

# A SYSTEMATICAL FORECASTING PARADIGM OF THE CONTAINER THROUGHPUT BY MODELLING THE RELATIONSHIP BETWEEN DIFFERENT PORTS

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## ABSTRACT

While substantial studies have been conducted on the container throughput forecasting, most of them are focused on the forecasting for individual port without considering the interaction between the ports belonging to the same port group, subsequently lead to big forecast errors. This paper proposes a forecasting paradigm which is able to systematically forecast the interactive ports by modelling the relationship between them. The paradigm is composed of a relationship identification model and a systematical forecasting model. After the model estimation method is elaborated, an empirical study of Hong Kong Port and Shenzhen Port is conducted by comparing the proposed forecasting model with others, which shows the superiority of the proposed over its rivals in terms of the forecasting accuracy.

**Keywords:** systematical forecasting, container throughput, relationship between ports

## Introduction

Container throughput forecasting is of great value to the scientific development planning of ports. It is an important prerequisite for port management to formulate strategic investment decision and specific market operation plan.

A large body of studies have been focused on forecasting the container throughput of an individual port based on the arbitrary assumption that the targeted ports are independent of others, such as Peng & Chu (2009), Rashed et al. (2016) among others. (2016). However, it is notable that between different ports there frequently exist competition, or mutual benefit, or coexistence of them, due to the complex factors such as sharing the overlapped economic hinterland, or operating the same shipping routes, and so on. For example, Tian et al. (2013) analyzed the evolving competing relationship between Hong Kong Port and Shenzhen Port. This is one of the most important factors leading to unsatisfactory forecasting accuracy of the forecasting methods proposed by these studies. Consequently, it is desired to propose new forecasting methods addressing the interaction between different ports.

## Literature Review

In terms of container throughput forecasting, time series models are one of the most

frequently used and widely accepted categories, including univariate models, multivariable models, artificial intelligence models, gray system models, exponential smoothing models and so on.

Rashed et al. (2016) used the ARIMA model, the ARIMA-intervention model and the ARIMA model with integrated index to predict container throughput in Antwerp Port. Huang et al. (2016) used an ARIMA model as a reference model to predict the container throughput of Guangzhou Port. Hui et al. (2010) constructed a VEC model for container throughput forecasting by using real estate prices as a substitute variable for the port charge. Schulze & Prinz (2009) compared the Holt-Winter index smoothing model and the SARIMA model in terms of the forecast performance of German ports' re-exports and showed the slight superiority of the SARIMA model over the Holt-Winter exponential smoothing model.

ARIMA models only utilize one variable and simulate the linear trend hidden in the data. In order to capture the nonlinear trend, intelligent models are widely used. Gosasang et al. (2011) used the artificial neural networks to predict the container throughput in Bangkok, Thailand. The results show that the prediction accuracy of artificial neural networks is significantly higher than that of traditional regression models. Xie et al. (2013) used the LSSVM to build the container throughput integration forecasting model. Xiao et al. (2016) proposed a TF-PSO container throughput migration prediction method and achieved better forecasting performance than the linear models.

To deal with small sample data, grey system models are frequently applied. Peng & Chu (2009) compared the forecasting performance of six univariate time series models for container throughput of three ports in Taiwan, including a GM(1,1) model. Twrdy & Batista (2016) used the gray system model, along with the Markov chain annual growth model, the time series trend model and the seasonal time series trend model, to predict the container throughput of the northern Adriatic port.

The above models suffer from a common weakness of neglecting the correlation between different ports. The systematical forecasting paradigm proposed by this paper is capable to take advantage of the correlation, more close to the reality, and thus has good potential of providing a more sharp tool for container throughput forecasting.

