 726).

The continuous innovative activity is of high interest in areas such as economics of innovation and applied industrial economics (Tavassoli and Karlsson, 2015; Córcoles et al., 2016), an emerging area of empirical research (Triguero et al., 2014), and a central issue for public policy (Hecker and Ganter, 2014). As Le Bas and Scellato (2014: 423) content “[t]he analysis of the drivers and the underlying mechanisms of persistency in innovation performance of firms can relevantly improve our understanding of both the long-run industry dynamics and the expected effects of policies to sustain R&D and innovation”. From the public policy angle, analyzing intertemporal effects is important for the effectiveness of innovation funding (Hecker and Ganter, 2014).

The existence of time dependence indicates that incumbent firms and creative accumulation are central drivers of innovation, which, to a certain extent, may downplay the ‘creative destruction’ potential of new entrants (Malerba and Orsenigo 1999; Aghion, 2017). Such evidence may force rethinking the conventional policy practice of subsidizing start-up firms and new market entrants when innovation promotion is the primary funding goal (Hecker and Ganter, 2014).

Understanding the links between past and present innovative behavior is critical in ‘Moderate innovators’ (EC, 2017). Indeed, these countries present low innovative profiles with the production of new technologies seldom being the result of radical advances and the processes of R&D and innovation being influenced by a myriad of factors, most notably technological opportunities, market structure, demand conditions, firms’ capabilities, organizational arrangements, and appropriability conditions (Le Bas and Latham, 2006; Altuzarra, 2017).

Up to the present date, a reasonable amount of empirical evidence regarding innovation persistence has been gathered, however, it is not yet fully understood (Juliao-Rossi and Schmutzler, 2016; Altuzarra, 2017). Most of extant research focus on the innovation persistence of firms, mainly from the manufacturing sector, located in ‘Innovation Leaders’ (e.g., Finland - Deschryvere (2014); Germany - Hecker and Ganter (2014), Peters (2009); Sweden - Karlsson and Tavassoli (2016), Tavassoli and Karlsson (2015)) or ‘Strong Innovators’ (France - Cefis and Orsenigo (2001), Malerba et al. (1997), Haned et al. (2014); Ireland- Roper and Hewitt-Dundas (2008); Luxembourg - Le Bas and Poussing (2014); UK - Geroski et al. (1997), Cefis (2003), Frenz and Prevezer (2012)). Despite being the most numerous group (14 countries), the evidence focusing on ‘Moderate Innovators’ is almost exclusively concentrated on Spanish manufacturing firms (Martinez-Ros and Labeaga, 2009; Triguero et al., 2014, Córcoles et al., 2016; Altuzarra, 2017).

Additionally, with exception of Suárez (2014), who has analyzed a group of 800 Argentinean manufacturing firms over 3 periods (1998–2001, 2002–2004, and 2005–2006), innovative persistence in unstable environments has been overlooked. Indeed, extant empirical literature implicitly assume that environmental conditions do not change and "what the firm did in the past is useful for the things the firm has to deal with in the present" (Suárez, 2014: 726), neglecting the possible changes in the innovative strategy.

From 2004 to 2006, Portugal faced high political instability with 3 distinct governments. Additionally, the economic performance which started to deteriorate markedly after 2000 (see Royo, 2010), with real GDP growth averaged less than 1 percent between 2000 and 2005, having contracted 0.8% in 2003, remained fragile until 2006. Productivity growth in the business sector fell to around 1% between 2004 and 2005. Unemployment rose to highest rate in 20 years: 7.6% in 2005 and 8% in 2007 (IMF, 2009). Although there was a slight recovery in 2007, in 2009 real GDP per capita fell by 3.1% and unemployment reach a socially problematic figure of 9.4%. Continuing fall of investment and gross saving along with escalate public debt between 2006 and 2010 culminated in the Bailout programme. Given all these fluctuations and uncertainties in the macroeconomic and political environments, it is reasonable to expect that firms have reacted by changing their innovative behavior.

Based on a balanced panel of 1099 firms located in Portugal and covering the 2004-2010 period (CIS 6, CIS 8 and CIS 10), the empirical analysis is twofold: firstly, we test 'true state dependence' (or true persistence), in which past innovative behavior, per se explains the present and therefore firms do not react to environmental fluctuations or iterative. Secondly, iterative strategies (new, sporadic, non-innovative) are considered as a response to exogenous changes.

Due to unobservable time correlated firm characteristics raising innovative propensity (e.g. strategic orientation, innovation capabilities development or R&D investments), the problem of 'spurious state dependency' might arise (see Peters, 2009; Juliao-Rossi and Schmutzler, 2016). To overcome this problem, we follow, Peters (2009) and Hecker and Ganter (2014) econometrically separating the influence of unobserved firm heterogeneity and initial conditions from causal effects of past innovative activity. Such procedure decomposes observable innovation persistence into spurious and true state dependence. We assess the determinants of the latter by comparatively evaluating alternative theoretical accounts (the market power and innovation – Schumpeter, 1934, 1942; the success-breeds-success - Mansfield, 1968; Stoneman, 1983; the sunk costs - Sutton, 1991; the evolutionary - Nelson and Winter, 1982) against the empirically determined patterns of persistence.

This paper is structured as follows. Section 2 presents the literature review and the hypotheses in test; section 3 provides a database description and the exploratory results. Section 4 presents the econometric estimations and the results; section 5 concludes and puts some policy measures to consideration.

2. Literature Review

2.1 Past and path dependence of the innovation process

Either past dependence or path dependence explains the Innovation process. The first underlies that the determinants of the innovative process and its results fully determined by the initial conditions (Antonelli, 2011). Persistence depends on the first innovation, along with long-lasting innovative skills. Conversely, path dependence explains that, throughout a random process, knowledge is planted in a localized context ('historical accident'). The success of innovation will depend on the ability of the firm to benefit from the 'accident'. So it is strongly tied to existing competences and networking.

Persistence will be contingent to the exploitation of complementarities and interdependencies under the proper institutional environment (Collombelli and von Tunzelmann, 2011). Accessing knowledge pools, reinforcement of networks, linkages among firms is thus recommended.

Opting to persist in innovation is part of the innovative strategy thus determining technological change (Cefis and Orsenigo, 2001). It is essential for firms to continue investing in these projects to accommodate the changes in economic environment. Hence, there will be a strong cleavage among firms and persistence will occur among 'great innovators' (Cefis, 2003). Managers may opt for pursuing innovation in a regular base, perceiving some inertia in the process. Innovative behaviour over time is not a random process, if the firm is market oriented the propensity to become a persistent innovator will raise, as well as if it is R&D intensive or science based (Clausen et al., 2012).

2.2 Complementary approaches of persistence in innovation

Four complementary frameworks can be considered concerning persistence of innovation (Le Bas and Scellato, 2014; Altuzarra, 2017): market power and innovation (Schumpeter, 1934, 1942); success-breeds-success (Mansfield, 1968; Stoneman, 1983); sunk costs (Sutton 1991); and the evolutionary innovation theory (Nelson and Winter, 1982).

According to the 'market power and innovation' approach (Schumpeter, 1934, 1942), innovators are temporary monopolists, benefiting from abnormal profits; as this is a fleeting position, the firm will move the next innovation, thus raising the propensity to persist. New entrants will decrease the monopoly profits, therefore incumbents will persist in innovation as a way to create barriers to entry (Le Bas and Scellato, 2014).

The 'success-breeds-success' approach (Mansfield, 1968; Stoneman, 1983) states that previous innovation reinforces technological opportunities, leveraging future innovation success. Income and profit is generated by the subsequent commercial success of innovators which allows firms to increase their internal funds, making it possible to finance future innovation projects (Le Bas and Latham, 2006; Le Bas and Scellato, 2014). In the presence of asymmetric information between the innovator and the lender, the accessibility to internal funds is a key factor directly related to innovative activity. Firms achieving innovations will be considered as successful, standing out from their competitors due to their abnormal profits which will be reinvested in the development of new innovative activities, hereby creating a virtuous cycle (Nelson and Winter, 1982). When a firm reaches innovation, it conquers market power, achieves higher profit levels, thus creating an advantage from its competitors. Past innovations will generate the finance to support present innovative activities which raise the likelihood of future innovations.

The large upfront costs of R&D activity, as well as continuous funding to move a product through the various stages of the R&D process until the product comes to market (installation of laboratories, recruitment of researchers or training of employees), entails considerable 'sunk costs' (Sutton, 1991). Because firms need to recover the cost of R&D investments, conducting R&D activities require both persistent commitment and a long-term horizon (Kuratko et al., 1997). Additionally, once firms have engaged in R&D, the continuation of this activity becomes increasingly less costly, which encourages firms to carry on performing R&D.

Finally, the evolutionary innovation theory (Nelson and Winter, 1982) put forwards the hypothesis of dynamic increasing returns in innovation. Arguing that current knowledge is dependent on previous knowledge and the foundation upon which future knowledge rests.

Knowledge, namely tacit knowledge, is accumulated in people working in the organization; knowledge is not perishable and is likely to be used in multiple ways. Knowledge is cumulative and non-extinguishable generating a permanent advantage enhancing the probability of persistence. The systematic interaction between the knowledge stock and the productive routines converts innovation in a competitive advantage (Antonelli et al., 2013). Former innovations generate financial availability for the future, as past success will raise profitability and credibility towards external sources (Latham and Le Bas, 2006).

These approaches act as complementary and self-reinforcing; virtuous cycles will emerge from the dynamic interaction between the "knowledge accumulation" and the "success breeds success" in which, the returns from present R&D will retro-feed new ones (Latham and Le Bas, 2006). Due to strategic options, firms decide to invest in R&D, this cost is considered as sunk, and therefore, it will rationally be supported in the long-run. Innovative firms create a certain stock of knowledge, this process enhances the success-breeds-success hypothesis, and the profits generated with the on-going innovative process will retro-feed the system, financing new R&D activities enabling the system to continue working. This setting portraits a virtuous cycle in which the learning process will indefinitely continue.

2.3 Hypotheses in test

Albeit the existence of a reasonable number of high quality studies on the persistence of innovation results are not consensual. The extant evidence is mixed; most works identify weak elements of persistence and do not provide a convincing consensus about its determinants and, most importantly, about the specificities of the dynamic process (see Antonelli et al., 2012).

Most of previous empirical studies have focused on patenting activity finding limited evidence of persistence (see, for instance, Geroski et al., 1997; Cefis and Orsenigo, 2001; Cefis, 2003; Latham and Le Bas, 2006). the Resorting to the innovative history of UK firms in the period 1969–1988 using the patent records and the introduction of 'major' innovations, Geroski et al. (1997) show that only a minority of firms (those introducing 'major' innovations) is persistently innovative. Using 1400 manufacturing firms in five European countries in the years 1978–1993, Cefis and Orsenigo (2001) find weak persistence of patenting activity. They show that both low-innovators and great-innovators tend to remain in their classes and that much of the persistence in innovation activities seems to be determined by the 'economic' persistency of the firms themselves. In a later study, Cefis (2003) focused on 577 UK patenting firms in the period 1978–1991, and again found evidence of overall little persistence (only great innovators have a stronger probability to keep innovating). Focusing on French and US patents, Latham and Le Bas (2006) confirm that the persistence of innovation takes place, but only and mainly in a limited time span.

In contrast to patent-based studies, empirical analyses based on survey data find stronger evidence of innovation persistence (see Córcoles et al., 2016; Altuzarra, 2017), namely when dealing with product innovation (Tavassoli and Karlsson, 2015) and complex products (Fontana and Vezzulli, 2016). Early studies on innovation persistence using survey data by König et al. (1994) and Flaig and Stadler (1994) found evidence of state dependence in innovative outcomes on a panel of manufacturing firms in West Germany. More recently Raymond et al. (2010), albeit failing to find true state persistence in introducing product or process innovations by Dutch manufacturing firms for the years 1994–2000, show that within the group of continuous innovators there was persistence in innovation (i.e., the market success of previous innovation positively influenced the success of subsequent innovations).

The above mentioned studies have generally tested innovation persistence in stable contexts. In volatile environments, continuity in innovative activities will be an expression of deliberate strategic behavior rather than sheer time correlation. Persistence generates feedback and accumulation but they are indeed the outcome of continuous innovative strategies. The framework of persistence will be designed by the managerial strategy as well as the dynamic interaction of the firm and its environment (Suárez, 2014). Thus, in contrast to what one would expect in the context of stable environments, one might find past successful innovative behavior to have no impact or even a detrimental impact on future innovative behavior in contexts of changing (or uncertain) environments. As noted by Nelson and Winter (1982) this could happen if, for example, past successful innovative behavior generated from specific problem-solving processes that are not necessarily useful for the new environment. On the other hand, the new environment may create opportunities for previously non-innovative firms. These innovative firms may therefore be more likely to innovate in the future if their innovation process is adapted, from the start, to the new environment.

Firm Strategic behavior, in some cases, points to non-innovative strategies as being the more effective; conversely, in other cases, the most efficient option is to invest in innovation. The empirical evidence points to the fact that some innovative actions generate new innovative actions; albeit others fail to boost the virtuous innovation cycles.

The assumption that changing the environment conditions may change the innovation strategy in each period, poses a binary decision in each moment: whether or not to innovate independent of what has been done in the past. Consequently, considering one time transition the firm can be: a) non-innovative, if deciding not to innovate in the two time periods; b) sporadic innovator if the firm stops innovating from one moment to the other; c) new innovator if the firm commences the innovative process; d) persistent innovator if the firm continues to innovate from one moment to the other. Combined trajectories will appear if more time periods are added (see Table 1). Discussing iterative innovative strategies over time in the context of a moderate innovator is a further contribution to the persistence literature.

Independent of the conceptual framework, the literature highlights the existence of persistence, which means that past innovations will positively influence the probability of new ones. Therefore, [H1], states that former persistent innovators will continue in innovation. Pure time persistence will be tested ignoring other possibilities, focusing on the influence of past innovation on the present, along with other innovation inputs and structural controls (Models A). The objective is to address the existence of conventional persistence in moderate innovators.

The empirical evidence shows that, frequently, firms change their attitude towards innovation from one period to other; most of the works unveil persistence given certain characteristics, or non-innovativeness, but, very few explain the transition from one to another. The following hypotheses will depict the managerial strategies that comprise changes along the period. Strategic changes are described by three alternative hypotheses:

Table 1 Innovative strategies pursued

Innovative strategies(3 time periods)	**DESCRIPTION**
Continuous	The firm reports having performed innovative activities in all periods of analysis
Continuous - Sporadic	The firm reports having performed innovative activities in the first and the second period of analysis, and stopped innovating in the third
Sporadic - New	The firm has innovated in the first period, stopped innovating in the second and started innovating in the third
Sporadic - Non innovative	The firm has performed innovative activities in the first period of analysis and stopped in the next two
New-Continuous	The firm did not perform innovative activities in the first period, commenced in the second and continued in the third
New - Sporadic	The firm did not innovate in the first period, has innovated in the second, immediately stopping in the third
Non - innovative - New	The firm did not innovate in either the first and the second period and started innovating in the third
Non - Innovative	The firm did not innovate at all in all periods of analysis

[H2] – Being a continuous innovator in the transition from t-2 to t-1, will enhance the probability to continue innovation in the transition to t. So, if the firm did innovate in the two periods before it is more likely to be an innovator at present as well.

[H3] – Sporadic innovators in t-1 will have a decreased probability to pursuit innovation in t. Firms that did innovate in t-2, but which have stopped innovation in t-1, will have fewer chances to innovate in t.

[H4] – Firms which are new to innovation in t-1, so to say that they started innovation in the transition from t-2 to t-1, have an increased probability to continue innovation at present. This means that the innovation wave started in t-1 will leverage innovation in t.

In analyzing the previous hypothesis, the concepts connected to persistence, in both continuous and intermittent strategies will be tested along with the hypothesis of intermittence [H2] [H3] and [H4].

In sum figure 1 summarizes what will be tested.

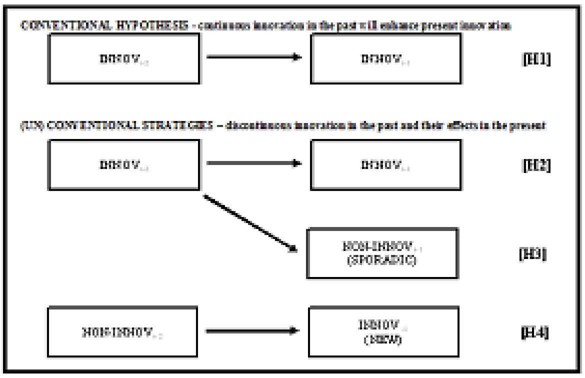

Fig. 1 Summary of the Hypotheses

Under the conventional persistence hypothesis, present innovation outcomes are explained by past innovation achievements, subject to the extension of investments in resources and capabilities (investments in R&D and machinery, skilled human resources) and firm's structural characteristics (size, sector, age, capital ownership) (Le Bas and Scellato, 2014; Altuzarra, 2017). The iterative hypothesis allows for changes in the innovative strategy caused by exogenous changes in the economic environment, despite the innovative heritage.

3. Database and descriptive results

3.1. Database and sample

The literature frameworks describe persistence as a time connection between past innovative actions and the present. Therefore, past managerial decisions will influence the present is a continuous way. Still, the empirical evidence shows that firms stop and initiate innovative actions for more than pure past dependence. Strategic behaviour changes due to several constraints, either endogenous or exogenous. We aim at identify the motivations for intermittences in innovation and explain the expectable changes under adverse economic environments.

Empirical support will rely on a panel of firms comprising several CIS waves, as it is the most extensive survey in this field undergoing through the recommendation of the European authorities. It comprises three biennia (CIS 6, CIS 8 and CIS 10), covering the period between 2004 and 2010. The appraisal of time span effects is made throughout balanced data, leading to a sample of 1099 firms observed over the entire period; intertemporal connections are made throughout dynamic panel estimations. Therefore, present innovative behaviour is explained by past innovative actions (allowing for complex strategies rather than pure time dependence) along with firm size, use of internal and external sources to perform R&D, connections with external sources of Knowledge, the reliance on public funds and belonging to an economic group.

Empirical evidence relying on exploratory analysis avowals that firms start, stop or continue in innovation strategically rather than by time inertia. Therefore, the past is insufficient to explain the present, and, policy actions encompass these fluctuations.

When analyzing the entire sample of the CIS in separate, and nearly two thirds of firms report performing some type of innovation; this figure is somehow encouraging as Portugal is a moderate innovator. The panel evidences persistence in 56,8% of firms; the rest has opted for intermittent actions in their innovative strategy. Here our aim is twofold: understand the structural characteristics that explain persistence rather than accepting persistence as time dependence and explain strategic intermittence and the role of public policy to leverage the success in innovation.

3.2. Exploratory analysis - Panel Characteristics

Persistence implies multiple time periods as it is a synonym of continuing innovative activities, so, only firms traceable in the period are kept, producing a balanced panel with 1099 heterogeneous firms.

Despite the dispersion in terms of dimension, it is essentially composed by medium sized firms (44%); which seem an accurate representation of the Portuguese reality, despite the biasedness in favor of large firms due to an additional effort in data collection from them due to methodological requirements of the survey. The secondary sector represents 62% (all industries), the primary 2%, and services 36%. Concerning equity, half of the firms belong to an economic group. Half the firms belong to a high tech sector, one fifth to a low tech and one third to a mid tech (according to Pavitt's taxonomy, 1984). High tech firms are naturally expected to be more innovative than others.

The R&D intensity (measured by the amount of resources devoted to innovative activities compared to the total turnover), is poor as 45% of firms do not perform any R&D activity at all, and, 41% of the firms present a 3% R&D intensity. Undergraduates or educational titles in the workforce are often used as a proxy for education intensity. In the panel, 86 firms have no workers with top education, being the workforce classified as unskilled. Conversely, 53 firms report more than three quarters of their workforce highly skilled. Almost 9% of the firms in the panel have reported performing innovative activities in the innovation types considered on the survey; contrarily, one quarter of the firms declared not performing any innovative activity during the period of analysis. There were 371 firms not finding relevant the use of any source of information for their innovative activities.

Three quarters of the firms have mentioned not relying on any type of external funds, showing some disconnectedness with the innovation policy. As public funding seems to be important to support innovation, policy makers should be aware of this failure.

3.3. Transition frequencies

In each period, firms face binary decisions: whether or not to invest in innovation. In dynamic terms, it means stopping or starting/continuing innovative activities. The transition is appraised twice: from CIS 6 to the CIS 8 and from the CIS 8 to the CIS 10 with eight possible paths. Firms may adopt invariant strategies, (continuous in (non-)innovation), or intermittent strategies (starting or stopping innovation) in the different periods. The transition frequencies allow us to understand the innovation trajectories over time.

When moving from one period to the following there are four possibilities: persistent (a double yes to the performance of innovative activities), non-innovative (a double no to the performance of innovative activities), sporadic (a yes/no sequence) and a new innovator (no/yes sequence).

Independent of the innovation type, in the CIS6, 857 firms reported having performed somehow innovation (78% of the panel). Moving to the CIS8 725 remained in innovation, considered as persistent. Carrying to the CIS10, persistent innovators felt to 624. Dissimilarly, 100 firms reported no innovation activities over the three consecutive periods.

Table 2 Aggregation of the innovative strategies in the period of analysis

PATH	INNOV STRAT (TPM=3)	N	%
ACG	Continuous	624	56,8
ACH	Continuous - Sporadic	101	9,2
ADI	Sporadic - New	77	7
ADJ	Sporadic - Non innov	55	5
BFG	New - Continuous	74	6,7
BFH	New - Sporadic	26	2,4
BEI	Non - innovative - New	42	3,8
BEJ	Non – Innovative	100	9,1
	TOTAL	1099	100

The analysis of the transition probability matrix (Figure 2) illustrates that most of the firms are continuous innovators, reinforcing the conventional hypothesis of persistence. On the contrary, 100 firms never innovate during the period and 375 evidenced intermittent strategies.

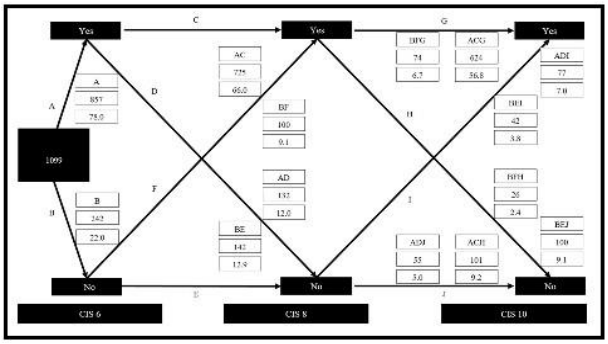

Fig. 2 Transition frequencies: innovation in general

4. Econometric analysis

4.1. Proxies and methodology

In order to understand the probability of innovating in period t, the regression includes a set of explanatory variables relating to past innovative behavior (continuing, sporadic and new) and a set of controls such as technological intensity, availability of skilled labor force, access to innovation sources, size, use of public funds, equity provenience and economic sector. Variable description detailed in Table 3.

Table 3 Variable description

Variable	Type	Description
RD_intensity	Count	Ratio comparing the expenditures in R&D compared to the total turnover
Mid_tech	Binary	1 if the firm belongs to a SIC code classified as being mid tech [1]
High_tech	Binary	1 if the firm belongs to a SIC code classified as being high tech [1]
Balance	Binary	1 if the firm combines investments in endogenous and exogenous knowledge
Educ_intensity	Connt	Ratio comparing the number of top educated workers to the total
Openness	Count	Counts for the number of sources of innovation the firm uses
Funds	Binary	1 if the firm uses public funds
Medium_size	Binary	1 if the firm in medium
Large_size	Binary	1 if the firm in large
Group	Binary	1 if the firm belongs to an economic group
Industry	Binary	1 if the firm belongs to the industrial sector
Services	Binary	1 if the firm belongs to the services

[1] Technological intensity defined according to the Pavitt taxonomy in what concerns the manufacturing sector and extended to the other activities as seen in diffused literature from the OECD and the European Commission

Table 4 presents the descriptive statistics of the variables in use.