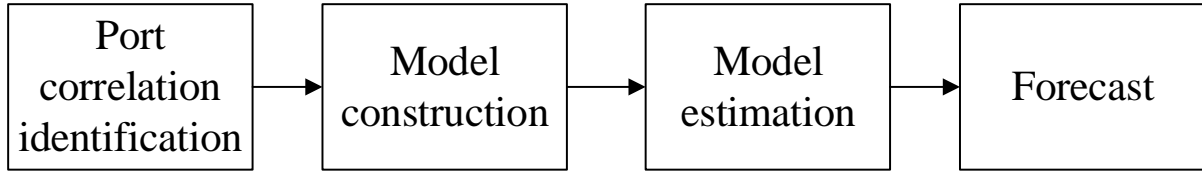
## **Objective**

To construct a systematical forecasting method of container throughput considering the correlation between the correlated ports, which is involved in three problems including (a) how to analyze the underlying correlation between ports, (b) how to specify a systematical forecasting model with the relationship between ports and (c) how to estimate the model.

## **Methods**

### **1. Systematical forecasting paradigm**

Picture 1 describes the systematical forecasting paradigm for container throughput, composed of the following four parts.



**Picture1:** Framework of the systematical forecasting paradigm

Firstly, define the relationship between ports. Use the Granger causal test to verify whether there is a stable association between ports, which is a prerequisite for building a systematical forecasting model.

Secondly, model establishment. In this stage, in light of the result of the Granger test, the structure of the forecasting model is determined, which could be generally presented as a SVAR model.

Thirdly, select the appropriate method to estimate the model parameters. BP-ANN is used to overcome the difficulty of estimating a SAVR model.

Fourthly, forecast with the estimated model. Use the estimated model to predict the container throughput of the port in the forecasting horizon, which is the ultimate goal of the above work.

## 2. Port relationship identification

For any two correlated ports, the container throughput sequences are recorded as  $\{y_{1t}, t = 1, \dots, n\}$  and  $\{y_{2t}, t = 1, \dots, n\}$ , and the relationship between the ports can be identified through the following steps:

Firstly, use the ADF test (Said & Dickey, 1984) to verify that  $\{y_{1t}, t = 1, \dots, n\}$  and  $\{y_{2t}, t = 1, \dots, n\}$  are smooth. The specific method of ADF test is the estimation equation

$$\Delta y_{kt} = \alpha y_{kt-1} + \sum_{i=1}^p \beta_i \Delta y_{kt-i} + u_{kt}, \quad k = 1, 2; t = 1, \dots, n. \quad (1)$$

where  $\Delta y_{kt} = y_{kt} - y_{kt-1}$ , and the value of  $p$  can be determined by the AIC criterion (Akaike, 1973).  $\alpha = 0$  indicates that the sequence has a unit root, i.e., not stationary;  $\alpha < 0$  indicates that the sequence has no unit root, which means the sequence is stationary.

Secondly, use the Granger causal test to verify whether there is a Granger causality between  $\{y_{1t}, t = 1, \dots, n\}$  and  $\{y_{2t}, t = 1, \dots, n\}$ . The specific method can be found in the literature (Granger, 1969).

Thirdly, if there is a Granger causality (assuming  $y_{2t}$  is the Granger cause of  $y_{1t}$ ) between the two sequences, the  $y_{2t}$  can be used as the explanatory variable for  $y_{1t}$  to build the ADL model. The mathematical expression of ADL can be written as

$$y_{1t} = b + \alpha y_{1t-1} + c y_{2t} + d y_{2t-1} + u_{1t} \quad (2)$$

where  $u_{1t} \stackrel{iid}{\sim} N(0, \sigma^2)$ .

Compute the expected value of both sides of the formula and record  $\gamma_0 = b/(1-a)$ ,  $\gamma_1 = (c+d)/(1-a)$ , then the following equation is available

$$E(y_{1t}) = \gamma_0 + \gamma_1 E(y_{2t}). (3)$$

$\gamma_1$  is the long-term correlation coefficient between the  $\{y_{1t}, t=1, \dots, n\}$  and  $\{y_{2t}, t=1, \dots, n\}$ ;  $\gamma_1 < 0$  indicates that the two sequences have a negative long-term correlation, which means that there is a competition between the container throughput of the two ports;  $\gamma_1 > 0$  means that there is mutual promotion between the two ports.