Table 4 Descriptive statistics of the variables in analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
SIC_code	3297			7	74
tech_int	3297	2.298	0.778	1	3
sector	3297	2.329	0.517	1	3
size	3297	2.868	0.748	2	4
group	3297	0.485	0.500	0	1
Innov g	3297	0.758	0.428	0	1
Funds g	3297	0.189	0.392	0	1
Openess	3297	4.914	4.081	0	10
R&D_int	3297	4.533	115.682	0	6615.23
Educ int	3297	2.521	1.557	0	6

The econometric estimations were run using dynamic random effects probit, still, conventional and unconventional hypotheses were separated as it was unfeasible to combine them in a single equation (see Table 5). Model(s) 1 test the conventional hypothesis of persistence, as they do not consider intermittent innovative behaviors; in these cases, pure past dependence is estimated posing that being innovative in the past will influence the probability to innovate in the present. Model(s) 2 include strategic options concerning past innovative behaviors (firms may have opted for continuing, starting, stopping or not innovating at all). In all models, a set of explanatory variables is included, comprising the firm's structural traits and illustrating innovation efforts.

4.2. Econometric specification

Using either the conventional or the unconventional hypotheses of persistence, the aim of the present research is to determine the probability of being an innovator in period t subject to what has been done by the firm in the past. Therefore, the dependent variable in both equations is binary: it takes the value of 1 if the firm i innovates at time t and the value of 0 otherwise. Due to the nature of the dependent variable the best suiting models are the probit (or logit).

The estimation of the panel can be addressed through fixed-effects or random-effects, even though, some of the explanatory variables of interest are time-invariant making the use of fixed effects unfeasible, forcing the choice to random-effects. However, the use of random effects is only valid if the unobserved time invariant firm effects are uncorrelated to the explanatory variables, which is impossible given that the lagged value of the dependent variable is an explanatory variable. Wooldridge (2005) developed a solution to relax the "independence assumption" in random effects dynamic probit models. This solution consists in replacing the αi in the equations below by a linear function of the firm's observable characteristic's (i.e. the average values of the time-variant exogenous characteristics) added to the value of the so-called "initial condition", i.e., the innovative or non-innovative state of the firm at the starting period in observation.

Therefore, the estimation of either the model presented in the following equations (equation (1) and equation (2)) will be completed using a dynamic random effects probit model.

The conventional hypothesis of persistence, presented in model(s)1 will consist of a dynamic random effects probit specified as follows:

$$INNOV_{it} = \beta_1 + \beta_2\, INNOV_{it-1} + \boldsymbol{\beta} W_{it} + \boldsymbol{\delta} V_i + \alpha_i + \varepsilon_{it} \quad (1)$$

Where firm i is innovative at time t by (Innovit) depending on innovations at time t-1, a set of time-variant (Wit) and time-invariant (Vi) observable characteristics of the firm, and an unobservable firm-specific characteristic (αi).

This model only allows for the assessment of the traditional hypothesis of persistence, modelling the effect that past innovations have on present innovations without any discontinuity or variability added to a vector of explanatory variables. In all regressions ran this coefficient fails to be statistically significant, this result may present some evidence supporting the failure of pure persistence.

The analysis of intermittence in innovative strategies requires the construction of subgroups according to the past innovative behavior. The group dissection was performed according to the proposal of the European Innovation Scoreboard (2004) and Sauréz (2014), creating four different sub-groups:

a) Continuous innovators – firms that reported performing innovation in two consecutive time periods (Continuous_Innov);

b) Sporadic innovators – firms that reported having performed innovation two periods ago, and stopped in the next period (Sporadic_Innov);

c) New innovators – firms that reported not having performed innovation two periods ago and started innovation in the next period (New_Innov);

d) Non-innovative - firms which did not perform innovation in any of the periods (Non-innov), this category is considered as default in our estimation.

In this context, the model previously presented (equation (1)) is restructured as follows:

$$\begin{aligned} INNOV_{it} = \beta_1 &+ \beta_2 CONTINUOUS_{INNOV\ it-1} \\ &+ \beta_3 SPORADIC_{INNOV\ it-1} \\ &+ \beta_4 NEW_{INNOV\ it-1} + \boldsymbol{\beta}\ _{it} + W \boldsymbol{\delta}\ _i \quad V \\ &+ \alpha_i + \varepsilon_{it} \end{aligned} \quad (2)$$

The second group of regressions allows for unconventional hypotheses of persistence, as it models intermittence. In this case, evidence in favor of persistence could come from a positive coefficient on Continuous_Innovit-1 or New_Innovit-1. Concerning Sporadic_Innovit-1, if the hypothesis of persistence is confirmed one would expect a negative effect in the probability of innovating at present.

When the intermittence regressions are run, the coefficients of past innovative strategy variables appear as statistically significant. Albeit, in this case, the results provide a different perspective, which may reinforce the heterogeneity in terms of innovative strategic behavior of moderate innovators.

4.3. Estimation Results

The objective of analysis is the understanding of persistency in innovative activities, which means, the relation between being an innovator in former time periods and continuing in innovation in the present. In the dynamic probit with random effects, the propensity to be an innovator at present (binary) is explained by past innovative behaviors, and a set of controls corresponding to the firm structural characteristics. Namely firm characteristics such as size, economic group, economic sector, use of funds, R&D intensity, technological intensity, intra and extramural R&D activities [this vector of variables is chosen according to the findings of former studies (e.g. Peters, 2009; Raymond et al. 2010; Frenz and Pevezer 2012; Ganter and Hecker 2013; Le Bas and Poussing, 2014)].

The complete set of firms, regardless the sector of activity or the size is presented in models A (1 and 2). Given the previous belief that firms operating in industry should present a different pattern than those in services, models B(1 and 2) only include firms from industrial sectors and models C(1 and 2) contain firms from services. Significant differences are found in terms of the effect of past innovative strategies in present innovation along with some structural characteristics. Models D, E and F (1 and 2) separate firms according their size, following the CIS's taxonomy; this segmentation allowed understanding the existence of important differences in terms of the innovative behavior of small, medium and large firms.

Concerning the traditional hypothesis of persistence (illustrated in model(s)1) being innovative in the past does not influence the probability of being innovative in the present. In other words, the hypothesis fails being proved for innovation in general. Our empirical evidence, independent of the model being run does no support pure innovation persistence.

The present results cannot be directly compared the existing literature, as to us, being an innovator means having performed innovation independent of the type. Pure persistence should hold, still, the result is not statistically significant. The statistical insignificance of the conventional hypothesis of persistence occurs in all models, independent of the segmentation operated. It is of worth underlying that increases in R&D intensity raise the probability of innovation along with openness highlighting the importance of the sources of innovation to develop different innovative strategies and adapt to the changing environment. Here the empirical evidence for Portugal differs from the German, as Peters (2009) has found that German firms are persistent innovators in terms of product innovation.

When considering intermittent strategies different results appear, being a persistent innovator in the past reduces the probability of innovating at present by 8.17 percentage points compared to the non-innovative firms. This result is contrary to the expectation about pure persistence, indicating that firms deliberately discontinue their innovation activities. Past sporadic innovators also have a reduced probability to innovate at present; those firms that stopped innovation will be less prone to restart it. On the contrary, firms that are new to innovation will have an increased probability to continue their innovations, perhaps closing their innovation cycle.

So far, most of the works have only considered firms operating on the industrial sector, albeit the increasing importance of the services impelled to the estimation of both groups in separate. In the case of the industry similar results from the entire group appear, but, in the tertiary sector either conventional or unconventional persistence fails to be statistically significant, this result deserves further reflection as policy makers cannot reach these sectors of activity with the present policy design.

Peters (2009), when analysing conventional persistence in product innovation for German firms did find statistical significance for size, with larger firms being more prone to persist in innovation. Frenz and Prevezer (2012), exploring the British evidence confirm the conventional persistence hypothesis, also supporting the significance of size and sector. In this vein, the division of firms according to their size was operated to understand if there is a similar pattern of innovative strategy among them. In the Portuguese case, either in small, medium and large firms pure persistence fails to be significant (models D1, E1 and F1).

The models that include intermittence bring up differences across firm sizes. In the case of small and medium sized firms, being persistent in the past does not influence the probability of innovating at present. This effect is only evident in the case of large firms. Being a sporadic innovator in the past reduces the probability of innovation in the present for small and medium sized firms, and does not produce any effect in the case of large firms. New innovators have an increased probability to innovate in the present, in all firm sizes, reinforcing the idea of innovation cycles.

Concerning the controls, and in parallel with the Dutch case explored by Raymond et al. (2010), exists persistence among mid-high and high tech firms; our results go in a similar direction as the marginal effects of technological intensity punctually appears as positive.

The existing literature did not proxy the influence of innovation sources in the probability to innovate, even though, to us, this effect cannot be neglected, and, it appears as significant in the models run. More open firms have an increased probability to innovate, which reinforces the need to establish strong connections among the actors operating inside and outside the production chain to leverage innovation. Table 5 (in Appendix) evidences the estimation results for the different models in discussion.

5. Conclusion and Policy Recommendations

Despite the extant works in innovation persistence, there is no comprehensive understanding about the leitmotif of continuity or intermittence in innovation (Juliao-Rossi and Schmutzler, 2016; Altuzarra, 2017). Additionally, analysts focus on Leaders or Strong Innovators rather than on Moderate countries, whose difficulties are of worth more attention given the convergence targets. The firm strategy is appraised in a ceteris paribus assumption towards the economic environment, removing realism from the findings; unstable economic environments are overlooked in both theoretical and empirical terms.

Focusing on a balanced panel of 1099 firms located in Portugal and analyzing the three biennia 2004 and 2010 the hypothesis of ‘true state dependence’ failed to be proved throughout the conventional models in which no intermittences were allowed. Even though, when the estimation encompasses reaction to exogenous changes, former persistence disincentives present innovations. This result holds in either the entire sample or the industrial sub-sample.

Results obtained are only partially in line with Suárez’s (2014) regarding Argentinian firms, and contrast significantly with extant literature on European countries, namely that analyzing other ‘Moderate Innovator’, Spain (Martinez-Ros and Labeaga, 2009; Triguero et al., 2014, Córcoles et al., 2016; Altuzarra, 2017). Two main results are worth highlighting.

First, although exploratory analysis, based on the transition probability matrices, uncover a very high degree of state dependence or innovation persistence (in Table 1), the econometric estimations (in Table 5) evidence that, when changes in innovative behavior are not accounted for (Models A/…/F1), such innovation persistence is mainly spurious rather than true innovation persistence. In other words, the observed persistence is the result of other factors such as firms' characteristics, most notably openness (number of distinct external sources of information for innovation the firm uses) and the capability to effectively combine internal and external investments in intangible assets (more precisely, R&D activities). Additionally, heterogeneity was found between industrial firms and services, requiring fine tuning adjustments in policy design.

Second, results suggest that in unstable environments (and when we account for dynamics in firms' innovative behavior – Models A/…/F2), we cannot assume an intertemporal relationship between past innovations, present innovative behavior, and future results. Specifically, empirical evidence suggests, particularly in large manufacturing firms that are 'Continuing innovators' in the past have a decreased odds of innovating in the future. In contrast, 'New innovators', and to large extent those of small and medium size, observe an increased odds of innovation. Thus, the persistent levels among 'New innovative' firms evidence path independence rather than path dependency and cast doubts on the capacity of firms, particularly large incumbent firms, to respond swiftly to changes in the environment.

These results have important policy implications. First, because innovation persistence does not hold in our sample, it is likely that innovation policy programs do not have long-lasting effect on innovative behavior of firms. As firms do not tend to persist on engaging in innovation themselves if policy makers have a strong reason to stimulate innovation, then innovation policies must be prepared to do such stimulation as a longer term commitment and not change policies in the short and medium run. Moreover, attention should be paid to the importance of external sources of knowledge in enhancing the probability to innovate. Second, in the absence of evidence of innovation persistence, potential intertemporal spillovers are unlikely to emerge, in order words, it is unlikely that incumbent past innovators be the drivers of creative accumulation and future innovation. There is, however, some evidence that new, smaller, innovators might lead the creative wave. In this vein, there might be a rational to encourage public policies targeting start-up firms and new market entrants when innovation is the main primary funding goal.

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Table 5: Dynamic random effect probit estimations with endogenous initial conditions (average marginal effects) [dependent variable: the firm innovates in the current period)]

		All		Industry		Services		Small		Medium		Large	
		Model A1	**Model A2**	**Model B1**	**Model B2**	**Model C1**	**Model C2**	**Model D1**	**Model D2**	**Model E1**	**Model E2**	**Model F1**	**Model F2**
Persistence	Innovation $_{t-1}$	0.0250 (0.2594)		0.0250 (0.0259)		0.0113 (0.0560)		0.0365 (0.0470)		0.0222 (0.0348)		-0.1173 (0.5388)	
Dynamic innovative behavior (default: 'never innovates')	Continuing $_{t-1}$		**-0.0817***** (0.0202)		**-0.0816***** (0.0195)		-0.0937 (0.5210)		-0.0576 (0.0381)		-0.8664 (0.5852)		**-0.0532***** (0.0172)
	Sporadic $_{t-1}$		**-0.0997***** (0.0434)		**-0.0996**** (0.0410)		-0.0707 (1.1421)		**-0.1091**** (0.0477)		**-1.0390*** (0.5428)		0.0154 (0.0944)
	New $_{t-1}$		**0.1209***** (0.0278)		**0.1210***** (0.0273)		0.1442 (0.3595)		**0.1791***** (0.0391)		**0.5957*** (0.3701)		**0.0920**** (0.0457)
R&D activities	R&D intensity	**0.0129**** (0.0060)	-0.0001 (0.0002)	**0.0128**** (0.0060)	-0.0001 (0.0002)	0.0167 (0.0178)	-0.0009 (0.0006)	0.0208 (0.0184)	0.0242 (0.0227)	**0.0092*** (0.0055)	-0.0053 (0.0050)	0.7322 (3.3620)	**0.2074***** (0.0600)
	R&D balance (Perform both internal and external R&D activities)	0.0356 (0.0600)	0.0346 (0.0476)	0.0357 (0.0600)	0.0344 (0.0475)	**0.8458***** (0.2392)	6.4971 (20.876)	**0.6798***** (0.1297)	**0.6875***** (0.0890)	0.0141 (0.0596)	0.2136 (0.4043)	0.5927 (2.1524)	0.3218 (0.2662)
Education	Education intensity	0.0118 (0.0101)	0.0015 (0.0074)	0.0119 (0.0101)	0.0016 (0.0074)	0.0082 (0.0158)	-0.0036 (0.0389)	0.0009 (0.0149)	-0.0169 (0.0113)	**0.0377*** (0.0195)	**0.2775*** (0.1628)		
Openness	Openness (Number of distinct sources of information for innovation)	**0.0559***** (0.0040)	**0.0465***** (0.0039)	**0.0559***** (0.0040)	**0.0465***** (0.0038)	**0.0595***** (0.0081)	0.0515 (0.1184)	**0.0998***** (0.0189)	**0.0860***** (0.0190)	**0.0483***** (0.0044)	**0.3244**** (0.1613)	0.0430 (0.1521)	**0.0194***** (0.0030)
Funds	Public funds	-0.0380 (0.0397)	-0.0077 (0.0304)	-0.0395 (0.0391)	-0.0083 (0.0301)	**-0.2313***** (0.0684)	-0.1491 (0.3276)	0.0110 (0.1555)	**-0.0187** (0.1417)	-0.0371 (0.0441)	-0.0943 (0.2672)	-0.1412 (0.8275)	-0.0597 (0.0520)
Size (default: Small)	Medium	-0.0130 (0.0141)	-0.0077 (0.0097)	-0.0135 (0.0141)	-0.0079 (0.0097)	0.0048 (0.0232)	0.0059 (0.0358)						
	Large	0.0319 (0.0223)	**0.0268*** (0.0139)	0.0320 (0.0223)	**0.0267*** (0.0139)	0.0353 (0.0332)	0.0304 (0.0646)						
Group	Group (1 if the firm belongs to a Group)	-0.0001 (0.0157)	-0.0063 (0.0108)	0.0008 (0.0156)	-0.0057 (0.0108)	-0.0309 (0.0232)	-0.0244 (0.1554)	-0.0000 (0.0325)	-0.0067 (0.0226)	-0.0004 (0.0211)	-0.0338 (0.1222)	0.0098 (0.0746)	-0.0116 (0.0140)
Sector (default: Primary)	Industry (1 if the firm operates in Industry)	-0.0061 (0.0347)	-0.0059 (0.0247)					-0.0955 (0.0608)	**-0.0601*** (0.0349)	0.0593 (0.0530)	0.2295 (0.4434)		
	Services (1 if the firm operates in Services)	0.0026 (0.0364)	-0.0015 (0.0254)					-0.0766 (0.0635)	-0.0496 (0.0371)	0.0770 (0.0553)	0.3687 (0.4866)	-0.0203 (0.1441)	-0.0044 (0.0173)
Initial endogeneity and individual heterogeneity	$Inno_0$	**0.0671***** (0.0215)	**0.2137***** (0.0096)	**0.0673***** (0.0216)	**0.2137***** (0.0096)	0.0454 (0.0402)	0.2074 (0.1458)	0.0436 (0.0362)	**0.2400***** (0.0150)	0.0454 (0.0323)	**1.6300***** (0.5820)	0.2094 (0.9613)	**0.1403***** (0.0201)
	mean_rd_intensity	0.0006 (0.0009)	0.0004 (0.0007)	0.0006 (0.0009)	0.0004 (0.0007)	**0.0002***** (0.0001)	0.0002 (0.0007)	0.0042 (0.0033)	0.00176 (0.0016)	-0.0007 (0.0006)	-0.0020 (0.0040)	0.0164 (0.0755)	0.0050 (0.0060)
	mean_educ_intensity	-0.0100 (0.0114)	0.0004 (0.0081)	-0.0092 (0.0113)	0.0008 (0.0080)	-0.0062 (0.0169)	0.0057 (0.0324)	0.0011 (0.0184)	0.0192 (0.0129)	**-0.0348*** (0.0203)	-0.2661 (0.1998)	0.0024 (0.0612)	0.0008 (0.0006)
	mean_openness	0.0003 (0.0050)	-0.0016 (0.0028)	0.0001 (0.0050)	-0.0017 (0.0028)	0.0015 (0.0078)	-0.0016 (0.0249)	0.0112 (0.0107)	0.0006 (0.0056)	-0.0022 (0.0070)	-0.0154 (0.0338)	-0.0063 (0.0161)	-0.0022 (0.0039)
	No. observations	2198	3297	2198	3297	780	1170	756	1134	969	1456	468	702
	No. of groups	1099	1099	1099	1099	390	390	378	378	485	487	234	234
	Wald test (p-value)	188.44 (0.000)	781.48 (0.000)	188.48 (0.000)	781.68 (0.000)	60.81 (0.000)	222.74 (0.000)	61.08 (0.000)	231.48 (0.000)	85.33 (0.000)	366.50 (0.000)	18.90 (0.063)	78.21 (0.000)

TRIZ Application on Fishing Pole with an Active Scent Release Lure

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Abstract

To attract fish, fishermen generally use lures, which offer high catch rates and environmental friendliness. Fishermen who use lures must constantly move the line to make the lures move back and forth, stimulating fish attacks on the lures and increasing catch rates. However, each person can only fish with one pole at a time. This study uses the Theory of Inventive Problem Solving (TRIZ) to conduct a trend analysis of fishing lure improvement and construct a technical contradiction matrix, by using an active scent releasing device connected with a buoy lure. This device has a camera inside that uses scent as a fish attractant. The scent is released by a control button on the fishing pole. When fishing with this pole, fishermen can watch the screen attached to the fishing pole and observe the fish to decide the timing of scent release. This fishing pole with an active scent release lure can be effective in improving fishing performance. It is also different from traditional fishing methods in that one person can control more than one hand pole at a time.

Key words: culture and leisure fish farms, TRIZ, active scent release lures, buoy

1. Introduction

Taiwan is an island located in the subtropics, with numerous rivers and streams, a rich variety of fish, and many culture and leisure fish farms. Fishing is thus a traditional recreational activity. Taiwan society has become wealthier and more leisure oriented in recent years, and fishing has become more popular. At present there are roughly 200,000 recreational fishermen in Taiwan, 40% of whom fish in the sea, 55% in ponds, and 5% in streams, making it the third most popular leisure activity in Taiwan[1].

Most fisherman use lures, popular because of their high catch rates and environmental friendliness. However, because the lure is dead, the fisherman must manipulate the line to make the lure move back and force, since the lure is most effective when it imitates the movements of living bait. This research addresses the problem of developing a fishing pole with an active scent release lure that moves in a lifelike way but also releases an attractant. Using a trend analysis of a systematic approach to creating new technology, construction of a technical contradiction matrix and implementation of a function and attribute analysis, the dead lure is improved. In this research, the fishing pole is designed to trigger the scent releasing device with the attractant packed inside. Fish in the water will taste the scent and come to forage. Moreover, the fishing pole is equipped with a camera and screen which enables the fishermen to watch the fish, which helps to enhancing the entertainment in fishing as well as increase the fish catch rate, Further, one person can control more than one pole at the same time.

2. Literature Review

Traditionally many things are used as bait, from rice and leaves to worms and insects. Bait is not convenient, however. Hence, fishermen use lures, a form of artificial bait. Lures are moved by the fisherman, making it look like live bait to game fish. When the fish strikes, it is captured by the hook attached to the lure.

Rapala (1936) became the first to use thin pine boards to carve artificial minnow bodies, which he then wrapped in tin foil to give them a fishlike look, thus making the world's first lure[2]. Using lures, he then found that if the lure resembled live bait, game fish would strike. Because the lure had the function of live bait but was far more convenient and more environmentally friendly than live bait, they have steadily grown in popularity. Taiwan's largest lure maker, Strikepro, produces 400,000 lures annually, helping to make Taiwan an advanced maker of lures.

Fish have a sensitive receptor system (Butler, Field and Maruska, 2016). Olfactory and taste are the most critical senses. The fish's olfactory system is in the tip of the nose beneath the olfactory cortex (Kotrschal, 2000) and the taste sense of fish is located in its lips (Hamdani and Døving, 2007). Experienced fishermen spread scented bait across the water to draw fish. Fishermen often use starchy flours or other foods with fried flavors, and add a sticky material to make sticky bait. They then use the sticky bait on a hook or plaster the lure to stimulate the fish's sense of taste and smell. However, this technique can only be used with fish in shallow water. In deeper water or in rivers, the scent may disperse without effect. In this paper the authors

[1] Taiwan Fishing Right Organization http://1207834082401.tw66.com.tw/web/Blog?command=Intro, accessed on 2019/6/26.

develop a fishing pole with an active scent release device that increases the impact of scent in water and increases the catch rate.