Fourthly, no Granger causality between  $\{y_{1t}, t=1, \dots, n\}$  and  $\{y_{2t}, t=1, \dots, n\}$  implies no long-term stable relationship existing between the two ports.

### 3. Model construction

Assume we have two time series  $\{y_{1t}, t=1, \dots, n\}$  and  $\{y_{2t}, t=1, \dots, n\}$ , according to the direction of Granger causality, there are three specific forms of correlation prediction models for two ports, which can be recorded as:

$$\begin{aligned} & \text{① } y_{2t} \underline{\text{G}} y_{1t} \\ & \begin{cases} y_{1t} = \alpha_1^1 y_{1t-1} + \dots + \alpha_j^1 y_{1t-j} + \beta_1^1 y_{2t} + \dots + \beta_{k+1}^1 y_{2t-k} + u_{1t} \\ y_{2t} = \beta_1^2 y_{2t-1} + \dots + \beta_k^2 y_{2t-k} + u_{2t} \end{cases} \quad (4) \\ & \text{② } y_{1t} \underline{\text{G}} y_{2t} \\ & \begin{cases} y_{1t} = \alpha_1^1 y_{1t-1} + \dots + \alpha_j^1 y_{1t-j} + u_{1t} \\ y_{2t} = \alpha_1^2 y_{1t} + \dots + \alpha_{j+1}^2 y_{1t-j} + \beta_1^2 y_{2t-1} + \dots + \beta_k^2 y_{2t-k} + u_{2t} \end{cases} \quad (5) \\ & \text{③ } y_{2t} \underline{\text{G}} y_{1t} \\ & \begin{cases} y_{1t} = \alpha_1^1 y_{1t-1} + \dots + \alpha_j^1 y_{1t-j} + \beta_1^1 y_{2t} + \dots + \beta_{k+1}^1 y_{2t-k} + u_{1t} \\ y_{2t} = \alpha_1^2 y_{1t} + \dots + \alpha_{j+1}^2 y_{1t-j} + \beta_1^2 y_{2t-1} + \dots + \beta_k^2 y_{2t-k} + u_{2t} \end{cases} \quad (6) \end{aligned}$$

where the  $y_{2t} \underline{\text{G}} y_{1t}$  indicates that the Granger causality from  $y_{2t}$  to  $y_{1t}$  is existent,  $y_{2t} \underline{\text{G}} y_{1t}$  indicates that there is a Granger causality from  $y_{2t}$  to  $y_{1t}$  and from  $y_{1t}$  to  $y_{2t}$  at the same time. The essential difference between Formula (6) and the VAR model is that the terms on the right side of both equations in formula (6) contains the contemporaneous variable of another variable, which means Formula (6) can reflect the interrelationships of the container throughput of different ports at same period.

The above model can be extended to the multi-port situation. Assuming there are  $k$  ports, the container throughput at period  $t$  is recorded as the vector  $y_t$  of  $k \times 1$  dimension, where the  $y_{it} (i=1, \dots, k)$  denotes the container throughput of port  $i$  at period  $t$ .  $A = [a_{ij}]$

denotes a matrix of  $k \times k$  dimension and all the diagonal elements are 1;  $a_{ij} = 0$  if there is no Granger causality of between the port  $i$  and  $j$ , otherwise,  $a_{ij} \neq 0$ . The general form of the multi-port forecasting model can be written as

$$\mathbf{A}y_t = \mathbf{\Gamma}_1 y_{t-1} + \mathbf{\Gamma}_2 y_{t-2} + \cdots + \mathbf{\Gamma}_p y_{t-p} + \mathbf{u}_t, \quad (7)$$

where  $\mathbf{\Gamma}_i$  ( $i = 1, \dots, k$ ) is a  $k \times k$  matrix,  $\mathbf{u}_t$  is a  $k \times 1$  vector to represent the disturbance.