The Theory of Inventive Problem Solving (TRIZ), from the Russian Teoriya Resheniya Izobreatatelskikh Zadatch) is a systematic approach to technology innovation. It was developed by the Russian inventor Genrich Altshuller and his colleagues beginning in 1946. They analyzed 200,000 patented inventions for pens and classified the innovations into different levels and types to create a systematic approach to innovation (Altshuller, 1996). TRIZ offers an innovation system for inventors to help them resolve technology innovation problems. First, the type of potential specific problems associated with the invention must be clarified. Based on the thinking of previous inventors in solving problems, through research and thinking of improvements, they classified problem solving approaches. TRIZ standardizes problem solving, enabling any problem to be treated as a standard problem. Key tools of TRIZ include: 40 inventing principles, 39 engineering elements, a contradiction matrix, and substance field analysis. TRIZ permits standardized problem approaches to converge on a particular solution. This enables to problem solving to break through the problems of individual experience, talent, and psychology that, when using traditional methods, may cause solutions to diverge.

This research uses the TRIZ convergence process structure of Mann (2002). It uses the convergence of evolutionary trends to view the current status of fishing lures. The trend predicts the future evolution of lures. This is paired with a function attribute analysis that performs similarity matching of the functions and attributes of lures, as well as improvement of lifeless lures or equipping them with the ability to move on their own. This process is shown in Figure 1 (Mann, 2002).

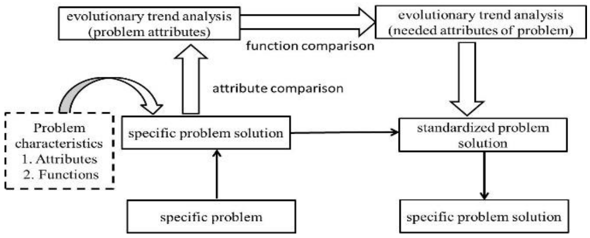

Fig. 1 The TRIZ process of evolutionary trend and function attribute analysis used in this research.

3. Considerations in Enhancing Lure Effectiveness

In order to enhance the lure's ability to move and attract game fish, this research considers two technology levels. First, it examines the evolutionary trends of bait. It then explores the future evolution of lures. Second, it uses the technical contradiction innovation principles to identify the elements the fishing pole needs and find the best design for an active scent release function.

3.1 Evolutionary trend

Every technological system moves along a predictable evolutionary path, known as its evolutionary trend or line of evolution. The concept of similar technology types that repeatedly appear across different fields can be useful in predicting the development of technology. Mann (2002) divided evolutionary trend analysis into three categories comprising 31 items in total. The first category is time and contains six items: Action Co-ordination, Rhythm Co-ordination, Non-Linearities, Mono-Bi-Poly (Similar), Mono-Bi-Poly (Various), and Mono-Bi-Poly (Increasing difference). The second category is space and consists of 12 items: Smart Materials, Space Segmentation, Surface Segmentation, Object Segmentation, Evolution Macro to Nano Scale, Webs and Fiber, Decreasing Density, Increasing Asymmetry, Boundary Breakdown, Geometric Evolution(linear), Geometric Evolution (volumetric), and Dynamization. The third category, interface, consists of 13 items: Reduced Damping, Increased use of Senses, Increasing Use of Colour, Increasing Transparency, Customer Purchase Focus, Market Evolution, Design Point, Degree of Freedom, Trimming, Controllability, Reducing Human Involvement, Design Methodology, and Reducing Number of Energy Conversions (Mann, 2002).

The authors found that fisherman using traditional live bait used worms, flies, and maggots, which was more effective in attracting game fish than dead bait such as leaves, rice, and food. Anglers using lures used lifeless lures that they had to constantly move back and forth to make them resemble fish, forcing them to continuously operate the reel. Long periods spent moving lures can cause fatigue. Consequently, it is expected that in the future lifeless lures will evolve toward active lures that can induce game fish to strike. Of the 31 items reviewed in this research, 5 evolutionary trends were found to be associated with the evolution of lures: Mono-Bi-Poly (Various), Smart Materials, Dynamization, Increasing Use of Color and Reducing Human Involvement.

The first of the five aspects of the evolution of bait, Mono-Bi-Poly (Various). There are four stages in carrying out the evolution of this item: Single system, dual system, three systems, and multi system. At present in the aspect of Mono-Bi-Poly (Various), lures have evolved to increase the elements and functions of the system. The next step is three systems. The second evolutionary aspect is Smart Materials, consisting of four stages: Passive material, One-way adaptive material, Two-way adaptive material, and Fully adaptive material. Currently lures are in the Two-way adaptive material stage moving toward the next stage of Fully adaptive material. The third evolutionary aspect is Dynamization, which has five stages: Immobile system, Jointed system, Fully flexible system, Fluid or pneumatic system, and Field based system. Currently lures have reached the stage of Jointed system, with the next being Fully Flexible system. The fourth evolutionary aspect is Increasing use of color. It has four stages: Monochrome, Binary use of colour, Use of visible spectrum, and Full spectrum use of colour. At present lures have evolved to look like fish and are in the Use of visible spectrum stage, evolving toward Full spectrum use of colour. The fifth evolutionary aspect, Reducing Human Involvement has six stages: Human, Human with tool, Human with powered tool, Human with semi-automated tool, Human with automated tool, and Automated tool. At present in the aspect of Reducing Human Involvement, lures have evolved to the Human with semi-automated tool stage.

Figure 2 shows that Mono-Bi-Poly (Various) are evolving toward increasing the number of elements and functions of the system. Smart Materials are evolving in the direction of fully adaptive materials. In Dynamization, baits are evolving in the direction of fully flexible multiple connection systems. In Increasing use of color, they are evolving to use the full spectrum of color, just as a real fish does. Reducing human involvement is moving in the direction of reducing human fatigue. Thus, the future development of lures will move toward reduced use of human operation, dynamic ability to move as a fish does and release scent in the water, and colors and materials that closely resemble those of a real fish, making it more effective in enticing game fish to strike. The current evolution of lures is shown in Figure 3.

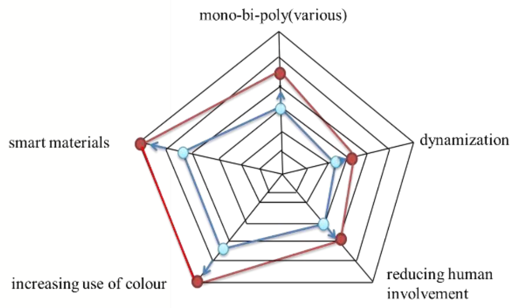

Fig. 2 The five aspects of lures evolution potential on red circle presents on blue circle

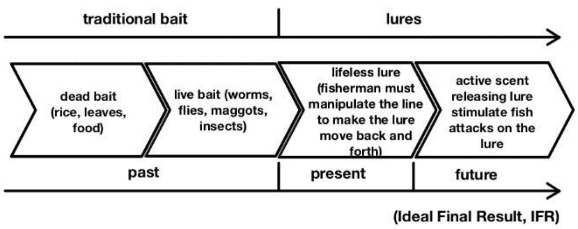

Fig. 3 Evolutionary trends of lures

3.2 Technical Contradiction

This research explores the lifeless lures currently used by fisherman, that require the fisherman to continuously move them. For a lure, swimming like a real fish represents a dynamic function. Thus, the parameters that must be improved in this system should not reduce the lure's ability to function at different depths and in different water layers without outside assistance, force, and management of the time fish are caught by bait. This represents the technical contradiction problem (Hsia, Huang, and Chen, 2011; Bukhman, 2012). The 39 engineering parameters are used to solve technical contradictions (Yang and Chen, 2011). When the features of the system's contradictions are known, the items that should be improved include Item 10, Force, Item 35, Adaptibility and Item 37, Complexity of Control. Parameters that should not be worsened include Item 13, Stability of object, because the lure needs to be stable in the water, and Item 14, Strength, because the lure must be strong in order to move in the water like a lure on a fishing line. These problems are used to construct the technical contradiction matrix, as shown in Table 1. Based on the technical contradiction matrix shown in Table 1, 15 inventive principles can be used: 35, 10, 21, 30, 14, 11, 22, 39, 27, 3, 32, 6, 15, and 28.

Table 1 Technical Contradiction Matrix

Parameters that should not be worsened / Parameters that must be improved		Stability of Object	Strength
		Item 13	Item 14
Force	Item 10	35 10 21	35 10 14 27 15
Adaptability	Item 35	35 30 14	35 3 32 6
Complexity of Control	Item 37	11 22 39 30	27 3 15 28

Among the 15 inventive principles, to enable the lure to swim like a fish without outside assistance, the necessary elements were found to include the six inventive principles: 15, 22, 10, 11, 30, 3, 32 and 27. The remaining six did not appear to have any clear effect on improvement of the lure and were notused.

Inventive principle 15, Dynamics, states that in order to adjust the object or its environmental performance and enable all stages of work to achieve optimal performance, the object should be divided into parts capable of movement relative to each other. If an object (or process) is rigid or inflexible, it should be made movable or adaptive. To use these principles to resolve the problems found, the lure must be equipped either internally or externally with a propulsion unit to enable it to move without outside assistance.

Inventive principle 22, Blessing in disguise, states that harmful factors (especially harmful environmental effects) can lead to beneficial consequences. For example, one harmful factor may be combined with another to eliminate the negative effects of either or both, or a harmful factor may be increased to such a degree that it is no longer harmful. Using this principle to find solutions for problems indicates that a water battery should be used to provide propulsion. This is more economical and does not cause water pollution like an ordinary battery since it uses contact with water to generate electricity.

Inventive principle 10, Preliminary action, states that required changes to the object (whole or in part) must be implemented before they are needed. Objects should be pre-positioned in the most convenient location, enabling them to be used without loss of time. Using this principle to find solutions for the problem shows that control board must be built into the lure in order to enable to simulate the swimming motion of a fish.

Inventive Principle 11, Beforehand cushioning, states that emergency measures must be prepared in advance to compensate for the relatively low reliability of an object. This principle is used to solve the problem. For the buoy shell design, the propulsion unit is matched with a buoy shell, and the lure is connected with the buoy. When the propulsion unit is running, the lures will swirl.

Inventive principle 30, Flexible shells and thin films, states that flexible shells and thin films should be used instead of three dimensional structures. Using this principle to solve the problem, flexible shells and thin films are used to enhance the floatability via an inflatable buoy shell.

Inventive principle 3, Local quality, states that an object's structure can be changed from uniform to non-uniform, or an external environment or influence may be changed from uniform to non-uniform. Each of the object's parts should be made to function in the conditions most suitable for its operation, and each part should fulfill a different and useful function. Gunzo and Toshihisa (2002) found that the catch rate was highest when the lure was red, or black, followed by yellow, green, orange, and pink [11]. Using this principle to solve the problem, the exterior of the lure should be a color that is attractive to game fish, and the lure should resemble a fish in appearance to the extent possible.

Inventive principle 27, Cheap short-lived objects, means replacing an inexpensive object with a multitude of inexpensive objects, comprising certain qualities. Lures under water can release the scent, so it is necessary to install a device which is designed with an inner and outer feeder can. The inner can is filled with the scent bait, while the outer can includes the compressor and camera lens. The compressor consists of a battery, motor, and spring. When the fishermen pushes a button on the fishing pole, the feeder outer can extrudes the feeder inner can and the compressor scent is emitted immediately from scent feeding hole to attract fish as shown in Figure 4.

scent feeding holes holes
feeder inner can
spring
motor
compressor
battery
feeder outer can
camera

Fig. 4 Active scent release device

Inventive principle 6, Universality, Make a part or object perform multiple functions. A camera is installed at the bottom of the active scent releasing device and connected to a screen on the fishing pole. The fisherman can observe the fish and decide whether to trigger the scent release control button on the fishing pole.

The technical contradiction matrix shows that to make a lifeless lure into a lure that simulates the movements of a fish and releases scent, at least 6 components should be added to the lure, and its color should be changed. These five items include: (1) a water battery; (2) control board; (3) propulsion unit; (4) inflatable buoy shell; (5) active scent release device; and (6) a screen. The screen installed on the fishing pole is not an underwater component. The authors next perform a function attribute analysis of the underwater components. Through examination of their cause and effect relationships, the authors identify the optimal design for the active scent release lures.

4. Function attribute analysis

Function attribute analysis (FAA) examines system and subsystem components to identify relationships between components and assemblies, as well as the components of main and subsidiary functions. The purpose of this analysis is to determine which functions and relationships exceed, are insufficient, or harm system functioning. Such functions are termed negative functions. Using the relationships between negative functions and each component, points of contradiction of problems may be identified and used to resolve the problems.

This study investigated the active scent releasing device using function attribute analysis. It draws a border around the causal chain of the function attributes. The causal chain shows the cause and effect relationships between the 6 components. Function attribute analysis is then performed. As shown in Figure 5, the water battery adds weight, which must be prevented from affecting the swimming motion of the lure. Consequently, an inflatable bag must be added to enhance its ability to float and move in the water. As a result, the water battery, and inflatable bag are excessive functions. The water battery merely drives the propulsion unit, and both are insufficient functions. A control board is necessary to control the operation of the two propulsion units in order to enable the propulsion unit to operate when water is flowing through the lure, intake and release differing amounts of water, and simulate the movements of a fish. Because of this, the propulsion unit and the water pipe are useful functions. Since the tool is attached to the inflatable bag body, the inflatable bag body has useful functions. To maintain the lure’s ability to swim, all components must balance each other. Because the water battery is heavy, it is necessary to place it at a location where it balances the water pipe. Consequently, their relationship is harmful. Since water goes in and out of the pipe, it will make the lure unstable. Further, the battery, water pipe, and propulsion unit must be balanced. Thus, using stabilizer fins and an inflatable bag to enable the lure to stably produce the swimming motion of a fish requires overcoming the harmful function of the water pipe, water battery, and inflatable bag.

Additionally, the lure’s color must be one that is attractive to fish, such as red or black, mimicking a real fish, to give it a higher catch rate.

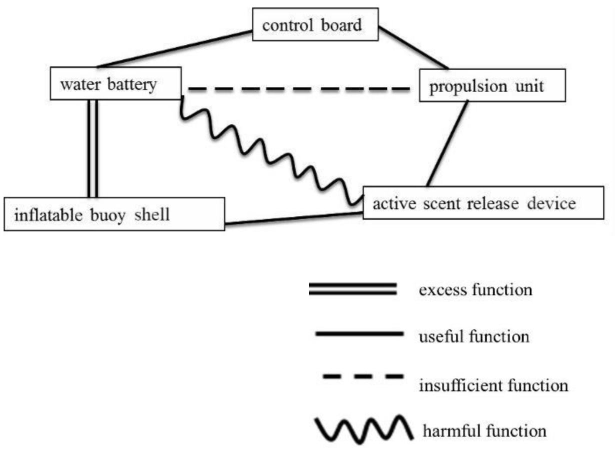

Fig. 5 Lure Component Function Attribute analysis

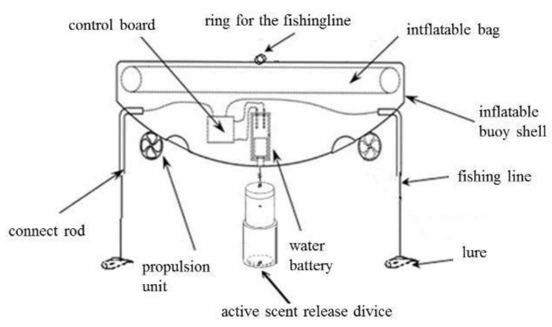

Fig. 6 An active scent release device connected to the inflatable buoy shell

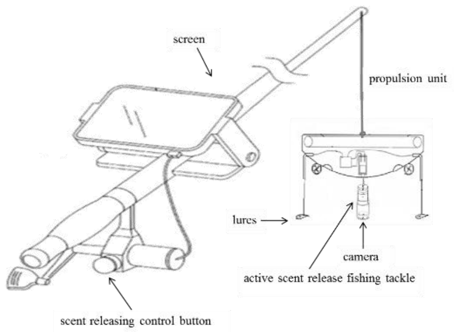

Fig. 7 An active scent release device connected to the inflatable buoy shell

5. Design of the fishing pole with an active scent release lure

Through the analysis of evolutionary trends, technical contradiction matrix and functional attribute analysis, the authors develop a fishing pole with an active scent release lure. The design principles for this fishing pole are discussed below.

An active scent release device with a real fish-like dynamic swimming function can adapt to the fishing pole with an inflatable buoy shell in the water. The battery is fixed in the center of the buoy. The control circuit is placed next to the buoy and filled with the inflatable balloon, which helps to maintain the stability of the reciprocating operation. In addition, the camera signal lens is installed at the bottom of the active scent releasing device, and the signal line is connected to the screen at the front end of the fishing pole. When the battery is activated, the propulsion unit turns on and the bait is operated as a swimming fish, as shown in Figure **6.** Fishermen can watch the activities of fish under the water and decide whether to release scent bait, as shown in Figure 7.

Since the camera enables underwater observation of the lure and nearby fish, fishing may become more entertaining. Moreover, this innovation changes the traditional way of fishing. Using our fishing pole, a fisherman can control several hand poles at the same time.

6. Conclusion

In this study, TRIZ is applied to develop an active scent release lure which can swim actively in the water. First, the authors performed an evolutionary trend analysis in order to determine the future path of lure development. This found that lures are moving toward active lures that embody reduced user operation, and increased ability to move like a fish. Materials are moving toward becoming as soft and colorful as an actual fish. Second, a technical contradiction matrix was used to identify functions to enable the active lure to simulate a fish. The six components are: (1) a water battery; (2) control board; (3) propulsion unit; (4) inflatable buoy shell; (5) active scent release device; and (6) a screen. The design of these six components can make the bait appear to be real swimming fish. Third, a function attribute analysis was performed. This found that the buoy shell can carry lures that dangle beneath a buoy.

This design enables the lure to simulate the movements of a fish. Fishermen, using the camera and the screen, can watch fish to determine the timing of the scent release. Using this innovation, fishing can become a more entertaining leisure activity, with increased catch rates since one person can control more than one pole at same time. Along with the improvement of technology by time on time, the volume and weight of the active scent release lure can be reduced, and become for the fishing operations in the fishery production.

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Applying TRIZ Systematic Innovative Methods to Solve Semiconductor Photo Resist Remains

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Abstract

In order to change the electrical property of the semiconductor, the semiconductor manufacturing process adds other atoms in the silicon wafer (such as boron, phosphorus, nitrogen…etc.) during a process called doping. There are some common doping techniques such as high-temperature diffusion doping, high energy ion beam implantation, plasma doping, and so on. This research focuses on the topic of over doping of nitrogen ions in the plasma doping process. The over doping of nitrogen easily causes a reaction between the nitrogen ion and photo-resist. It leads to the photoresist fail to strip on cleaning procedure, which affects the production rate. In our study, we use Function Analysis, Cause-Effect Contradiction Chain Analysis, Contradiction Matrix & 40 Invention Principles and other analytical tools to solve the engineering contradictions and the physical contradictions of nitrogen doping process based on the Systematic innovation procedure.

Keywords: Ion implantation, Plasma doping, Photoresist stripping, Systematic innovation, TRIZ.

1. Introduction

Introduction describes the research background, purpose and literature review of this paper. Section **1.1** introduces the research background, Section 1.2 describes the purpose of this paper, and Section 1.3 describes the literature review of this paper.

1.1 Research background

Su, Jiawei (2017) mentioned that the total export value of Taiwan in 2017 is about 8.4 trillion NTD, the import value is about 7.7 trillion NTD, and the trade surplus is about 0.8 trillion NTD, of which the IC industry trade export amount is 2.4 trillion NTD, and the import amount is 1.3 trillion NTD, and the surplus of trade in IC industry is 1.1 trillion NTD. That is, without the contribution of the IC industry trade, there would be a trade deficit of 0.4 trillion NTD, indicating the importance of Taiwan's semiconductor output value for the overall economic contribution.

In order to maintain Taiwan's leading position in the semiconductor market, continuous innovation, instead research, and development and improvement are necessary means to keep market competitiveness. This paper attempts to introduce the systematic innovation method of TRIZ into the semiconductor manufacturing industry, verifying how the systematic problem-solving process of TRIZ Theory can be applied to the problems encountered in the semiconductor industry, and provide an empirical case for the domestic industry. In the end, we hope the research results will accelerate the energy of production and research, and continue to inject momentum into the leading position of Taiwan’s semiconductor industry.

Zhang, Ping (2016) mentioned that the process of semiconductor manufacturing can be divided into the front and the back, which are:

Front process：Including film formation, lithography, etching, doping, chemical mechanical polishing, cleaning and circuit testing.

Back process：Includes back grinding, cutting, die bonding, wire bonding, packaging, wire processing, marking and circuit testing.

In the front process, the semiconductor basically repeats the manufacturing process, and the layers are stacked to meet the design requirements. This paper will focus on the "doping" process in the prestage process, and apply a series of analysis and discussion.

1.2 Research purposes

In order to change the conductive properties of semiconductors, semiconductors are fabricated with other atoms (such as boron, phosphorus, nitrogen, etc.) which added to the wafer process. This process is called doping. Common doping techniques are high temperature diffusion doping, high current ion implantation and plasma doping. This paper focuses on the topic of excessive nitrogen ion doping in plasma doping processes. In the case of plasma doping, if the nitrogen ions are excessively doped, it is easy to cause the nitrogen ions to react with the photoresist, which cause the photoresist may cannot be smoothly peeled off during the subsequent cleaning process, thereby affecting the product yield.

This paper uses Function Analysis (FA), Cause-Effect & Contradiction Chain Analysis (CECCA), Contradiction Matrix and 40 Invention Principles. (CMIP), Parameter Deployment and Operation etc. analysis tools to analyze the engineering contradiction and physical contradiction encountered in the plasma doping process, and systematically analyze and discuss the process, expecting to find an effective solution that is over doped without reducing the production rate. We also hope to provide an empirical case of the theory of TRIZ applied to the semiconductor industry to help the industry accelerate the improvement of the problem.

1.3 Literature review

This section makes a brief literature review of the core of this paper which are divided into 2 subsections, "TRIZ Systematic Innovation Theory" and "Semiconductor Doping Process".

1.3.1 TRIZ systematic innovation theory

The so-called systemic innovation refers to the "thinking process of systematically generating innovative/creative methods to solve problems." The theory of TRIZ is part of a systemic innovation founded by the former Soviet inventor Genrich Altshuller. Altshuller has studied ten thousands of patent researches in the world and found that lots of patents can be logically integrated into a systematic and innovative thinking process. Compared with the idea of problem solving such as random or unconventional thinking, TRIZ Theory provides us with a set of traceable logic to form a solution step by step. As a result, there is a higher chance of quickly focusing on the core of the problem and shortening the time course for solving the problem.

The classical contradiction matrix (CM) and inventive principles (IPs) developed by Altshuller were based on patents from traditional industries in the 1950s. To date, no research has developed any CM and IP specifically suitable for the semiconductor industry (Sheu, D. D., Chen, C.H., 2012).

TRIZ innovative problem-solving techniques can be divided into the following processes:

A. Problem definition stage: This stage includes the formation of a project team to identify key issues and their related contradiction.

B. Solution generation stage: At this stage, the contradiction matrix in theory, Contradiction Matrix and 40 Invention Principles, parameter deployment and operation, etc. are applied to solve the problem. This stage is also the essence of the theory of TRIZ. With the above tools, there are opportunities to generate many possible answers.

C. Solution Filtering, Evaluation, and Integration stage: This stage evaluates the answers generated in the previous steps and selects the appropriate answers for implementation and evaluation. Further, this thinking process can be expanded to other areas for integration to expand the impact of systemic innovation.

1.3.2 Semiconductor doping process

Xiao, Hong (2012) said that one of the most important characteristics of semiconductor materials is that conductivity can be controlled by doping different materials, such as boron, phosphorus, nitrogen, etc. This doping process can be broadly divided into two categories: high temperature diffusion and ion implantation.

High-temperature diffusion is to provide doping atomic with kinetic energy through a high-temperature furnace to accelerate the free movement of the dopant atoms so that they have sufficient energy to impinge into the oxide layer. The design of such a process device is simple and cheaper, but the doping process time is long and the dopant concentration, impact depth and doping uniformity are not easy to control.

Ion implantation technology was first proposed by William Shockley at Bell Laboratories in 1954. It generates ions required for doping by an ion source, and the ion accelerator carries ions to carry enough energy to strike the oxide layer to complete the doping process. Compared with the high temperature diffusion method, the ion implantation can independently control the dopant concentration and depth, and the doping process time is greatly shortened.

2. Research methods

Research methods describe a series of analytical procedures for the application of the theory of TRIZ to the problem of excessive nitrogen ion doping, which is written in Section 2.1–2.3. The architecture of the entire process is shown in Figure 1.

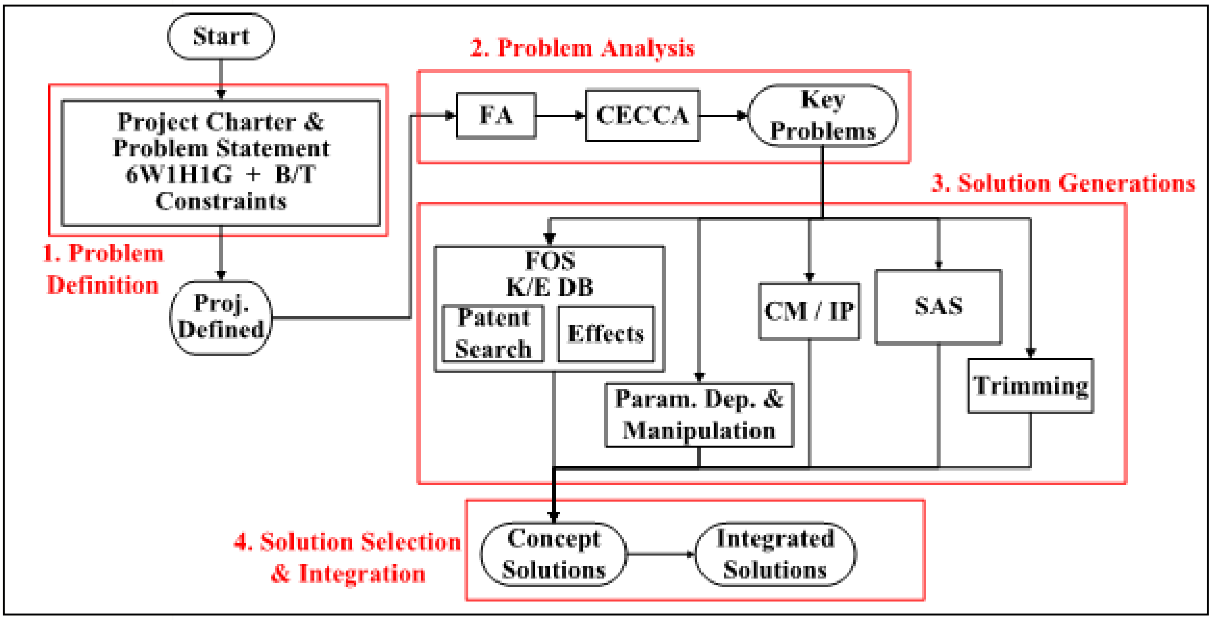

Fig. 1：Problem solving process diagram

2.1 Problem definition

With the development of semiconductor miniaturization, the use of lower energy ion implantation techniques and the need of shortening the doping time have been derived. Plasma doping technology is one of the ways to respond. Plasma doping is to introduce a doping gas (such as NH3) into a vacuum reaction chamber, and the doping gas is ionized into a plasma group with equal positive and negative charges by a radio frequency power source (RF Power). The doping ions (such as N+) are required to contact the surface of the oxide layer to complete doping. The process schematic is shown in Figure 2.

The problem in this study is that the nitrogen ion doping is excessive in the plasma doping process, which causes the photoresist to be smoothly peeled off during the subsequent cleaning process, therefore, affecting the product yield. The goal is to find a feasible solution to improve the problem of excessive doping without affecting the production rate. In this perspective, the teamwork and brainstorm behind the study gathers academic tutors, graduate student, and technical engineers.

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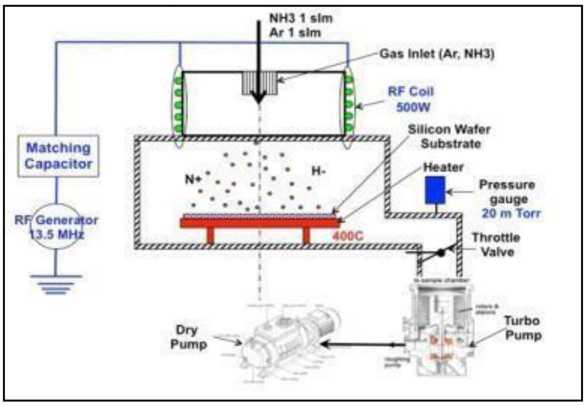

Fig. 2：Diagram of plasma doping process equipment

2.2 Method of problem analysis

First of all, from the point of view of components, we analyze the functions and interactions of all the components in the system one by one to focus on the core of the problem.

2.2.1 Method of function analysis

Function analysis is a tool for identifying problems. Through function analysis, one can understand the functions and relations between components in the system. At the same time, you can identify the functions between components are useful or negative. Usually, negative functions contain harm, excess and insufficiency. The function analysis is performed in three steps, namely component analysis, functional relationship matrix and graphic of FA. The explanation of the three steps is shown in Table 1 below.

Table 1: Function analysis table

Step	Step explanation
Component analysis	Through component analysis, the main function of the system should be identified first, and the component items included in the system and the super system should be understood to define the scope of the problem.
Functional relationship matrix	The functional relationship matrix is based on the result of component analysis. It knows all the components in the system and the operating system, and by putting each component into the functional relationship matrix, judge whether the components are in contact with each other. If two components are related, then determine whether there is a function between the components.
Graphic of FA	The graphic of FA is to complete the component analysis and functional relationship matrix, and then integrate the results into a graph, which can quickly focus on the function disadvantages, so as to make a Cause Effect Contradiction Chain Analysis later.

2.2.2 Method of Cause Effect Contradiction Chain Analysis

After the function analysis is completed, it is possible to identify the target disadvantages in the system, listing the target disadvantages in a table, and to select one or several target disadvantage points. When the target disadvantage point selection is completed, the cause effect relationship can be found through the selected target disadvantage point, and keep find until the disadvantage can't be found, and the last disadvantage point is marked as a key disadvantage point. Then, keep find the positive relationship from the key disadvantage point to the target disadvantage point. If there is a disadvantage point that has both positive and negative functions, then the disadvantage is the physical contradiction, and the relationship deduced by the physical contradiction is the engineering contradiction.

2.2.3 Families of contradiction

After the Cause Effect Contradiction Chain Analysis is completed, the physical contradiction and engineering contradiction in the system can be identified and presented by the method of "IF...THEN...BUT..." model, so-called families of contradiction. IF indicates the possibility of the solution, THEN indicates the purpose of the solution, and BUT indicates the disadvantage of the solution. Through the Families of contradiction, can make it clearer about the cause of the engineering contradiction.

2.3 Method of solution generation

At this stage, we introduce two innovative solutions which are "Contradiction Matrix and 40 Invention Principles" and " parameter deployment and operation".

2.3.1 Method of Contradiction Matrix and 40 Invention Principles

Altshuller conducted extensive research based on past patents and found that these patents can be grouped into 40 invention principles. Such as segmentation, asymmetry, nested structure, etc. Using 40 invention principles to solve the problem is to absorb the wisdom of the predecessors to solve the problem at hand. Based on problem analysis, we can use the 40 invention principles to think about possible solutions.

2.3.2 Method of parameter deployment and operation

Parameter deployment and operation is an integrated solution to solve physical contradiction in the system. Physical contradiction refers to the requirement of two contradictions for the same parameter of the same system. Firstly, it is judged whether the problem can be solved by the separation conflict requirement, and the problem is solved by the order of space, time, association, and system separation (Sheu, D. D. and Li, H. C., 2014). For example, the customer wants the smart phone screen to be large and easy to read, but still hopes that the screen is small enough to be portable. Here, the customer has a contradiction for the size (i.e. parameters) of the smartphone screen, which is a physical contradiction. To solve physical contradiction, the relevant parameters influencing, or affecting, the two objectives O1 and O2 or the contradictory parameter P need to be investigated (Sheu, D. Daniel and Rachel Yeh, 2018).

Parameter deployment helps us to start from the problem point, find the relevant components and parameters of the problem point, and clarify the parameters that may be used to solve the problem. Parameter operation solves the problem by changing various parameters. The parameter operation can be divided into three categories: "parameter domination", "parameter separation" and "parameter transfer". The difference is that "parameter separation" uses the parameters around the problem point to solve the problem, while "parameter transfer" may solve the problem with external parameters that appear to be unrelated to the problem.

The method of parameter deployment and parameter manipulation (Parameter domination and Parameter separation) can help user to perform different problem solving strategies

(PD/CPS/COPE/COEP/COEE), and propose more and more comprehensive solutions to improve the problem-solving performance of the company (Cheng, Chi-Ying and D. Daniel Sheu, 2018). Once the parameter deployment is complete, the tool can be manipulated with parameters to generate a variety of possible solutions. Figure 3 is the architecture diagram of summarizes the strategies in the parameter operation.

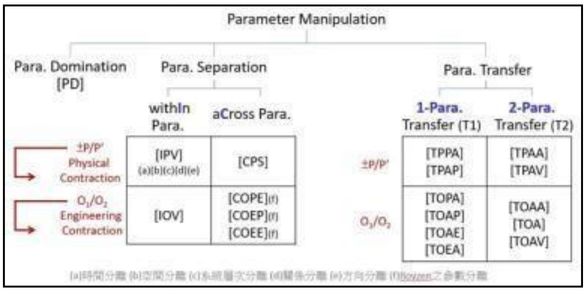

Fig. 3: Overview of the parameter operation problem solving

Following a series of detail of acronyms of the strategies (Sheu, D. D., 2015) are summarized and explain in Table 2.

Table 2. List of the various strategies

PD	**P**arameter **D**omination. By enhancing one or multiple compatible constituent parameters (Z_k) greatly to the extent that the influence by Z_k dominate the influence of P_j thus O1 and O2 can be achieved simultaneously.
IPV	With**I**n **P**arameter separation by **V**alue range. This includes all existing separation principles and more as indicated by separation at different value range of X_{jm} in Eq. 2.
CPS	**C**ross **P**arameter separation by **S**plitting parameter. Splitting a contradictory parameter into two
COPE/ COEP	**C**ross **P**arameter separation. PE: Use +P to satisfy O1 and Exclusive parameter of O2 to satisfy O2. EP: Use -P to satisfy O2 and Exclusive parameter of O1 to satisfy O1.
TPPA/ TPAP	**T**ransfer a parameter to satisfy a contradictory parameter **P**. **PA**: Let P = +P and use an Additional (external) parameter to satisfy –P. AP: Let P = -P and use an Additional (external) parameter to satisfy +P.
TOPA/ TOAP	TOPA: **T**ransfer satisfaction of **O**2 to an **A**dditional parameter while letting **P = +P** to satisfy O1. TOAP: **T**ransfer satisfaction of **O**1 to an **A**dditional parameter while letting **P = -P** to satisfy O2.
TOAE/ TOEA	TOAE: Using **E**xclusive parameter of **O**2 to satisfy O2 and **T**ransfer satisfaction of O1 to an **A**dditional parameter. TOEA: Using **E**xclusive parameter of **O**1 to satisfy O1 and **T**ransfer satisfaction of O2 to an **A**dditional parameter.
TOAA/ TOA/TOAV	Transfer satisfaction of O1/O2 (TO) to: 1) two distinct Additional parameters (AA), 2) one Additional parameter on which the contradiction disappear or become non-effectual, 3) one **A**dditional parameter but separate them by **V**alue range (AV).

3. Research Results

Research results describe the result from research method. Section 3.1 introduces the result of problem analysis, Section 3.2 describes the result of answer generation, and Section 3.3 describes the solution selection and integration.

3.1 Result of problem analysis

This section describes the result of problem analysis. Subsection 3.1.1 introduces the result of function analysis, and Subsection 3.1.2 describes the result of Cause Effect Contradiction Chain Analysis.

3.1.1 Result of function analysis

Through component analysis, the main function of the system should be identified first. The plasma doping process discussed in this study consists of a wafer substrate, an oxide layer, a plasma cluster, a heater, a vacuum pump, a reaction chamber, a pressure regulating valve, a radio frequency power, a paired capacitor, and a pressure gauge.

After the component analysis, the functional relationship matrix is based on the result of component analysis. Next, we put each component into the functional relationship matrix to judge whether the components are in contact with each other. At last, integrating the results into a graph (Figure 4), which can quickly focus on the function disadvantages

By analyzing the interactions of components in the system from the perspective of components, we are able to identify the core of the problem and focus on the contradiction points of the problem.

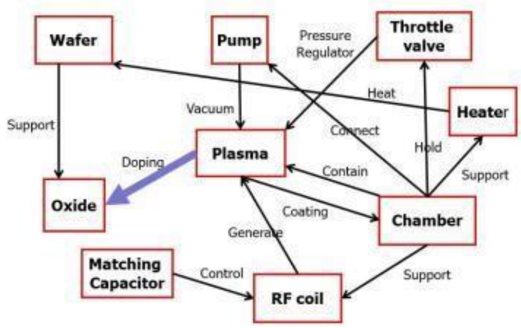

Fig. 4: Functional Attribute Analysis Chart

3.1.2 Result of Cause Effect Contradiction Chain Analysis

Through Cause Effect Contradiction Chain Analysis, we can identify the most important key disadvantage point, and Cause Effect Contradiction Chain Analysis as shown in Figure 5.

As shown in the Figure 5, we start by looking for the cause from the target disadvantages. We can find “High plasma density” combine “High oxide reactivity” are the reason cause the “High plasma N^{+}”.”High gas flow rate of NH_3” and “Low chamber pressure” and “High RF power” cause “High plasma density”. At last, since we can’t find the result of “High RF power”, we take it as the key disadvantage.

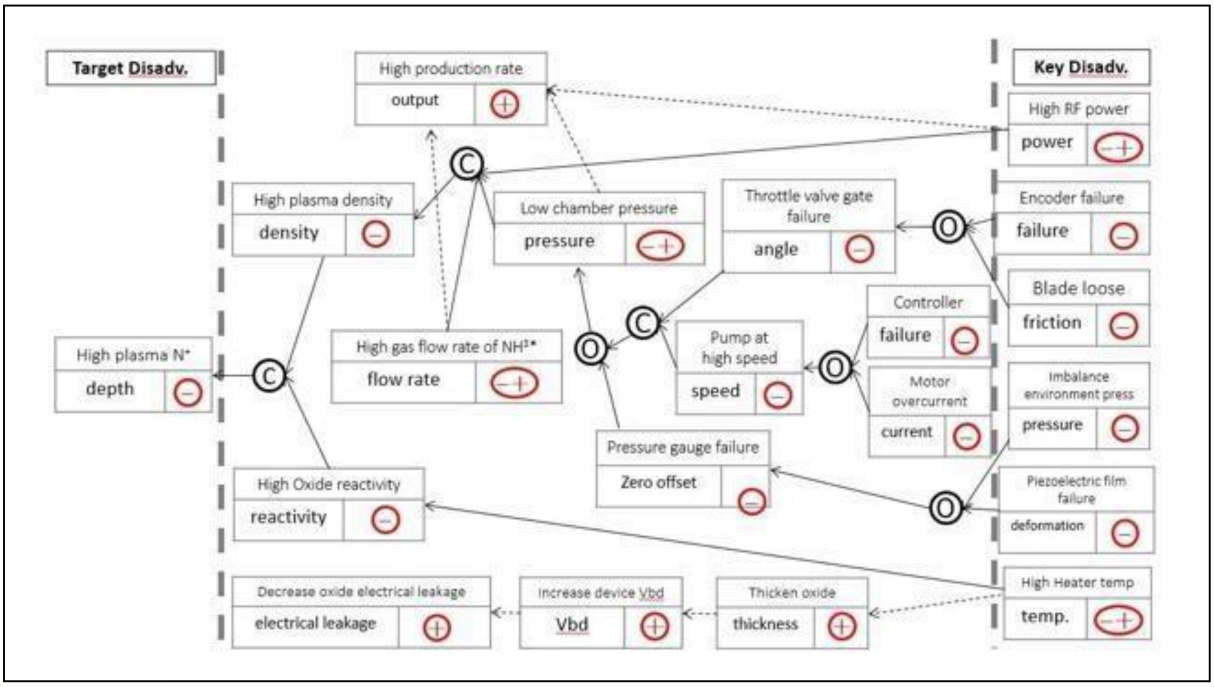

Fig. 5: Cause Effect Contradiction Chain Analysis

3.2 Result of answer generation

At this stage, we apply two innovative solutions, which are "Contradiction Matrix and 40 Invention Principles" and " parameter deployment and operation" into our case. The process is described in the following subsection 3.2.1-3.2.2.

3.2.1 Result of Contradiction Matrix and 40 Invention Principles

In this study, the plasma concentration was reduced to reach the target of excessive doping, and the radio frequency power was reduced as a means to generate a collision matrix.

The improvement parameters listed here are the loss of matter and the deterioration parameter is productivity. Based on the 40 invention principles, we can find the principles of "mechanical system replacement", "parameter change", "feedback". Guided by these inventive principles, this study proposes four possible solutions, presented in tabular form in Table 3, with schematic views of Figures 6-9.

Table 3: Answer sheet generated using 40 invention principles

40 invention principles	Innovation solution
(28) Mechanical system replacement	The plasma diffusion is replaced by a thermal diffusion method. As shown in Figure 6
(35) Parameter change	An inert gas (such as helium He) is mixed into the ammonia (NH_3) to reduce the doping plasma concentration. As shown in Figure 7
(23) Feedback	The surface of the oxide layer is irradiated with ultraviolet rays, and the change in reflectance is detected as a monitoring index of the doping concentration. As shown in Figure 8
(23) Feedback	The conductive device is mounted around the wafer substrate, and the doping concentration is monitored by detecting the current generated by the ion ground. As shown in Figure 9

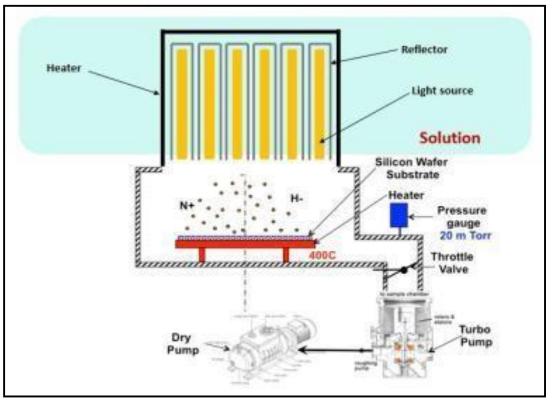

Fig. 6: Using thermal diffusion to replace plasma doping

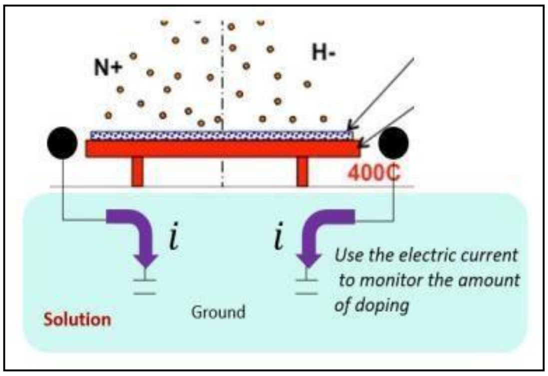

Fig. 9: Current monitoring doping concentration generated by detecting plasma grounding

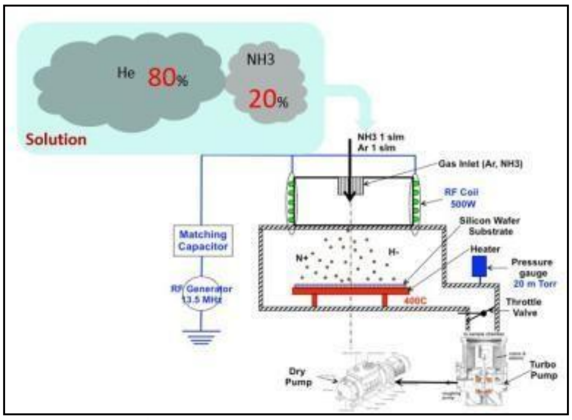

Fig. 7: Mixing inert gas to reduce plasma concentration

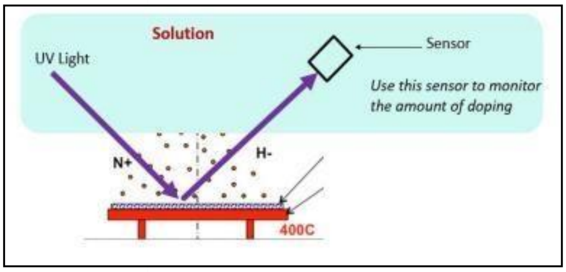

Fig. 8: Monitoring the doping concentration using UV light

3.2.2 Result of parameter deployment and operation

In this step, we first deploy the parameters, list the local system of the problem, and identify the surrounding components and related parameters, as shown in Figure 10.

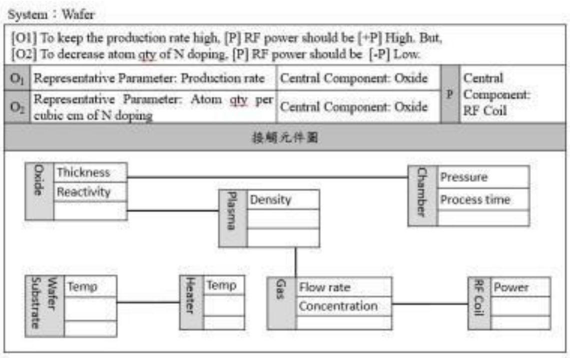

Fig. 10: Diagram of component identification

The object 1(The following is called "O1") is “High productivity”, object 2(The following is called "O2") is “Reduce the doping depth”, and the contradiction parameter is the radio frequency power. In order to meet the O1, we hope that the radio frequency power is large, but on the other hand, in order to meet the O2, we also hope that the radio frequency power is small. In order to resolve this contradiction, the parameters can be deployed after the local system is identified, as shown in Figure 11. By parameter deployment table, we can quickly focus on the parameters that can be used to solve the problem. The parameters can be classified into three categories, namely contradiction parameters, exclusive parameters and compatible parameters.

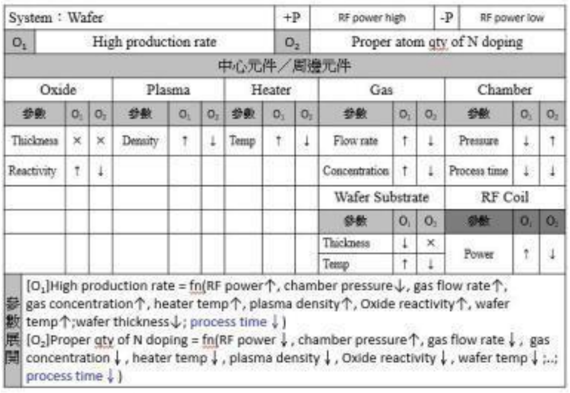

Fig. 11: Diagram of parameter deployment

Once parameter deployment is complete, the tool can be manipulated with parameters to generate a variety of possible solutions. Table 4 summarizes the various possible problem-solving combinations in the parameter operation. With a series of questions and thoughts in Table 4, we can systematically find possible solutions to the problem.