#### 4. Model estimation

The SVAR model shown in the formula (7) has a total of  $k^2 p + k^2$  parameters to be estimated. It is necessary to add  $(k^2 - k)/2$  constraint conditions to the model to estimate the model parameters. There are three general ways to increase the constraints. The first is to establish a recursive short term constraint by Cholesky decomposition. But this method assumes that, for any element in  $y_{jt}, y_{j+1t}, \dots, y_{kt}$  have no effect on  $y_{1t}, \dots, y_{jt}$ , which implies the container throughput of ports  $j+1, j+2, \dots, k$  have no effect on ports  $1, 2, \dots, j$ . This assumption is clearly not in line with the actual situation. The second way is to increase the constraints according to the economic theory. However, the economic theory is rarely seen describing the quantitative relationship between the container throughput and its explanatory variables. The third method is to assume that a variable has a zero long-term cumulative effect on another variable. However, it is difficult to determine the long-term relationship between variables in the actual practice.

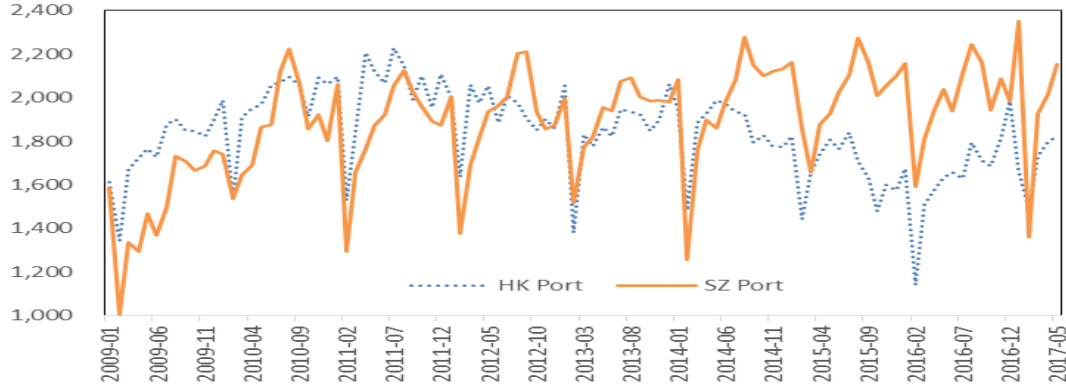
The above challenges render it impractical to some degree to estimate model (7) by increasing the constraints, therefore it is necessary to find a more simple and feasible estimation method. Considering that the formula (7) is a multi-input and multi-output system, and the ANN model is also a typical multi-input and multi-output system with strong fitting capabilities. Hornik et al. (1989) demonstrated that a three-layer neural network with enough hidden nodes can achieve a perfect approximation to any continuous function, therefore this paper uses the ANN model to estimate the formula (7). Formula (4)-(6) are the special variation of formula (7), which also can be estimated by using ANN model.

#### 5. Empirical study

For validation purposes, an empirical study is carried out in this section.

##### 5.1. Data description and processing

Monthly container data for Hong Kong and Shenzhen ports used in this section were downloaded from the CEIC Macroeconomic Database, with data periods ranging from January 2009 to May 2017 (Picture 2).



**Picture 2:** Container Throughput of Shenzhen Port and Hong Kong Port (million TEUs)

The data from January 2009 to June 2016 were used to estimate the model parameters, and the data from July 2016 to May 2017 were used to verify the model performance.

In order to test and deal with the anomalies in the data, the X12 season adjustment program was used to separate the trend items and seasonal items in the time series. To deal with the outliers in the series, an effective method proposed by Huang et al. (2015) is applied.