Table 4: Innovative solutions generated using parametric operations

strategy	solution
TOEA	Thermal diffusion doping instead of plasma doping- the use of a high temperature lamp rapidly heats the gas, allowing the gas to diffuse freely to dope the oxide layer. See Figure 6.
TOA	Change gas concentration- Inert gas (such as helium) is mixed with ammonia gas to change the plasma concentration. See Figure 7.
PD	Reduce process time-O1: High Productivity, O2: Reduce Doping Depth. By decreasing the doping process time, both O1 and O2 are satisfied.
IPV	RF power decreases by time-Rapidly increase RF power at the beginning of the process, and decrease gradually as the process progresses to mid-range. See Figure 12.
CPS	Strengthen chamber insulation-Leakage currents are prevented from entering the chamber to create additional electromagnetic fields that affect the plasma concentration. See Figure 13.
COEP	Use thinner oxide layers- using a thinner oxide layer to meet O1, and lower RF power to meet O2.
TOPA	Using sensors to monitor doping depth-dynamically control the power of wireless RF power. See Figure 8, 9.
	Increase the angle of wafer base-Using high RF power to meet O1 (high productivity) and meet O2 by adjusting the angle of the wafer base (reducing doping depth). See Figure 14.
	External electric field-Apply a new electric field around the chamber or on the bottom of the wafer. See Figure 15.
	The use of the slide rail let the RF power adjust the angle, which in turn affects the plasma concentration to meet the O2 (reduced doping depth). See Figure 16.
	Using a rotatable wafer pedestal, multiple wafers are placed in the chamber to meet O1 (high productivity), reduced RF power to meet O2 (reduced doping depth). See Figure 17.
TOAP	Multiple inlet air-change the original single inlet to multiple inlet. See Figure 18.
	A magnetic field controller will be added to change the state of the plasma flow to meet the O1 (high productivity), and the reduced radio frequency power to meet the

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	O2 (reduced doping depth). See Figure 19.
	Use light heater-The use of lamp-heated heating rapidly increases the temperature. See Figure 20.
	Preheat ammonia-Pre-heat ammonia to meet O1 and O2. See Figure 21.
	Increase plasma guidance channel-add a plasma guide channel in the chamber to meet O1 and O2. See figure 22.
	Increase vacuum pump-increase vacuum pumping and speed up chamber decompression to meet O1 and O2. See Figure 23.
TOA	Composite materials-using composite materials to meet O1 and O2. See Figure 24.
	Elevating wafer base-using a vertically movable wafer base to meet O1 and O2. See figure 25.
Trimming	Trim the rotary pressure control valve with high failure rate and replace it with a higher pressure control device. See Figure 26.
TPPA	RF power pulse mode-using a capacitor divider to adjust RF power from continuous mode to pulse mode. See Figure 27.

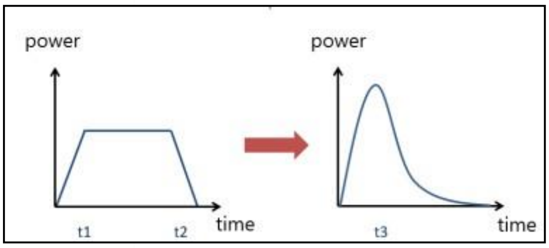

Fig. 12: Diagram of strategy IPV

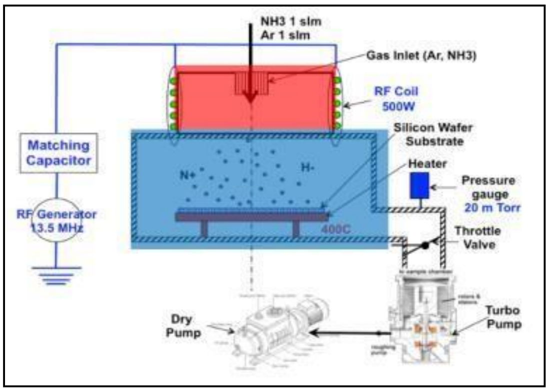

Fig. 13: Diagram of strategy CPS

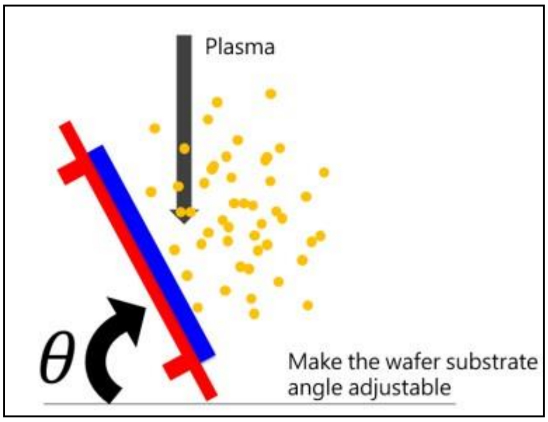

Fig. 14: Diagram of strategy TOPA (1)

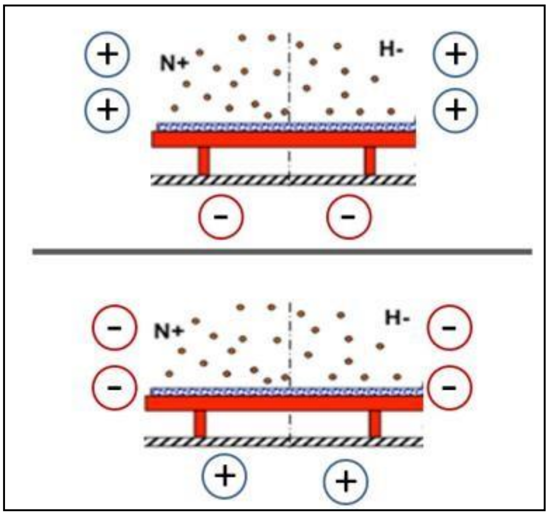

Fig. 15: Diagram of strategy TOPA (2)

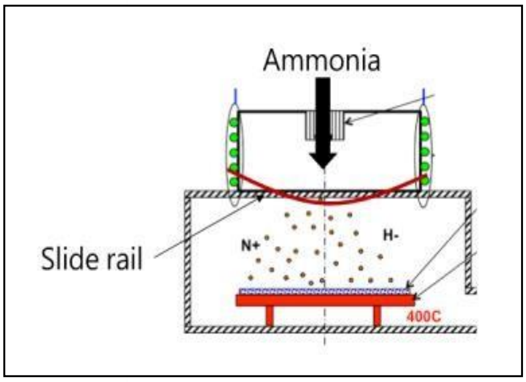

Fig. 16: Diagram of strategy TOPA (3)

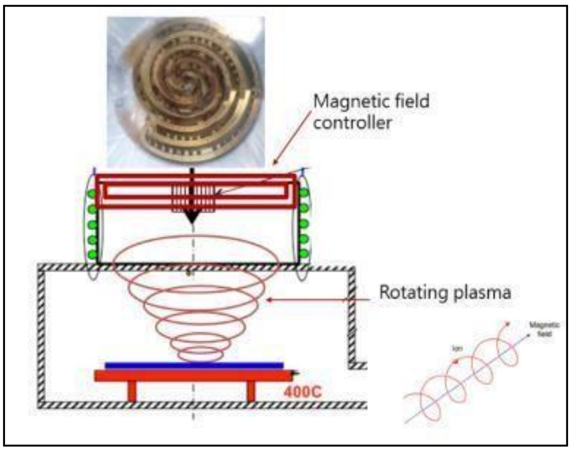

Fig. 19: Diagram of strategy TOAP (2)

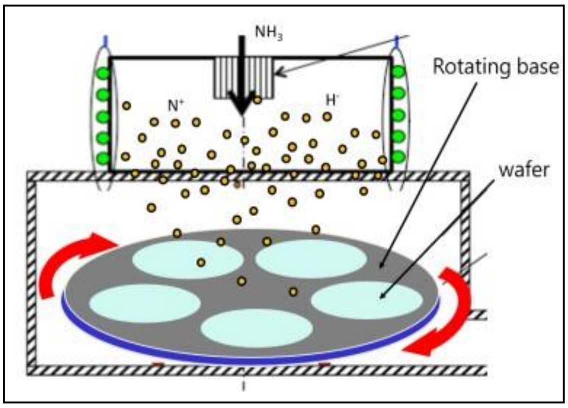

Fig. 17: Diagram of strategy TOPA(4)

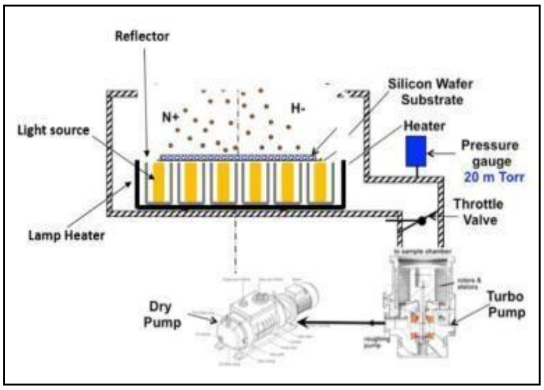

Fig. 20: Diagram of strategy TOAP(3)

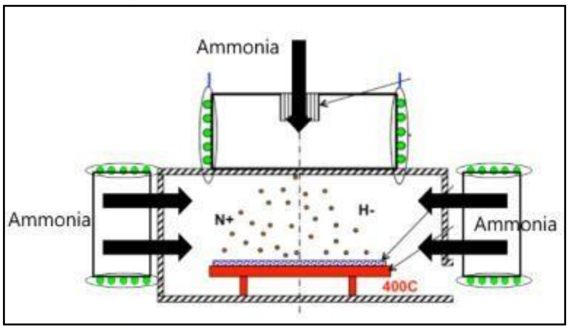

Fig. 18: Diagram of strategy TOAP(1)

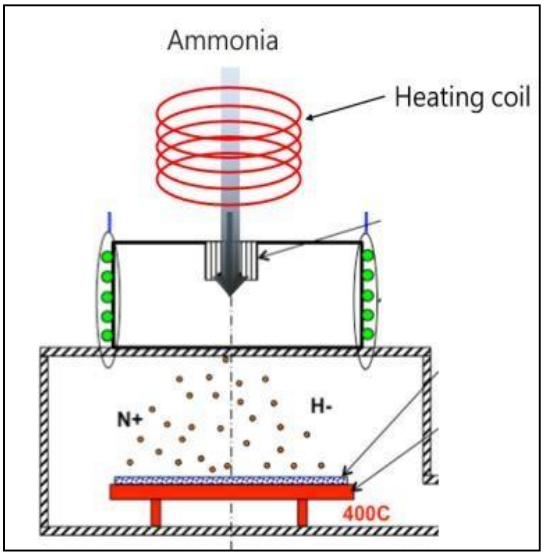

Fig. 21: Diagram of strategy TOAP(4)

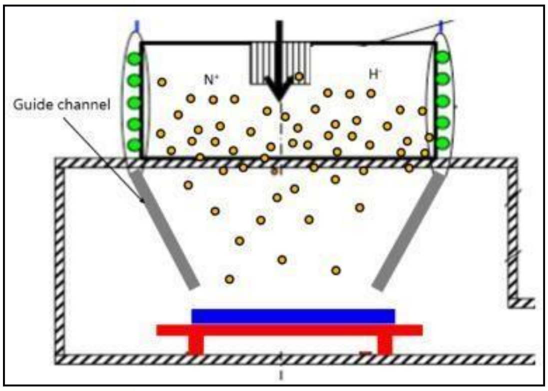

Fig. 22: Diagram of strategy TOAP (5)

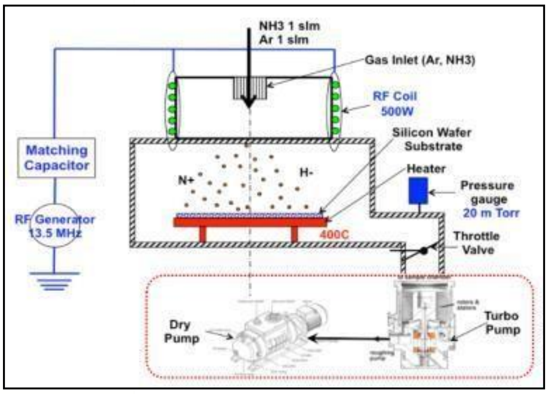

Fig. 23: Diagram of strategy TOAP (6)

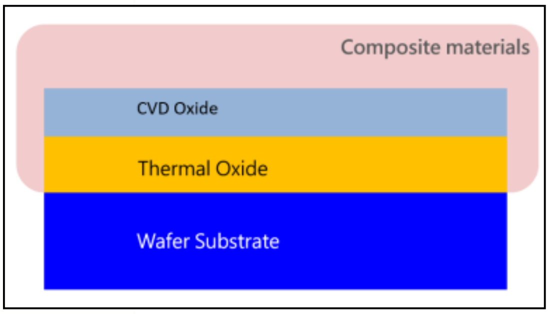

Fig. 24: Diagram of strategy TOA (1)

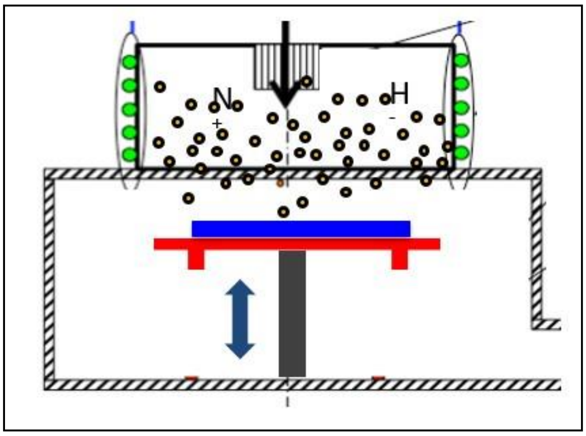

Fig. 25: Diagram of strategy TOA (2)

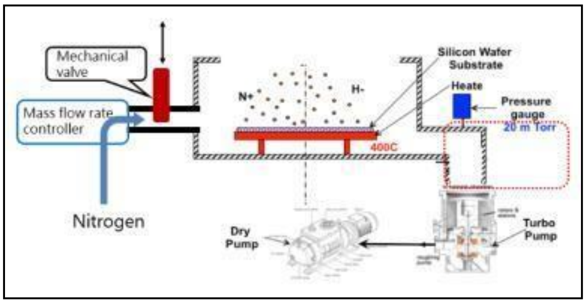

Fig. 26: Diagram of strategy trimming

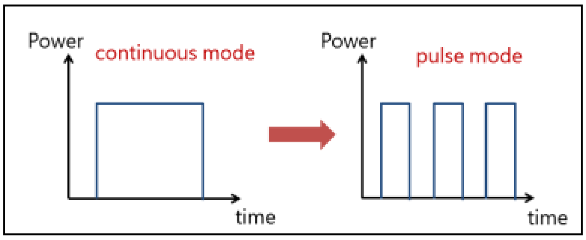

Fig. 27: Diagram of strategy TPPA

3.3 Solution selection and integration

After using different tools in the solution generation phase, we are able to come up with possible solutions based on a series of logical thinking processes and aids. In the stage of answering selection and integration, this study evaluates the feasibility and benefits of various solutions with the expertise and experience of senior technical engineers in the semiconductor industry. Finally, the "radio frequency power source pulse mode" solution generated by the TPPA problem-solving strategy in the "parameter deployment and operation" thinking process is selected and experimentally designed to verify if this solution helps to improve the excessive nitrogen ion doping. The research results are summarized in Chapter 4.

4. Summary and conclusions

This research used the theory of TRIZ systemic innovation to gradually focus on the core of the problem through a series of logical thinking processes and auxiliary tools in the process of problem definition, analysis and solution generation, resulting in more than 20 possible solutions. Compared with the traditional randomized problem-solving process, TRIZ Theory really helps us to shorten the process of solving problems. In the course of the research, the discussion and creative thinking of the project team was described as "a kind of grasping the standard of the sky and approaching the core of the problem."

In this case study, we selected the "radio frequency power source pulse mode" solution for verification. The experimental design was carried out by a well-known domestic semiconductor manufacturer, and the data was collected for analysis to test how it would help to improve the excessive nitrogen ion doping. However, due to business confidentiality, this article only briefly extracts the experimental results. It has been experimentally verified that by adjusting the time-varying rate of the wireless RF power source from the original continuous operation mode to the pulse mode, the performance index of 20% nitrogen ion doping excess is effectively reduced, and the result shows that this solution is a feasible strategy.

TRIZ Theory has been deeply integrated and summarized the wisdom of past people into a systematic study. At each stage of the problem-solving, there are a series of mature tools that help us to focus on the core of the problem. This study applied the theory of TRIZ to the improvement of nitrogen ion doping excess in the semiconductor industry. It has been proved by experiments that this systematic solution to problems does help to improve the problem. It is a mature and effective tool for solving problems.

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Exploring the Formulation of Book Pricing Strategies in Economics with a TRIZ Approach to Business Management

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Abstract

This study first explores the factors that influence the pricing of e-books and physical books, and then book pricing strategies formulated with a TRIZ approach to business management. In this study, the conflict points of book pricing are spotted first, namely exchange rate fluctuation, market share, update speed, penetration price, preferential activity, and differential price. The corresponding positive and negative effects for the six conflict points are identified respectively. Next, the corresponding parameters for the positive and negative effects are used to identify each parameter's corresponding TRIZ-based principle of invention respectively. The principles of invention are then used to formulate book pricing strategies. Finally, the book pricing strategies are recommended to the publishing industry as a reference for new book pricing.

Key words: Book pricing strategy, TRIZ approach to Business Management, TRIZ-based principles of invention, Publishing Industry.

1. Introduction

The development of the globalized publishing industry faces multiple challenges that change quickly. The factors that influence book pricing not only involve markets and competitors, but also those such as interdependence, supply and demand between the publishing industry and readers.

Take the book market in Taiwan in 2015 for ex-ample. The publishing industry market for physical books (upstream) is estimated to be NTD 19.93 billion, and that for bookstores (downstream) is estimated NTD 23.85 billion. The e-book publishing industry (up-stream) is estimated to be NTD 0.32 billion while the digital dealer market (downstream) is estimated to be NTD 0.61 billion. With a market worth nearly NTD 45 billion, how to use pricing strategies to create a competitive pricing niche for books is the key issue for this study. E-book pricing models are divided into five categories: long tail theory, brand value, reader positioning, product life cycle, and free pricing. Paper book pricing models are also divided into five types, namely demand elasticity, resale price maintenance system, production cost, psychological pricing and competitor pricing.

This study aims to formulate strategies for book pricing with TRIZ-based principles of invention, which will have been spotted with the positive and negative effects of the conflict points. The conflict points will be found out with the TRIZ approach to business management, which is detailed in the book Hands-On Systematic Innovation for Business and Management by Darrell Mann (2004).

2. Literature Review

Book prices were determined by previous experiences of the supplier and the demander of the book market. Nowadays, the factors that influence book pricing are determined by expert judgments, customer surveys, historical data analysis, etc. Consequently, the pricing will differ along with the changes of customer habits, competitive positions, distribution channels, and national conditions. Books are divided into physical books and e-books when they are priced with different pricing strategies. In this way, the publishing industry and readers are both able to maximize their profits and needs. Therefore, the study will discuss the pricing strategies for e-books and physical books, respectively.

2.1 E-book pricing strategy

E-books are referred to the published physical books whose words, pictures and images are digitalized and presented with multimedia. Consequently, the e-books are interactive, and they have hyperlinks and can be retrieved. E-book pricing strategies consist of long tail theory, brand value, reader positioning, product life cycle and free pricing.

2.1.1 Long Tail Theory

The Long Tail Theory is founded on the 80/20 Rule. The theory enables businessman to continue making profits until in the late phase of sales so that a considerable profit can be obtained by multiplying the long-tailed niche commodity with a very low unit price. Based on the Long Tail Theory, two strategies can be formulated for e-books, namely bundling pricing and custom pricing.

Bundling pricing refers to the strategy that a sales system will automatically recommend relevant e-books when customers buy one, and the customers enjoy discounts if they buy the recommended books. The more e-books they buy, the lower the unit price for the e-books will be. In this way, the consumers are led to buy more e-books at a time. As for custom pricing, it means that various customized supplies and demands can prolong the long tail of the e-book sales without limits. Online bookstores can analyze the interest, profession and educational needs of the consumers with their purchase records. With that, the bookstore will customize book information for them, which will be sent to them by e-mail or by phone message. In this way, promotional information of the similar and relevant books is sent to the previous consumers so as to promote sales.

2.1.2 Brand Value

Brand value is an intangible asset for enterprises, which represents the enterprises' reputation, brand image, consumers' recognition for the brand, and consumers' loyalty to the brand. A successful brand will help the enterprise spot its position in the market and its own strengths and weaknesses when compared to other brands. If consumers like the brand and they are willing to buy, they will buy its new arrivals. For instance, consumers will wait in a queue to buy NIKE sneakers that are newly issued products. Similarly, the brand value of e-books is closely related to their pricing strategy.

2.1.3 Reader positioning

The publication of e-books needs to take into account the needs of readers. When they are published, they need to be properly positioned. The introduction of the books should be concise yet powerful. If they can satisfy the needs of the readers, they can sell a good price.

2.1.4 Book life cycle

The life cycle refers to the process in which a book enters into the market and then exits the market. The process includes four stages, namely market entry, growth, maturity and recession. (Parker, 1992) conducted to test the dynamic behavior of elasticity over the product life cycle. The empirical results show that whether the product is necessary and the degree of substitution affects the elastic dynamics.

2.1.5 Free pricing

The price mechanism of free pricing is that the buyer and the seller determine the price together by way of bargaining. They decide on the final price for the book based on their objective judgment for its value. The key for the seller to make a profit lies in how to properly price e-books. Generally speaking, the prices for e-books are often low at first and later their prices are raised, for the seller means to make consumers get used to pay for the e-books first. Later he raises the price slowly. In this way, the publishers make a profit.

2.2 Physical book pricing strategy

Physical books are the ones with writing and printing as their media, enabling readers to leaf it through at any time and leaf it back and forth. The pricing strategies for physical books include demand elasticity, resale price maintenance system, production cost, psychological pricing and competitor pricing.

2.2.1 Demand Elasticity

Demand elasticity means the demand for a product changes along with the prices. The more substitutes a good has, the bigger its elasticity will be. The paper book is a commodity that lacks price elasticity. Usually, manufacturers increase sales revenue by raising prices. However, the price elasticity for diverse types of paper books is different. For instance, the price elasticity of textbooks is lower than that for educational reference books. The elasticity for the popular books about recipes, health and others is higher than that for professional books. That is why popular books are sold at a relatively low price.

2.2.2 Resale Price Maintenance System

Resale price maintenance refers to the price at which a fixed counterparty resells a commodity to a third party. The pricing of paper books is influenced by the diversification of the layout and the enthusiasm of the authors. As long as the books possess specialty, and of cultural and public nature, and the market mechanism is used flexibly, they will be able to exert effects on the pricing.

2.2.3 Production Cost

As for the pricing based on production costs, the price of a paper book is set according to actual production costs and appropriate profits. It has two pricing methods: one is cost-based pricing and the other is target profit pricing. The former is a pricing method based on the cost of a single book plus a certain percentage of profits. That is to say, the price of a single book = the cost of a single book * (1+ profit margin). The pricing of a paper book = (the price of the book + the royalty) * 3 or 2.5. The latter is the target profit pricing method. According to this method, a paper book is determined based on its total cost, target profit, and expected sales volume, namely the price of a paper book = (total cost + target profit) / expected sales volume. The advantage of the approach is that the target profit can be realized as long as the sale of the book reaches the expected sales volume.

2.2.4 Psychological pricing

The so-called psychological pricing is a pricing approach with the use of readers' psychology and their concept of prices. There are three specific practices for the psychological pricing. (1) Mantissa pricing: an integer is not chosen as a price, but 9 is taken as the mantissa of the price. In this way, the consumers will produce an illusion that the price is not high. (2) Integer pricing: the mantissa of the price is 0. This practice is often applied to high-end, high-value, and high-quality paper books. (3) High-price strategy: for those books which are treasured or preserved copies, or short-lived publications, they are often high priced. Usually, there are often limited copies for the books. In this way, a considerable profit can be achieved in a short-term.

2.2.5 Competitor pricing

Competitor pricing is based on the publication prices of market competitors. The price of paper books is set above the competitive price within the industry. In addition, the publishing industry will reserve profits for downstream bookstores when pricing to prevent the paper book from being unsalable.

This study uses the TRIZ approach to business management to draw up a book pricing strategy. This section first discusses the TRIZ theory and the TRIZ principles of invention. Later, it explains how to combine the pricing strategy with the principles.

3. Methodology

3.1 TRIZ Theory and Principles of Invention

TRIZ is the abbreviation of Teoriya Reahniya Izobretatelskikh Zadatch, the name of the theory in Russian. It means an inventive problem-solving theory. It was translated into English as Theory of Inventive Problem Solving, which means innovative problem solving theory. The TRIZ theory was developed into an analytical problem solving tool, which contains 39 engineering parameters, contradictory matrix, 40 principles of invention and the Algorithm of Invention Problem Solving (ARIZ).

Genrich Altshuller (1994, 1999) put forward 40 TRIZ-based invention principles by reviewing about 200,000 patents. TRIZ has been gradually applied to non-technical fields such as society, business, culture and art. In 2004, Darrell Mann published the book titled Hands on Systematic Innovation. In that book, he started using the TRIZ approach to business management. Also, he proposed many innovative business solutions. He

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combined the contradictory matrix with business, which became a contradiction matrix for business management, and later evolved into 40 TRIZ-based principles of invention for business management. Next, Valeri Souchkov proposed the 40 invention principles of TRIZ business management innovation, as shown in Table 1. (Sheu, 2017)

Table 1 The 40 TRIZ principles of invention used in business

No.	Inventive Principle	No.	Inventive Principle
1	Segmentation	21	Hurrying
2	Taking Out	22	Blessing in Disguise
3	Local Quality	23	Feedback
4	Asymmetry	24	Intermediary
5	Merging	25	Self-Service
6	Universality	26	Copying
7	Nesting	27	Cheap and Short Life
8	Counter-Balance	28	Principle Replacement
9	Prior Counter-Action	29	Flows and Flexibility
10	Prior Action	30	Border Conditions Change
11	Beforehand Cushioning	31	Holes and Networks
12	Remove Tension	32	Visibility Change
13	The Other Way Around	33	Homogeneity
14	Non-Linearity	34	Discard and Recovery
15	Dynamization	35	Parameter Changes
16	Slight Less Or More	36	Paradigm Shift
17	Another Dimension	37	Relative Change
18	Resonance	38	Enriched Atmosphere
19	Periodic Action	39	Calm Atmosphere
20	Action Continuity	40	Composite Structures

3.2 Combination of book pricing strategies with the principles of invention

The books can be categorized into e-books and paper books. In the literature review, this study describes the pricing strategies for e-books and paper books separately. There are five strategies for each category and 10 strategies in total. The 10 pricing strategies are combined with the 40 invention principles to find out the corresponding relationship between the strategies and the principles, as shown in Table 2. This table can be used when pricing conflicts are discussed later. When the contradiction produced by the 31 business management TRIZ parameters (as shown in Table 3) will be fed back to the invention principles, one can immediately spot the corresponding book pricing strategy.

Table 2 Pricing Strategy and Invention Principle

Category	Pricing strategy	Inventive Principle
E-book	1.Long tail theory	14 Non-Linearity \ 15 Dynamization \ 20 Action Continuity \ 28 Principle Replacement \ 37 Relative Change
	2.Brand value	10 Prior Action \ 38 Enriched Atmosphere
	3.Reader positioning	3 Local Quality \ 7 Nesting \ 14 Non-Linearity
	4. Book life cycle	19 Periodic Action \ 36 Paradigm Shift
	5. Free pricing	15 Dynamization
Paper book	1.Demand elasticity	14 Non-Linearity \ 29 Flows and Flexibility
	2.Resale price maintenance system	33 Homogeneity
	3. Production cost	35 Parameter Changes
	4.Psychological pricing	5 Merging\ 9 Prior Counter-Action \ 16 Slight Less Or More \ 22 Blessing in Disguise
	5.Competitor pricing	11 Beforehand Cushioning \ 12 Remove Tension \ 18 Resonance

Table 3 31 TRIZ parameters for business management

No.	Parameter	No.	Parameter
1	Activity Effectiveness	2	Activity Variability
3	Activity Expense	4	Activity Time
5	Activity Complexity	6	Activity Convenience
7	Activity Safety	8	Activity Reliability
9	System Effectiveness	10	System Variability
11	System Expense	12	System Time
13	System Complexity	14	System Convenience
15	System Safety	16	System Reliability
17	Internal Risk	18	External Risk
19	Information Sharing	20	Information Loss
21	Information Flow	22	Feedback
23	Material Flow	24	Harmful Effects to System
25	Harmful Effects from System	26	Adaptability /Versatility
27	Organizational Tension	28	Organizational Stability
29	Customer tension	30	Customer Stability
31	Environment Stability		

4. Book Pricing strategy

To find out book pricing strategies, the factors that are taken into account during the pricing should be spotted first based on the conflicting points of pricing. This section first discusses the conflicting points of book pricing. Secondly, the TRIZ parameters of business management are used to find out the corresponding invention principles. At last, the factors that determine the pricing of books are spotted with the principles of invention, and later the pricing strategies are formulated. They are now described as follows.

4.1 Conflicting points of book pricing

Book prices are subject to exchange rate fluctuations, market shares, and the speed of version updates, penetration prices, and preferential activities. (Dolan and Simon, 1996)

4.1.1 Exchange rate fluctuation

Book pricing is influenced by exchange rate fluctuations. The depreciation of domestic currency is conducive to the export of books, affect the price system and increase consumers' willingness to buy, so choose parameter 9 (System Effectiveness) while the appreciation of domestic currency is helpful to the import of books, affect the price system and increase consumers' willingness to buy, so choose Parameter 11 (System Expense).

4.1.2 Price increase

Along with book prices increasing, the unit profit of books rises, choosing parameter 9 (System Effectiveness). Accordingly, the relative market share will be reduced, affect the ability of stable achieving profits, choosing parameter 31 (Environment Stability).

4.1.3 Speed of version updates

To respond to changes in the market, the book editions should be constantly updated. It means the complexity of the firm's marketing strategy, so choose parameter 5 (activity complexity), If the editions are not updated for a long time, consumers will reduce their willingness to buy, which results in slow sales and increasing inventory costs. In this way, loyal customers may decrease. Also, the monopoly and leadership will be lost. Due to the loss of the original stable customer base and leadership position, parameter 31 (environmental stability) was chosen.

4.1.4 Penetration price

In order to stimulate sales, books are often issued with a low initial entry price to attract readers and gain market share. Duo to stable customer group was established, parameter 31 (environmental stability) was chosen. On the other hand, it will result in ineffective management for booksellers. For instance, defected books that enter into the market will lead to bad reputation due to their high market share. The original favorable factor (market share) becomes a harmful effect, so choose parameter 24 (the harmful effect to the system).

4.1.5 Preferential activity

The bookseller launches different preferential activities for varied types of books from time to time. Before the activities, different media are used to inform consumers of the news as quickly as possible, so choose parameter 21(Information Flow). If the promotional period has passed, the discount will no longer be available to the consumers. Consumers accustomed to the rapid and automatic inflow of information will be unable to adapt, resulting in a lack of information, which will reduce the profit of firm, so choose parameter 26 (Adaptability /Versatility).

4.1.6 Differential pricing

Booksellers will set different prices for books based on the consumers' different preference in order to increase elastic profits. This flexible pricing strategy is based on the understanding of the consumer information, so choose parameter 21(Information Flow). On the other hand, the method may make consumers feel unfair. Reduce consumer loyalty and increase instability, so choose parameter 26 (Adaptability /Versatility).

This study, based on the aforesaid six conflict points, finds out the positive and negative effects for each conflict point, as shown in Table 4.

Table 4 Conflict points for pricing

Contradiction	Positive effect	Negative effect
1. Exchange rate fluctuation	Domestic currency depreciation conducive to exporters	Domestic currency appreciation conducive to importers
2. Price increase	Unit profits increase	Market share decreases
3. Speed of version updates	Innovative/diversified versions update quickly	Leadership lost with a low update
4. Penetration price	Market share increases	Defected books
5. Preferential activity	Sellers respond quickly	Buyers respond slowly
6. Deferential pricing	Profits increase	Customers feel unfair

4.2 Find out corresponding principles of invention with TRIZ parameters

According to Table 4, the corresponding parameters for the positive and negative effects of the six conflict points are spotted respectively from the 31 TRIZ parameters. Later, corresponding invention principles for the parameters are found out, as shown in Table 5.

Table 5 The corresponding parameters of the positive and negative effects of conflict points

Contradiction	Positive effect	Negative effect
1.Exchange rate fluctuation	Parameter 9 (System Effectiveness)	Parameter 11 (System Expense)
2.Price increase	Parameter 9 (System Effectiveness)	Parameter 31 (Environment Stability)
3. Speed of version updates	Parameter 5(Activity Complexity)	Parameter 31 (Environment Stability)
4.Penetration price	Parameter 31(Environment Stability)	Parameter 24 (Harmful Effects to System)
5.Preferential activity	Parameter 21(Information Flow)	Parameter 26 (Adaptability /Versatility)
6.Deferential pricing	Parameter 9 (System Effectiveness)	Parameter 30 (Customer Stability)

4.3 The Principles of invention used to find out the factors that influence book pricing

In this section, according to the conflict points, their corresponding principles and the factors that influence book pricing will be found out.

4.3.1 Conflict Point One

The first conflict point is the exchange rate fluctuation. Parameter 9 and 11 and the corresponding TRIZ-based principles are Principe 11, 7, 29 and 36.

Strategy 5 for book pricing is found out with Principle 11 (Beforehand Cushioning), the strategy content, as shown in A1 below. Based on principle 7 (Nesting) and Table 2, e-book price strategy 3 is spotted, i.e. reader positioning, the strategy content, as shown in B1 below. Based on principle 29 (Flows and Flexibility) and Table 2, paper price strategy 1 is spotted, i.e. demand elasticity, the strategy content, as shown in C1 below.

Based on Principle 11, 7, and 29, this study can find out the strategies that correspond to Conflict Point One (Exchange rate fluctuation).

A1 The exchange rate fluctuation is taken into account to avoid exchange rate loss.

B1 The book positioning should be considered according to the topics of the books. In this way, consumers will not change their purchase along with the change of the pricing caused by the fluctuation of the exchange rate.

C1 When the domestic currency depreciates, the cost of imported books rises. In this instance, the prices of the books should be adjusted. For those with a low price elasticity of demand, professional books, for example, their prices can be significantly adjusted in this instance. For those with a high price elasticity of demand, their prices can be adjusted slightly or there are no changes in the prices in that case.

4.3.2 Conflict Point Two: Price increase

Parameter 9 and 31 and their corresponding principles are Principle 10, 19, 37 and 33.

Based on Principle 10 (Prior Action) and Table 2, e-book price strategy 2 is spotted, i.e. brand value, the strategy content, as shown in A2 below. Based on Principle 19 (Periodic Action) and Table 2, e-book price strategy 4 is spotted, i.e. life cycle the strategy content, as shown in B2 below. Based on Principle 33 (Homogeneity) and Table 2, paper book strategy 2 is spotted, i.e. resale price maintenance system, the strategy content, as shown in C2 below.

Based on Principle 10, 19 and 33, the strategies that correspond to Conflict Point Two can be spotted, respectively.

A2 If the publishing industry is raising book prices, it is advised to consolidate its brand value first. In this way, it can be avoided that the market share declines when product prices are raised.

B2 The bookseller can raise or decrease book prices to avoid the situation that the market share slips with an increased price.

C2 It is suggested to adopt a fixed resale price to avoid horizontal competition. In this way, a considerable profit space is reserved for downstream bookstores and a friendly and cooperative win-win relationship can be achieved.

4.3.3 Conflict Point 3: Speed of version updates

Parameter 5 and 31 and the corresponding principles are 5, 15, 34, and 24.

Based on Principle 5 (Merging) and Table 2, book price strategy 4 is spotted, i.e. psychological pricing, the strategy content, as shown in A3 below. Based on Principle 15 (Dynamization) and Table 2, e-book price strategy 1 is spotted, i.e. Long tail theory, the strategy content, as shown in B3 below.

With Principle 5 and 15, this study can find out the following strategies for the conflict of the speed of version updates.

A3 Different speeds of updates are adopted for different categories of books.

B3 Long Tail Theory can be used to avoid selling dilemmas caused by low version updates. Through bundling and a custom pricing strategy, the profit will continue to be made in the late phase of sales.

4.3.4 Conflict Point Four: Penetration price

Parameter 31 and 24 and their corresponding principles are Principle 35, 10, 37 and 24.

Based on Principle 10 (Prior Action) and Table 2, e-book price strategy 2 is spotted, i.e. brand value the strategy content, as shown in A4 below. Based on Principle 37 (Relative Change) and Table 2, e-book strategy 1 is spotted, i.e. Long tail theory the strategy content, as shown in B4 below.

With Principle 10 and 37, the researchers find out the strategies that correspond to Penetration Price.

A4 The sold books are of brand value. As long as the quality of the books is ensured, readers will be willing to purchase serial books and the like.

B4 The clearance books can be sold with a penetration price.

4.3.5 Conflict Point Five: Preferential activity

Parameter 21 and 26, and the corresponding principles include 18, 38, 12 and 14.

Based on Principle 18(Resonance) and Table 2, the fifth paper pricing strategy is spotted, i.e. competitor pricing, the strategy content, as shown in A5 below.

A5 New books are priced at the same level as the competitor when they are newly issued products. In this way, a price war can be avoided. Instead, other non-price competitions will be adopted to attract consumers.

4.3.6 Conflict Point Six: Deferential pricing

Parameter 9 and 30 and their corresponding principles are Principle 12, 27, 34 and 24.

Based on Principle 12 (Remove Tension) and Table 2, paper book price strategy 5 is spotted, i.e. competitor pricing, the strategy content, as shown in A6 below.

A6 The same pricing strategy is formulated with others in the industry when new books are issued. In this way, consumers will be less likely to feel unfair.

Base on e-books and paper books, we categorize the book price innovation strategies, as shown in the following Table 6:

Table 6 Book price innovation strategies

Contradiction	Paper book price strategy	E-book price strategy
1.Exchange rate fluctuation	A1, demand elasticity (C1)	A1, reader positioning (B1)
2.Price increase	resale price maintenance system (C2)	brand value (A2), life cycle the strategy content (B2)
3. Speed of version updates	psychological pricing (A3)	Long tail theory (B3)
4.Penetration price		brand value the strategy content (A4), Long tail theory (B4)
5.Preferential activity	Competitor pricing (A5)	
6.Deferential pricing	Competitor pricing (A6)	

5. Conclusion and Future research directions

Through literature review, this study first finds out the five pricing models for e-books, namely long tail theory, brand value, reader positioning, production life cycle and free pricing, and the five pricing models for paper books, i.e. demand elasticity, resale price maintenance system, production cost, psychological pricing and competitor pricing. Secondly, the ten book pricing strategies are mapped to the 40 TRIZ-based invention principles for business management. In this way, each book pricing model consists of one to several inventive principles. For example, the long tail pricing theory for e-books consists of Principle 14 Non-linearity, Principle 15 Dynamization, Principle 20 Action Continuity, Principle 28 Replacement, and Principle 37 Relative change. Thirdly, the TRIZ approach to business management is used to draw up a book pricing strategy. Six pricing conflict points are spotted based on the book Pricing Bible by Dolan and Simon (1996), namely exchange rate fluctuations, market share, the speed of version updates, penetration prices, preferential activities, and differential pricing. With these six pricing conflict points, appropriate and innovative pricing strategies are found out. The strategies can be used as the basis of book pricing for the publishing industry to maximize the niche in the competitive market. This article combines economics and innovation to explore the issue of book pricing. Pricing has always been the core issue of economics. This paper finds out the contradictions from the general problems of pricing, and then narrows it to the problems of book pricing. From table 6 there are some contractions that do not find the appropriate innovative pricing strategies, so the next study can be based on this article, in-depth use of more business management TRIZ tools to find out these solutions. Moreover, the same research methods can also be used to discuss the pricing of different commodities. It is expected that this paper should open up more research on the economics and business management, on the one hand, expand the development of economics in innovation theory, on the other hand, expand the application of business management TRIZ to the field of economics.

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Development of Online Collaboration Tools (OCT) for Collaborative Innovation Design

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Abstract

With the development of information technology and systematic innovation theory, the innovative design of products and service is no longer confined to individuals or one team. There are more and more cross-regional and multi-disciplinary collaborative design integrate the time, human and other resources to promote more innovation activities. However, there is still a lack of systematic and effective tools to cover the whole process of collaborative design activities. To address this gap, we provide a case example to solve this problem of using online collaboration tools (OCT) in collaborative design context, and further illustrate some implications through the systematic innovation perspective. In the present paper, we discuss how the adoption of online collaboration tools has influenced the collaborative design activities based on the IDEEA drone design workshop. Discuss the impact of online collaboration tools on the participants' learning and collaboration effect in the distributed systems. Online collaboration tools can be used to access knowledge that originates from external as well as internal sources, but it seems that online tools increase the visibility and accessibility of internal expertise and therefore the use of internal knowledge. The main contributions of this paper include:1) Our research revealed that the online collaboration tools can promote innovative design of multi-disciplinary and innovation design. The design tasks of the workshop are completed by each team with almost no traditional offline collaboration. 2) The implementation of collaborative design is divided into five types according to the design thinking process: empathize, define, ideate, prototype and test. Analyzing the attributes of different collaboration tools in the process of innovative design. 3) Discuss from the project what kind of technical methods and tools are suitable for the specific collaborative design system. Provide guidance for future collaborative design activities.

Keywords: Collaborative Design; Systematic Innovation; Computer-aided problem solving; Online Collaborative Tools.

1. Introduction

With the rapid development of cloud storage and mobile Internet, the way people work and learn is undergoing tremendous changes. It has become an accessible reality to use personal computers, smartphones, tablets and other devices to carry out online collaborative work or learning in teams anytime and anywhere. Online collaboration tools developed in recent years have challenged traditional office tools. The new appliances are widely used and make modern office working pattern move into new age. It makes up for the shortcomings of traditional online communication tools and document editing software in collaborative work, mobile storage and other aspects. More and more people have realized its increasing importance from the need of social development.

Collaboration refers to the coordination of resources, technology and information between departments and individuals in the process of achieving a certain goal. People need a certain place (office or classroom) where they can gather to realize face-to-face communication among members before the Internet and smartphones. If they want to cooperate in different places, they need to use telephone, letter, fax and other inefficient communication tools. Whether face-to-face or in different places, traditional methods are difficult to achieve synchronization and real-time collaboration. The inefficient way of information transmission cost a lot of time and energy while the team can't achieve the desired goals many times. With the advent of the information age, people began to use some social software such as Email, BBS, Blog, IM, Wiki for collaborative work and learning. These online tools shorten the distance between people. But this kind of social software is not developed for people to work and learn together. Like there are some online collaboration functions are integrated Facebook and WeChat, but they are mainly focus on social contact. The entertainment functions which unrelated to collaboration work will distract the attention of team members, and reducing the collaboration effect.

Through online collaboration tools, people can improve the way of information exchange, reduce the space barriers, save time and energy, and improving the quality of group works. It will gradually become an important tool of innovative work and solve many problems in the process of people's office work or learning, such as process log, task assignment, delegation, administration, online communication and so on. Online collaboration tools play an increasingly important role in business and collaboration work recently. And there are a variety of online collaboration tools for team collaboration showed up while they have many limitations for different reasons. Unlike the business activities, the innovative design involves more divergent thinking and design thinking. This paper will argue that whether the collaborative tools can really assist the process of innovative design and help people from different disciplines to communicate effectively in collaborative design? We explore the development and characteristics of online collaboration tools around the innovative design. Discussing the impact of online collaboration tools (OCT) on distributed participants' course learning and project collaboration. The research could provide support for future design learning and practice from the analysis of case study and discuss what kind of tools to implement specific collaborative design system.

2. Related work

2.1 Innovative Design Methods

The innovative design methods mainly focus on the innovative and application method and the to the engineering project while now there is no systematic innovative design theory and method. Some interdisciplinary methods, such as TRIZ and design thinking, are used to guide innovative design. Under the guidance of innovative design, different professionals work together to complete the design of industrial products or services. Innovative design methods lead people to develop their professional knowledge and constructing the framework of innovative design for carrying out innovative practice.

In the theory of innovation, TRIZ is a series of solving principles of patent problems for invention put forward by Altschuller, a former Soviet scientist. TRIZ is the acronym for the Russian phrase, "Teoriya, Resheniya, Izobreatatelskikh, Zadatch", roughly translated into English as "Theory of Inventive Problem Solving" (Sheu and Hou, 2015). Its core lies in organizing and managing patent knowledge through technical contradictions to facilitate its reuse in the process of product innovation and design. TRIZ solves how to give reference answers according to the problems and provide ideas and cases to solve technology conflicts. Since the early 1990s, TRIZ theory has attracted extensive attention of researchers in developed countries. Ang improved the standard engineering parameters and inventive principles of TRIZ, updated the contradiction matrix, and supported designers better to solve conflict problems (Ang et al, 2013). Zhang improved the ARIZ algorithm of TRIZ theory and proposed the RLI model based on Germany's WOIS theory, PI theory and MIS theory (Zhang, 2013). Song-Kyoo replaces TRIZ's material-field model with queuing theory model in order to improve the efficiency of problem analysis (Kim, 2011). Chang focus on solving the problem of Ecological Innovation in product design by material-field analysis (Chang, 2005). Yan provided a simple way to master and use the standard solutions (Yan et al, 2012).

Another theory of innovative design is Design Thinking. The concept of 'Design Thinking' was first introduced by Rowe in 1987, but has been over- simplified in many industry realms, leaving behind a trail of design thinking experts and a frustrated design research community (Dorst, 2011). More attention is paid nowadays to Design thinking by Tim Brown and the Stanford Design School. They let a large companies and businesses adopt design thinking to solve their complex problems in innovative ways (Brown, 2008). As a result of the link between design thinking and business innovation, many countries are investing in education that integrates design thinking processes, skills and mindsets across curricula, uniting the academic and vocational (Koh & Chai, 2015). Consequently, design thinking is increasingly regarded as an avenue to develop 21st century student capabilities, equipping them with the tools to effectively address the ever-evolving challenges facing global society in the future (Wright &Wrigley, 2017). An individual's design thinking capability is best acquired through practice, application and experience (Howard, 2012). Expanded from Dreyfus's (2004) general model of expertise, Dorst represents different ways of design thinking through seven levels of design expertise or practice, with each level having its own method, critical skill set and mode of reflection (Dorst, 2011). Facilitation of design thinking has gained traction in recent years particularly through industry workshops, with many facilitators being from a non-design trained background. As such, the value of design thinking in practice and academia can be diluted by those who have minimal design understanding and expertise. As suggested by Yilmaz and Daly (2016), the success of instruction relies partly upon the facilitator's ability to provide guidance and feedback on design paths and processes, in order to facilitate a practice where students can learn strategies to fully explore and define problems. It is a systematized process to create new user experiences and opportunities by utilizing the tools and a thinking process that designers use. It's a significant way of problem-solving, rather than just coloring a product.

2.2 Cooperative Design Tools and Methods

Online collaboration tools can assist learning and practical projects both. In recent years, there are many studies on the learning performance for online tools, while the research about practical projects application are also beginning to increase. Collaboration and product innovation using network platform have become a hotspot. More and more designers, researchers and individuals join in product innovation (Frank, 2009). "Wikinomics" discusses that the large-scale collaboration design can change the world. The book argues that the traditional concept of innovation usually refers to innovation in a closed environment and trying to commercialize it. Today's online collaboration allows small companies or groups to acquire the resources and knowledge they need as large companies without paying a lot.

To discuss appropriate online tools for design collaboration, we need to understand the characteristics of design problems and design activities. The synchronous collaboration is necessary for innovation design like a face-to-face collaboration. Collaborators can directly see each other and obtain rapid feedback. Moreover, there is access to a shared physical environment, which means that other types of visible information are available, such as shared information about physical objects and events (Whittaker, 2002). Olson also addressed one of key characteristics of face-to-face collaboration, called "spatiality of reference." "Spatiality of reference" indicates that "people and work objects are located in space" (Olson, 2000), and as a result, collaborators can communicate with each other by referencing objects in the shared environment. Given the importance of communication based on visual representations (e.g., visual images and hand-drawn sketches) for design problem-solving, a shared physical environment in face-to-face collaboration plays a critical role, especially for visual communication among designers. Because of the merits of face-to-face collaboration, designers in practice come together and conduct problem-solving activities in a project room (Brown, 2009).

Recently, the field of computer science has acknowledged the idea that findings from the domains of psychology and sociology matter to the design of group systems. The design of group systems that support Computer Supported Collaborative Learning and Working integrates knowledge of how people work and learn in groups with knowledge of enabling technologies (Schümmer & Lukosch, 2007). This had led to several requirements for task-related functionality, such as facilities for communication, file-sharing, calendaring and scheduling. However, there are other, often less-obvious requirements (Vick, 1998). These relate to the support of psychological and social processes, which impact group cohesion and team performance, such as group dynamics and people's perceptions of each other. These processes have traditionally been studied in social sciences. As they are essential corner stones for team performance and interaction, they are thus also relevant for team performance in mediated environments. Indeed, according to Ackerman (2000), the main problem in group systems nowadays is the discrepancy between the social needs and expectations of the user and the computer system functionality.

3. Conceptual Framework

The research chooses the Design Thinking for the online workshop's learning materials and design method.

3.1 Design thinking

3.1.1 Definition of Design thinking

Tim Brown, the CEO of IDEO, said, "Design thinking is a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success." (Brown, 2008).

Design thinking is a design concept which focuses on a product that can truly integrate into user's life and be relied on by understanding their internal mental model, the environment, and observing the user behavior. Design Thinking is a solution-based design method to solve problems. This method is extremely useful for solving undefined or unknown problems. It mainly involves the following means: understanding the human needs, re-deconstructing the problem in the human-centered approach, creating more ideas in brainstorming, and applying practical methods in prototyping and testing. Design thinking has developed into an innovation design model which for learning and practice. It focuses on the creativity of the professionals from different majors, from different perspectives rather than the creativity of designers, and generates an innovative idea, product or service. Design thinking refers to the use of designers' sensitivity and design methods to meet people's needs on the premise of technical realizability and commercial feasibility (Sheu and Chiu, 2016). Which explores the Designers' three starting points of thinking: Desirability, Feasibility and Viability. This is the same standards with the "three core" concept of design education in Dutch Delft University, which is "people", "commerce" and "science and technology".

3.1.2 Design thinking process

TRIZ method is an important method of innovative design, but the design thinking method is used in this paper and case. Therefore, the specific process of TRIZ is not described. There are five phase or stages for design thinking process. Understanding the five stages of design thinking will enable anyone to use design thinking methods and solve complex problems around us - in our companies, in our countries and even on our planet (Dreyfus, 2004).

Herbert Simon, the Nobel Prize winner, outlined the first formal models of the process of design thinking in his pioneering 1969 article on design methodology. Simon's model consists of seven main stages, each of them contains smaller stages and activities (Howard, 2012). It has a great influence on shaping some of the most widely used design thinking process models. And there are many variations in the design thinking process used today. Although they may vary in number from three to seven stages, they are all based on the same principles in Simon's 1969 model.

According to D. school's research, the five stages of design thinking are as follows: empathize, define, ideate, prototype; and test. In the thinking model, constant divergence and convergence in the process are adopted until the end for practical use (Sheu and Hou, 2015). The five design thinking stages for our innovative design are shown in Figure 1.

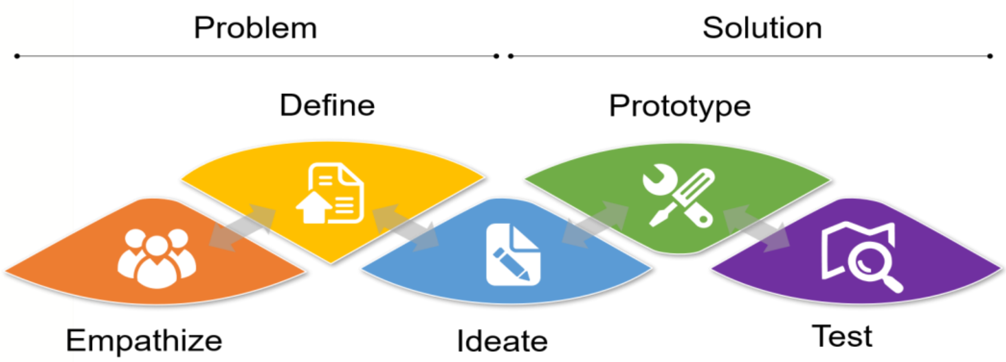


Fig. 1 The five stages of Design Thinking method

(1) Empathize

The first stage of the design thinking process is to gain a sympathetic understanding of the problem you are trying to solve.

This stage involves consulting experts, observing, participating, understanding users' experiences and motivations, and immersing oneself in a physical environment to gain a deeper understanding of the issues. Empathize is very important for human-centered design process such as design thinking. Empathize allows a designer to put aside his or her own assumptions about the world in order to gain a deeper understanding of users and their needs (Wright and Wrigley, 2017).

A large amount of information is collected at this stage so that it can be used in the next stages. Researchers can form the best understanding of users' needs and the problems behind the specific product development.

(2) Define

In this stage, designers can aggregate the information created and collected during the empathize stage. Then the team identify the core issues according to the observations and synthesize the information. The members should try to define problems in a "human-centered " way. Specifically, don't define the problem as their own desire or the needs of the team (Brown, 2009).

Defining the problem will help designers team gather great ideas to identify features, functions, and any other elements that can help users solve problems. Let users solve problems themselves with minimal difficulty at least. In this stage, by proposing problems that can help you find solutions, you will begin to gradually move into the third stage, the ideate stage.

(3) Ideate

In the third stage of the design thinking process, designers are ready to start generating ideas. The members have understood their users and needs in the first stage, and members have analyzed and synthesized their observations in the define stage, presenting the problem with a human-centered approach. With this background, the team members can start thinking outside the box, find new solutions to the problem, and they can start looking for alternative ways to solve the problems (Sheu, Hong and Ho, 2017).

Brainstorming is often used to stimulate divergent thinking and expand problem space. It is important to get as many ideas or problem solutions as possible at the beginning of the Ideate stage. At the end of this stage, members should choose other critical methods to help them investigate and test the ideas to find the best way to solve the problem.

(4) Prototype

The design team will now create a Low Fidelity Model which have a part of functions in products so that they can test the solutions to problems identified in the previous stage. Prototypes can be shared and tested among a small group of people outside the team. This is an experimental phase to find the best solution for each problem found in the first three phases (Brown, 2009).

These solutions are hided in the prototype and tested one by one: they may be accepted, optimized and re-tested, and rejected if the experience is not good. By the end of this stage, the team will have a better understanding of the limitations and problems in the product, as well as the behavior, ideas and feelings of real users when interacting with the product.

(5) Test

Designers or evaluators use the final solutions identified at the prototype stage to test the entire product. This is the last stage of the five-stage model while but in the iteration process, the results of the test stage are often used to redefine one or more problems and inform users of their cognition, usage conditions, way of thinking, behavior and feelings. Even at this stage, changes and improvements are ongoing to get the best solution and to get as much insight into the product and its users as possible (Brown, 2009).

3.1.3 The key points of "design thinking"

(1) Visualization and prototype: Designers use mind mapping, design sketch or prototype to visualize their abstract thinking to seek new ideas. Visualization and prototype enable designers to convey ideas faster than words.

(2) Iteration: Repeated the update-test-feedback-update process in the design process. Try to make the prototype better and better.

(3) Interdisciplinary: Design thinking emphasizes cooperation by people from different majors. In IDEO, a design team usually consists of three or five people, who come from various fields such as economics, business, psychology, engineering, design and even medicine. They choose different relevant professionals according to the project need. People from different majors observe and discuss from different perspectives could form a more comprehensive view and creativity.

(4) Divergence and convergence: The contradiction concepts, divergence and convergence, exist at every stage of the design process. First, designers converge the divergent thinking to continue the design process. Second, the divergence of creativity needs the constraints of technology and commerce. Only when these two contradictions are reconciled can the innovation design succeed.

More attention should be paid to users themselves and their environment rather than their behavior. Designers devote too much energy to thinking about how to make the product useful or beautiful and interesting. More and more companies begin to pay attention to the appearance, interface and operation experience of products. It is vital to consider "who will use it", "why they use it", "when and where to use".

(5) The Nonlinearity of Design Thought: The team may have a direct and linear design thinking process, which runs in a logical way. However, the process is more flexible and non-linear.

3.1.4 Summary

Essentially, the process of design thinking is iterative and flexible, focusing on collaboration between designers and users, focusing on turning ideas into reality according to the thinking, feelings and behaviors of users. Design thinking solves complex problems through the following methods:

(1) Empathize: understand the needs of the users involved;

(2) Define: reorganize and redefine issues in a human-centered approach;

(3) Ideate: create many ideas in the creative stage;

(4) Prototype: develop prototype/solution of problems;

(5) Test: constantly test the prototypes.

One of the main advantages of the five-stage model is that the knowledge acquired later can be fed back to the early stage. Information is constantly used to inform understanding of problems and solutions. This creates a permanent cycle in which designers always gain new insights, create new ways of looking and possible uses, develop a better understanding of users and the problems they face.

3.2 Online collaboration tools

The most common conception of design problems is to consider them as “ill-structured” problems (Détienne,2006). Initially, there is no definite criterion to test a proposed solution, much less a specific process to apply the criterion to (Herbert, 1973). To solve this type of problem, designers collaboratively conduct their process with rapid explorations of the problem and solutions in tandem, rather than following linear stages (Andrew, 2010). Accordingly, design activities for the problem and solution (e.g., information gathering, analyzing, idea generating, and evaluating) are also performed in parallel and iteratively. Due to the interrelations of activities, design problems are difficult to decompose into independent sub-problems (Olson, 2000). For this reason, designers work closely together during the whole process rather than working independently and combining the outcomes. According to the standard of synchronous collaboration, we divided the online collaboration tools into the function based on interacting with others and shared resources (graphics, documents and 3D models) in the group. Its application scenarios are divided into four aspects: communication session, resource sharing, process participation and model making according to the five steps of design thinking. We analyzed the common online collaboration tools to explore how online collaboration tools can be applied to innovative design. The figure 2 shows the match between online collaboration tools and design thinking process.

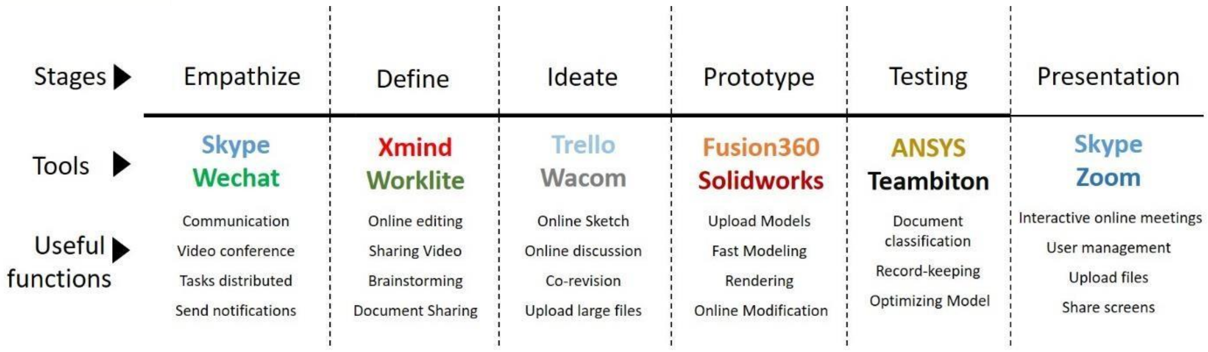


Fig. 2 The useful functions of online collaboration tools to Design Thinking process

Three major software company, Microsoft, Google and Apple, have launched their own online collaborative work platforms. The Office, Google Docs and iCloud all use cloud technology, which can create, edit, store, synchronize and share files online anytime, anywhere on different devices. People can cooperate with others to edit documents. These three platforms are undoubtedly the most powerful in terms of function. But for various reasons, they also have great limitations. For example, the high cost of Office 365 makes it difficult for ordinary users to bear. The Google Docs is limited by policy, and it is difficult to use it in some place. And iCloud is also difficult to promote in a wide range due to Apple's relatively closed hardware and software environment. In addition, many Internet companies have developed their own online collaboration tools. In recent years, several excellent collaboration tools have emerged, such as Dow Cloud, JingOal, Shimo, Teambition, Worktile, Zoom, Trello, ZOHO, Quip, Show-Document and so on. These collaboration tools are more lightweight and focused on one kind of work. The online tools should be easily upload, download and edit the common document, know when and where members doing for their task. We test the online collaboration tools for our workshop to see the functions of these software. Many online collaboration tools have the potential to be applied to innovative design. We need test them by the workshop to figure out their specific functions and application scenarios.

4. A Case Example

4.1 Case Background

This instructional program is designed to support the IDEEA global project for 2019 in collaborative design and engineering. The program instructional methodology will be to deliver at least one sequential instructional video each week during the program 10-week period. Each video will be delivered via both a dedicated IDEEA website and a YouTube Channel that can be viewed at any place in the world at any time as many times as desired if Internet access is available. The videos directly on the website and the same unlisted videos with YouTube URL links will be provided so that only the IDEEA participants can view them. It is intended that each participating IDEEA student team and mentors will view each video in sequence and apply the content to their project design and development as needed. The website and videos are designed to assist all the participating IDEEA project teams in Design Thinking and product design and development process, principles, skills and tools. The whole process will be online teaching and design without face-to-face communication.

4.2 Participants

There is a collaborative global teamwork on this project with student teams, guided by a team faculty mentor, that will develop, build and simulate a final drone concept. Individual team members will also develop and document their own project work appropriately. Each team will divide the project work up among the team members for developing the final integrated design concept.

The students were divided into 20 groups and there were 6 to 8 members in each project team, 2 from the same school of 4 global universities. Each team member will have specific tasks for the project development as well as general overall design input responsibility. Each student will be expected to do design research and document it, do brainstorming and idea-sketching and document it, do mockup making and CAD modeling and document it, and do user testing and validation and document it. The Design Thinking process works very well, but only if one applies it diligently and thoroughly. For the mentors to know if the process and work is actually done, students must document all their work diligently. The whole collaboration design process is online except the two students from same school can work together.

4.3 Procedure and Tasks

Student project teams and mentors will be introduced to the art, process and practice of physical cyber product design and to the product design process via Design Thinking. Student teams, with guidance and support from their mentors, will each research, develop and mockup a new physical smart cyber product design concept that resolves a human-centered need as a program project within fixed category parameters based on a design brief. All students will learn and execute required Design Thinking empathic research, project definition, brainstorming ideation with sketching, making with mockups and CAD modeling, and testing with design simulations. Students will work as project teams on their project with outside collaborative support teams as needed. Basic instruction via videos will be provided for required program processes, methodologies and skills. A final project and mockup presentation will be required for each student project during a final program event in the summer of 2019. Modern physical smart cyber product design is multidisciplinary and collaborative, integrating designers, engineers, various professionals, customers, users, and stakeholders, all from various disciplines, as well as the integration of smart cyber technologies into physical systems. This program will reflect that approach and will enhance students' collaborative teamwork experience, communication skills, and exposure to the various disciplines. This is a hands-on program that mixes video tutorials, experiential learning, field project research and execution work, and collaborative teamwork. Student teams will conduct a mentor-guided project that will include human need-finding, design research, project definition, concept ideation, mockups/simulations/modeling, testing and validation, and refinement of a final tangible physical smart cyber product system concept in mockup form. There will be a final presentation and display of student project team concepts, mockups, models, and process summary.

This project will follow the standard Design Thinking process of five modes or phases in stepped linear sequence, though several modes may be either utilized at one time or revisited more than once for proper project execution. Instruction for each project process mode/phase, as well as the associated skills and materials, will be provided to the teams online.

(1) Research: Intuitional/Contextual/Discovery empathic research-includes notes, images, media, video, sketches, interviews, etc., of real drones and drone situations, existing drones, components, users and customers, related issues, and data, all researched and developed by the student team.

(2) Define: Team project design a one-page project design brief written by the project team that summarizes their research and found needs, and defines their direction for their project development and target solution.

(3) Ideate: Concept ideation and Innovation-includes team brainstorming of ideas and basic 2D idea-sketches of concepts, ideas, processes, charts, diagrams, graphs, etc., based on research findings of issues and needs in the Project Design Brief.

(4) Prototype: Concept simulation via mockups and CAD models-multiple ideas and concepts in physical and digital 3D for possible solutions to overall design, modules, subassemblies, problems and needs.

(5) Test: Concept testing and validation-testing and validation of concepts and ideas using low-fidelity and high-fidelity mockups and CAD models with users and relevant stakeholders and situations to get responses, feedback and critique for the selection of best concepts for a final version.

(6) Presentation: Final refinement and presentation-combination/synthesis/integration of best ideas and concepts based on testing research and finalization of design solution in 2D media and 3D concept form in mockup and CAD model. Preparation of final team design solutions and presentation of research, ideas, sketching, mockups, models, process and design/solution results during a summer 2019 all-team IDEEA event TBA. Table 1 is a general summary of the above tasks. Participants at each stage need to collaborate to complete the following tasks online all the time.

Table 1 The tasks of innovation design at each stage

Tasks of stage	Context Research	Empathize	Definition	Ideation	Prototype	Testing
Task 1	General attributes &considerations	Interviews development	Overall document design	Application idea-sketches	Low-fidelity mockups for early testing	Testing setup & co-ordination
Task 2	Existing design & features	Personas development	Heading& summary statement	Component idea-sketches	CAD model of components	Early low-Fidelity mockup testing
Task 3	Technologies available	Surveys development	Key points/bullets	Controls idea-sketches	CAD model of overall design	Final mockup/model testing
Task 4	Applications possible	Observational research development	Editing, grammar, terminology	Module idea-sketches	CAD model of structure	Data presentation & analysis

4.4 Analysis

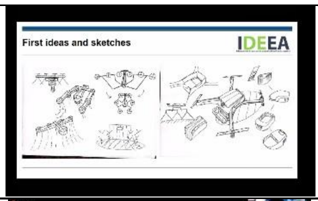
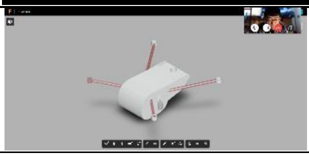
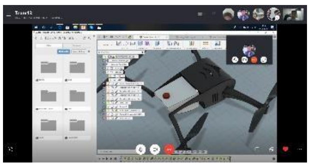
After the IDEEA's innovation design, we choose the Team 13 for a survey which include a questionnaire about the usability evaluation for the online collaboration tools they use and an in-depth interview. They basically use the online collaboration tools throughout the whole design process. The background information about the team members shows them is composed of typical multidisciplinary members with different majors and nationalities, as shown in Table 2.

Table 2 Background information of Team 13 members

Numbers	Region	Major	Online tools level	Design level
Member 1	Germany	Engineering	Skilled	Skilled
Member 2	Germany	Engineering	Ordinary	Skilled
Member 3	Brazil	Art	Skilled	Skilled
Member 4	Brazil	Engineering	Skilled	Ordinary
Member 5	China	Engineering	Ordinary	Ordinary
Member 6	China	Engineering	Ordinary	Ordinary
Member 7	China	Art	Skilled	Skilled
Member 8	China	Business	Skilled	Ordinary

After the IDEEA’s innovation design, we choose the Team 13 for a survey which include a questionnaire about the usability evaluation for the online collaboration tools they use and an in-depth interview. The design process of group 13 is relatively successful while the team were composed of students from different cultural backgrounds. Unlike some groups have high percent students with the same cultural background. They basically use the online collaboration tools throughout the whole design process. The background information about the team members shows them is composed of typical multidisciplinary members with different majors and nationalities, as shown in Table 3.

Table 3 Outline of the IDEEA workshop, April 2019

Schedule	Activities		Online tools	Functions used
Week 01 Breaking the ice	Introduction and Overview, Select topic		Skype, WeChat	Real-time editing, Sharing files, Real-time communication,
Week 02 Empathize	Contextual and Discovery Research		Trello, Teambition	Sharing files assigning tasks, Saving dialogues, Progress tracking
Week 03-04 Definition	Identify needs, Definition report		Skype, Shimo	Divergent & Convergent thinking, Document classification
Week 05-06 Ideation	Brainstorming, Sketching, Ideation report		PowerPoint, ProcessOn	Sketch, Visualization Uploading files
Week 07-08 Prototype	Mockup making, CAD modeling, Refinements		Fusion 360	Rapid prototypes, Easy learning, Cloud storage,
Week 09 Testing	Execute testing, Validation		Fusion 360, Skype	Communication, Field research, Personalization
Week 10 Presentation	Deliver presentations		Zoom, Skype	Setting permissions, Speech, Video Conferencing

This paper mainly focuses on the efficiency of online collaboration and the advantages and disadvantages of collaboration tools, providing methods and tool references for future online collaboration. This kind of collaboration among students from different regions and backgrounds is a potential innovative design form in the future. So, we choose five usability items from the research. There are five usability evaluation items for the team members' questionnaire for the online collaboration tools they use. The checklist was based on Jakob Nielsen's traditional usability heuristics and to suggest usability areas that need more investigation (Norman and Nielsen, 2010). Participants evaluated five usability indicators of each software, and 1-5 points represented the degree of poor to excellent. Figure 3 shows the average values of 8 participants' usability evaluation for 6 online collaboration tools.

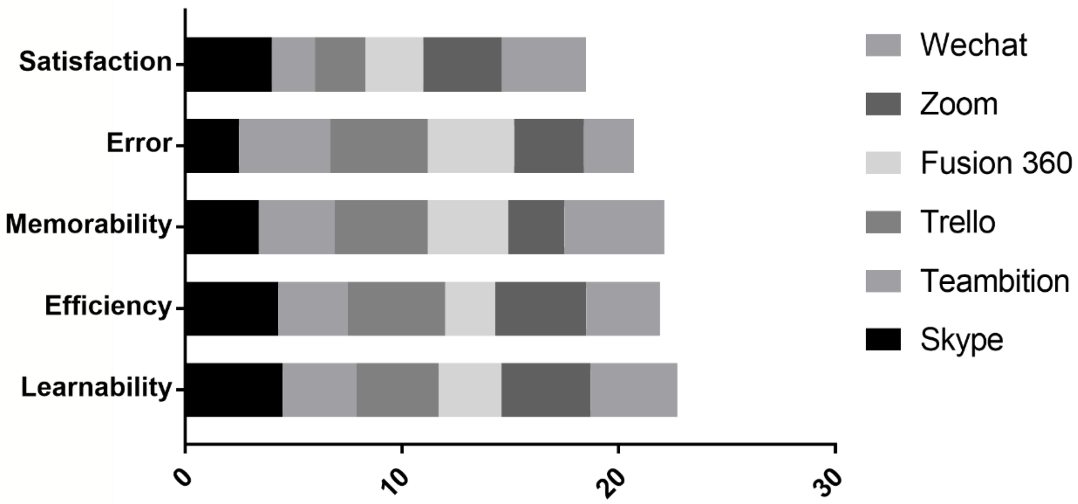


Fig. 3 The Mean of Usability Evaluation for the online collaboration tools

From the data analysis in Table 4, Skype and WeChat have a better overall usability performance. Trello is also quite concise, but it focuses on text work makes someone unsuitable for innovative design. For example, some people mentioned that uploading files is too limited and they cannot have real-time conversations. In addition, Zoom is a software that only suitable for giving speeches or meeting without saving records. Surprisingly, professional teamwork software such as Teambition has been abandoned after trying it out. Maybe its functions are too complex and redundant.

Table 4 Usability Evaluation for the online collaboration tools

	Skype	Teambition	Trello	Fusion 360	Zoom	WeChat
Learnability	4.5	3.4	3.8	2.9	4.1	4
Efficiency	4.3	3.2	4.5	2.3	4.2	3.4
Memorability	3.4	3.5	4.3	3.7	2.6	4.6
Error	2.5	4.2	4.5	4	3.2	2.3
Satisfaction	4	2	2.3	2.7	3.6	3.9

5. Conclusion

Our research revealed that the online collaboration tools may promote innovative design of multi-disciplinary members, though it is not evident that online collaborative tools promote innovation, probably it promotes process efficiency – in terms of cost and time reduction. The implication of the study is that the design tasks of the workshop are completed by each team with almost no traditional offline collaboration with good performance. It is feasible for people in different areas to collaborate and complete design activity online. On the one hand, this case experience can be extended to other kind of collaborative work. Online collaboration tools allow more resources to be integrated, and promote the development of collaborative design for other work like Medicine or Industry work. On the other hand, through the usability evaluation and interview for the members, we can improve the functions of online collaboration tools to make it more suitable for collaboration design rather than just for commercial collaboration. In order to increase the online collaboration tools contribution to innovation design, some suggestions are proposed based on the analyzed results of interview and evaluation.

For the online collaboration tools, we could do the modular design and adjustment according to the requirements of design, commerce or medicine projects. Full-featured online tools can cause too much interference to users. The normal online collaboration tools are inappropriate for other kind of tasks, such as Trello which is inappropriate for design activities. At the same time, online collaboration tools need more personalized settings. People play their own roles in the team. They may need their own setting to expand certain functions. If several tools can't complete the project, users will have to use more online tools at the same time. Too many tools would reduce the efficiency of teamwork badly.

For the online collaborative tools for innovative design, design activities need divergent thinking and multi-dimensional interaction. Designers need to share resources such as text, pictures, voice and video. Online tools should be able to upload and save these resources. Secondly, the design thinking process often needs to tract back to the previous process. It is very important to keep and classify the records. Designers need the multi-equipment communication to support people to communicate anytime, anywhere. And people may use different languages and need images instead of words for information design so that everyone can understand them. In addition, in collaborative design or collaborative learning, it is necessary to add a managerial role in job interviews. There were some members avoid responsibilities and work because of no statistics of their workload in the online collaboration tools. Joining managers or showing the amount of work each person has accomplished can urge everyone to contribute the team and promote the efficiency. In the future study, we should consider these problem and try to make the research more convinced.

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Research of Smartphone Industry Outsourcing Decision Model

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Abstract

Along with the change in the industrial environment and the rivalry among international marketing, many enterprises have been research to modify business model in order to compete with others. Outsourcing is one decision model for enterprises to focus on the main original technology into the competitive market. This research is going to study the smartphone as:

1. To confer the decision model while planning and executing outsourcing in smartphone industry.
2. To analyze the reference factors and limited extent of production.
3. To find out the main key in succeed outsourcing tactic. Also, this research becomes aware of the partner relationship between well executing outsourcing tactic and original equipment manufacturing factories.
4. To specialize an ability of core technology will not only effect enterprises management into positive way but also increase and keep the superiority in the competitive market.

Key words：outsourcing strategy, the ability of core technology, smart phone industry

1. The Purpose

As a result of keen competition in smartphone industry and production replaced frequently, brand enterprises have to put most resource into research and development new commodity and its marketing. However, this decision brings about low income and profits without non- core technology support if brand enterprises inspect the cost breakdown structure. Therefore, the brand enterprises must seek the probability in cost transfer positively in order to decrease the production cost, especially transfer non- core technology producing parts.

The producing characteristics in smartphone industry:

1. High elimination rate in technique and difficult in the producing process to assemble and install.

2. Keen competition, fast reaction in market and high engineering service level.

3. Unpredictable raw materials value and high purchasing cost.

This research focus on the trend in fast growth smartphone industry and keen competition in consumption market that integrate the smartphone producing characteristic by related technique of decision to investigate the process of formation and adopted policy of outsourcing in smartphone industry.

According to the market research report by IDC in 2014, the global outsourcing service market increases above 5.9% every year and be forecasted to reach 813 hundred million in 2018. Even so outsourcing is a method of operation to reduce the cost for enterprises; it is a strong business strategy to increase the production capability and production quality in order to rise above competitive market and forces on main business. Outsourcing is not only an important strategy in an organization development tactic and a common strategic for all （Lamminmaki；2011）but also provide main competitiveness in income, sale, and producing even more professional supporting. (Leeman and Reynolds；2012) Therefore, outsourcing suppliers attempt to change the OEM mode in order to increase the level and expand the coverage of professional outsourcing service; outsourcing suppliers establish high technology standard in OEM industry for customers and clients to create the most additional value that meet “win-win situation” between original equipment manufacturing suppliers and brand enterprises.（Jeremy et al.；2008）Consequently, brand enterprises try to reduce the cost and keep well cooperation relationship with outsourcing suppliers at the same time in this particular period. They expect to promote more effective and have lower cost by the division of labor on technical capability and specialization of outsourcing suppliers and then bring up stronger competitive capability in a competitive market. （Strange；2011）

The enterprises adopt external professional suppliers to execute non- core activities. This decision promotes the operation performance in order to increase enterprises competitive advantage by concentrated source into development of main capability. （Elmuti；2003）Especially smartphone industry is high elimination rate in technique, Keen competition and production replaced frequently, so this industry need mutually supporting outsourcing suppliers to strengthen itself competitive capability. However, outsourcing strategy is formed by enterprise future planning for production, itself competitive capability and reference enterprise long term development planning to determine the enterprise cooperation strategy. This research focuses on the mode how the smartphone brand enterprises consider and execute the outsourcing strategy. Also, this research examines how the smartphone industry form and plan the outsourcing strategy which is based on its technique of determination. According to the essence of outsourcing strategy and the key thought on determination, this research investigates how these main factors influence the smartphone industry in their performance and competitive advantage, and then expect to develop an appropriate outsourcing determined mode and reference for smartphone industry or related industry. The main purposes are:

1. Understanding the essence of outsourcing strategy, including the key thought on determination to select the outsourcing strategy.
2. To investigate how these main factors influence the smartphone industry in their performance and competitive advantage.
3. Well using outsourcing strategy; to seek and to cooperate appropriate outsourcing suppliers in order to strengthen brand enterprises itself production competitive capability.
4. To develop an appropriate planning mode of outsourcing strategy for smartphone industry and to become the reference for smartphone industry or related industry.

2. Reference

Core Competence

Core competence is the concealed specialty behind the production. This professional specialty integrates the technology and source internal of internal departments in the company. Core competence is not only difficult to copy for competitor but also bring about special utility and added value, and provide the production with unique competitive advantage and services for clients that make the enterprises to succeed and profits increasing conspicuously. According to the rising growth high technology in Taiwan, the enterprises change their composition to global overall arrangement. If the enterprises still keep their core capability in traditional manufacturing mode or hold any useful and useless internal enterprises resource; moreover, the enterprises enlighten itself the innovative thought and excellent professional technique, then they will be unable to confront the global impact. However, based on "Hafeez and Zhang" in 2002, core capability is formed by many valuable abilities which is unique and unmatched, and it is potential success key influence for enterprises. Therefore, the enterprises must possess high value and unique capability in order to keep its competitive advantage (Figure 1). Core capability integrates resource and abilities and increase organizational added value.

The enterprises have to integrate whole internal resource to develop the technique capability of competitive advantage. The scholar, Hope and Hope points at that core capability is the particular competitive advantage in his book, "Competing in the third wave "; for example, the ahead of technique, excellent operation or perfect customer service. By training core capability, the enter- prises will be able to create the productions and service in keeping with clients' demand in changeable competi- tive market.

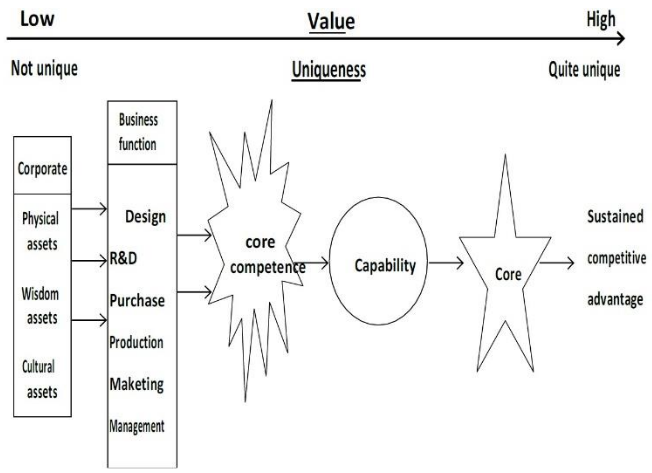

Fig. 1 The structural of core capability (Hafeez and Zhang；2002)

Outsourcing Strategy

How an enterprise running success business depend on its operating strategy. And what a success enterprise executing strategy would be different result with several factors; external and internal environment, whole enterprise resource, and the ability how to perform the source. Therefore, same strategy cannot be executed for other enterprises at the same time. Many enterprises choice the symbol learning method and reference the strategy from success enterprises in order to reach the goal in the short time. But then enterprises reach an impasse by conservative copy. For this reason, the purpose of executing strategy is forming the competitive advantage in order to confront the changeable competitive environment with saving capacity and establish itself in an unassailable position. However, the scholars, Tajdina and Nazari point out that the outsourcing is the dependence of the external resource for enterprises in 2012. The level of dependence of external resource is the index for enterprise to consider an appropriate outsourcing operating strategy. Therefore, based on characteristic of outsourcing and factor of consideration, the enterprises have to consider the outsourcing strategy with three determined factors; how to execute the resource in effect, how rely on resource and the cost of business transactions. They must invest their resource to main concentrated strategic goal and bring needed external resource to strengthen internal capability in order to have the utility with complementary. (Arnold；2000) consequently, before the strategy improvised and purchase is formed, it need to be inspected and integrate usable internal resource and coordinated external resource in order to get composite result with ineffective and cooperation.

But, along with global development, Keen competition and enormous market demand, the enterprises not only seek outsourcing to reduce cost but also expend itself relationship through external specialized suppliers or producers in order to ensure and handle the clear market position and operating strategy, and then focus on the resource to develop enterprise core competitive capability. Now outsourcing is an important tool to seek after excellent strategy. （Ehie；2001）The main purpose of outsourcing for enterprises is enhancing its competence by external specialized suppliers supporting, moreover, it will use limited resource on core activities in order to promote the running of enterprises and increase its benefits. In the slight profit age, the scholar, Adobor though that managers have not only to re-examine and make a thorough planning in the worthful activities of chain value of enterprises but also reflect on correct strategy selections in self-made or outsourcing. The enterprises become more concentrated and specialized on development focus in order to respond accordingly to this new environment of Keen competition and performance guide. Also, the enterprises begin to estimate and analyze if any occupational activity would provide typical competitive advantage and key running strategy to develop that influence enterprises to invest more resource into interior or expanding outsourcing service market.

3. The formation and determined model of outsourcing strategy

Along with global development and keen economical competition, competitive pressure causes enterprises to pursue the scale economy and decreasing running cost, especially in smartphone industry. Based on high level smartphone is near market saturation, more middle and low level mobile stores try lower price marketing strategy to hold the market share. For this reason, to reduce the cost is the primary goal because the smartphone industry needs to confront with increasing competitive pressure daily. Then, enterprises execute outsourcing strategy to control the cost and have flexible human resource in order to decrease the cost. The concealed benefit of outsourcing includes cost improvement and the core capability to well use the resource, in other words, it is easy to cause several situations, for example, the decreasing of ingenuity, the leak of knowledge and training the competitors by over depended on outsourcing strategy that is contested seriously. However, in the competitive market, some enterprises believe that outsourcing is the answer for all questions and forget outsourcing is only a strategy and a tool. All strategies come with risks. Without careful planning assessment, adjusted and managed execution, it might not achieve expected result. Therefore, the enterprises have to consider its production competitive advantage, uniqueness and the point of development of business running strategy.

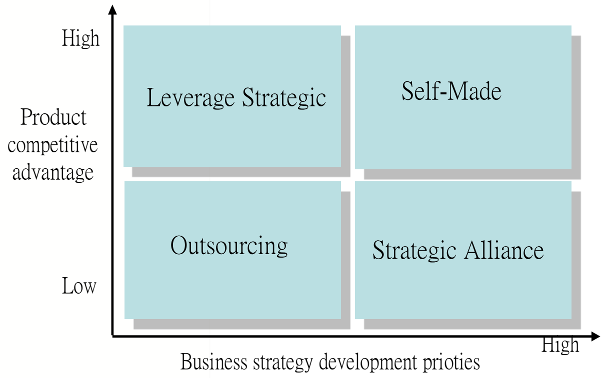

Fig. 2 The decision model of outsourcing strategy

This research inspects the decision model of outsourcing strategy by study of business strategy and production. And it analyzes the executing strategy in every stage of the decision process by the key development business strategy and production competitive advantage. (Figure 2)

The illustrations of decision strategy are:

1. To avoid the leak of technology and keep the business competitive advantage, the enterprises must take free development strategy, which is free manufacture strategy if business productions possess market competitive advantage and valuable activities in main strategy.

2. To strengthen and improve production competitive advantage, the enterprises take the method of strategic alliance to integrate with related specialty or leader of industry if business productions might not possess market competitive advantage but have valuable activities in main strategy.

3. The enterprises take leverage strategy that provide technology to related manufacturers to assist manufacturing development if business productions possess market competitive advantage but not have valuable activities in main strategy.

4. The enterprises take outsourcing strategy to assign specialized contractors who possess competitive advantage if business productions do not possess market competitive advantage and do not have valuable activities in main strategy.

4. The factors of considered outsourcing

According to the trend of fast growing in smartphone industry and division of labor based on specialization in competitive market, the brand enterprises of smartphone become to focus on and specialize in the main development in order to respond accordingly to this industrial environment of keen competition and performance oriented. The enterprises begin to estimate each business performance in order to analyze if these works can be able provided the effective methods to enterprises for its unique competitive advantage. In this way, the enterprises invest more resource into the territory of good business results, and dissolve the territory of uncompetitive advantage or turn to expanding external service market, such as outsourcing. However, there are many situations are needed to be consider to execute outsourcing strategy and each scholar gives their own view and recommends different opinions.

This research recommended related opinions what is needed to consider to draw up the outsourcing strategy that is based on several statements, for example, the characteristic of smartphone industry, the limit of producing goods and the reference to analyze whole enterprise resource (Figure 3). Therefore, in this research is expanded the considered factor in business outsourcing strategy. These factors are the enterprise core technology capability, the dependent level in external resource, the peculiarity in production and partnership with outsourcing original equipment manufacturing factories. In this research to point out that enterprise will rise up the dependent level in external resource while a functional department is without core competence. And the level of partnership with outsourcing original equipment manufacturing factories and the limited level of running strategy will be rise up for unique production, even to depend on outsourcing original equipment manufacturing factories completely to make up its core technology or reduce cost

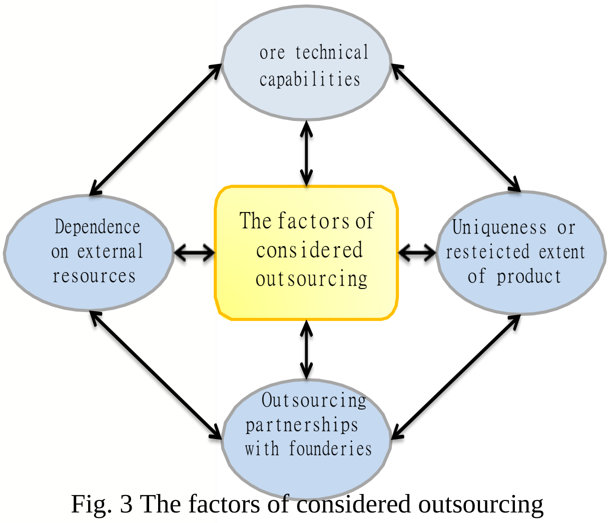

Fig. 3 The factors of considered outsourcing

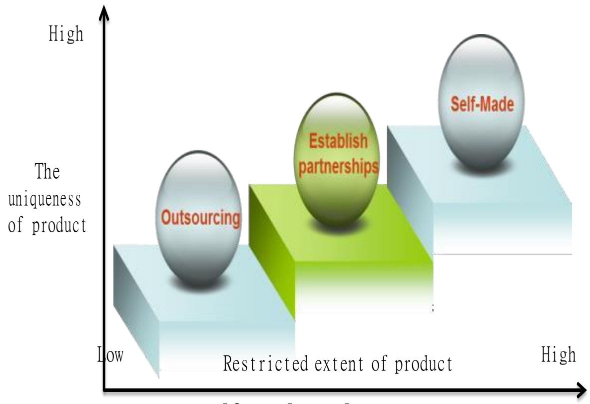

Fig. 4 Self-made and outsourcing

Otherwise, the enterprise will drop the dependent level in external resource, rise up the level of threshold to build a production and enhance the level in the peculiarity of production if its core technology capability is strong. Then the production is limited in its possibility. The outsourcing strategy is the method to keep the partnership with original equipment manufacturing factories.

However, the manufacturing factories are be concerned the organizations as manpower in intensive and high cost for most enterprise. For this reason, the most brand enterprises would consider how to cooperate with external specialized original equipment manufacturing factories in order to seek the benefits and managed convenience in the lower cost and profits age. Besides, the condition of business production is not only important to consider the outsourcing strategy but also main considered factor to choice outsourcing. So, the risk of technology leak in seeking outsourcing when the production is unique and good expectancy; on the other hand, it will come higher cost in self-made (Figure 4).

Therefore, to keep the partnership with original equipment manufacturing factories is necessary and consider the original equipment manufacturing factories as 2nd manufacturing factories would provide the high producing flexibility for brand enterprises.

5. The original equipment-manufacturing model

The original equipment-manufacturing model is the basic of the development of Taiwan industry. However, along with the change in the imitating of the competitive countries and quick extend in similar operation model such as EMS and CEM; the original equipment manufacturing is changed between cooperation model and operation model. Brand enterprises rely on original equipment manufacturer factories more than before because of the capacity improvement of original equipment manufacturing factories. And original equipment manufacturing suffers the pressure from brand enterprises and competitive environment, and then OEM model in lower value added transfer to ODM model in higher value added; finally transfer to JDM model in more competitive ability by the integration in whole supply chain. Even so, the improvement of technology, production capacity and creativity is the only method to keep competitive in the competitive environment of the original equipment manufacturing industry. Especially in the competitive environment of smartphone industry, the original equipment manufacturing factories cannot grow up by strong production capacity under the pressure between the cost and profit if the original equipment manufacturing factories only keep OEM order. Therefore, original equipment manufacturing factories must emphasize self-capability in research and development to transfer to ODM model in order to participate in the production design and increase the production decision-making power, moreover transfer to JDM model. And then JDM model is not only able to join the brand enterprises' nucleus production design and development, but also express the opinions about the materials selection and producing process. Further, it can expand the customer service and maintain service in order to increase the original equipment manufacturing factories' value added and competitiveness. "Fig. 5"

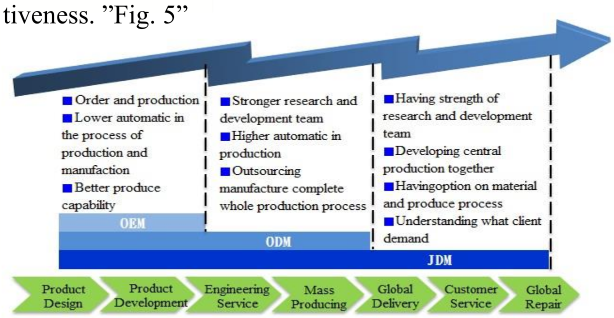

Fig. 5 The original equipment-manufacturing model

By the original equipment-manufacturing model of ODM and OEM, the productive activities only achieve brands' shipping goal; brands would execute by themselves or entrust professional service vendors to enforce the last technology service at customer side.

However, the capability of execution of original equipment manufacturing model usually depends on the level of original equipment-manufacturing factories' technology capability. It is able to offer complete service for brand vendors and the customers who are at the last part in productive activities. The technology capability of original equipment manufacturing of JDM model is not only able to help to design and develop now production with brand vendors, but also find the solution method and avoid same problem again by self-technology capability in the short time. Furthermore, the original equipment manufacturing of JDM model has not only the competitive advantage but also the capability to integrate the ability of related good vendors that create more value added for brand vendors by self- nucleus technology capability in order to increase self- competitiveness in the industry. Therefore, helping brand vendors' production to design, global shipping out and after-service all include in the service of JDM model that OEM and ODM models cannot compare.

6. Conclusion

According the many research reports, the enterprises seek excellent and specialized original equipment manufacturing factories to improve the production capability, reduce the cost and increase competitive advantage in competitive market in order to focus on itself core technology. However, the outsourcing strategy is not the cure-all, it often fails. For this reason, to ensure the success of outsourcing strategy is planning carefully outsourcing strategy, estimating and managing the original equipment manufacturing factories. This research is the reference for who intend to do service outsourcing industry to study the growth trend of smartphone industry and to cooperate in the development of outsourcing strategy. The conclusions are:

1. Well executing outsourcing strategy, integrating appropriate service outsourcing factories that let brand enterprises would focus on core technology and competitive production in order to improve its enterprise competence.

2. Outsourcing strategy affects enterprises in positive direction to engage in business and achieve its performance.

3. It is necessary in strategic direction to keep partnership with original equipment manufacturing factories. So, the original equipment manufacturing factories is the key factor for business strategy to keep the growth in elasticity.

4. Outsourcing strategy is not only the effective running model to respond fast to market demand but also the essential method to strengthen the enterprises core competence and keep its competitive advantage.

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Expiration Date	/ (month / year)	Card Type	☐VISA ☐MASTER ☐JCB
Card Number	☐☐☐☐-☐☐☐☐-☐☐☐☐-☐☐☐☐	Security Code	☐☐☐ 
Amount Authorized		Special Messages	
Full Address (Incl. Street, City, State, Country and Postal code)			

Please Sign your name here______________________(same as the signature on your card)

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