## 5.2 Reference models and evaluation criteria

In order to validate the forecasting performance of the proposed method, we use the traditional projection Pursuit Regression (PPR) model, the hybrid of PPR and genetic programming (GP), named PPR-GP, BP-ANN, and SARIMA as the reference models to independently forecast the container throughput of Hong Kong and Shenzhen ports. Then we use the proposed model to forecast the two ports, and compare the proposed and the reference models in terms of three evaluation criteria including *MAPE*, *NMSE* and *CDFR*.

Assume the container throughput of period  $i$  for a certain port is  $x_i$ ,  $\tilde{x}_i$  is the forecasted value, and the mathematical expression of MAPE and NMSE can be expressed as

$$MAPE = \frac{\sum_{i=1}^T |x_i - \tilde{x}_i| / x_i}{T} \quad (8)$$

$$NMSE = \frac{\sum_{i=1}^T (x_i - \tilde{x}_i)^2}{\sum_{i=1}^T (x_i - \bar{x})^2} \quad (9)$$

$CDFR$  can be used to evaluate the accuracy of the prediction direction, the mathematical expression is defined as follows:

$$CDFR = \frac{1}{T} \sum_{i=1}^T CDF_i \quad (10)$$

$$\text{If } (x_i - x_{i-1})(\tilde{x}_i - \tilde{x}_{i-1}) > 0, \quad CDF_i = 1 ;$$

$$\text{If } (x_i - x_{i-1})(\tilde{x}_i - \tilde{x}_{i-1}) < 0, \quad CDF_i = 0 .$$

## Results and Discussion

### 1. Smoothness test and Granger causality test results

The container throughput of Hong Kong and Shenzhen port is  $\{y_{ht}\}$  and  $\{y_{st}\}$ , and the two sequences are tested by ADF. The results are shown in Table 1. Since the P-values of the ADF test of the two first-order differences are less than 0.05. They are considered to be first-order stationary.

Table 2 shows the Granger causality test results for container throughput in Shenzhen and Hong Kong ports. From the p value in the table, it can be seen that the original hypothesis of " $\Delta y_{ht}$  is not the Granger reason of  $\Delta y_{st}$ " and " $\Delta y_{st}$  is not the Granger reason of  $\Delta y_{ht}$ " can be significantly rejected. This means that there is a two-way Granger causality relationship between  $\{\Delta y_{ht}\}$  and  $\{\Delta y_{st}\}$ .

**Table 1:** ADF test for container throughput in Hong Kong Port and Shenzhen Port

Variables	t value	p value
$\{\Delta y_{ht}\}$	-2.938595	0.0000
$\{\Delta y_{st}\}$	-11.98639	0.0000

**Table 2:** Granger Causality Test for Container Throughput in Shenzhen Port and Hong Kong Port

Null hypothesis	F value	p value
$\Delta y_{ht}$ is not the Granger cause of $\Delta y_{st}$	2.39248	0.0394
$\Delta y_{st}$ is not the Granger cause of $\Delta y_{ht}$	3.48461	0.0053

### 2. Systematical Forecasting Model and Long-term Relationship between Ports

Based on the above analysis, use the AIC rule to establish the following ADL model:

$$\Delta y_{st} = 1.147 - 0.370\Delta y_{st-1} + 0.162\Delta y_{st-2} - 0.122\Delta y_{st-6} + 0.997\Delta y_{ht} + 0.853\Delta y_{ht-1} \quad (11)$$

$$\Delta y_{ht} = -0.8192 - 0.583\Delta y_{ht-1} + 0.575\Delta y_{st} - 0.222\Delta y_{st-2} - 0.126\Delta y_{st-3} \quad (12)$$

The coefficients in both equations are at the level of significance of 0.05, and the goodness-of-fitness are 0.74 and 0.77, respectively. Adopted the formula (3), it can be calculated that the long-term impact of  $\Delta y_{ht}$  on  $\Delta y_{st}$  is  $(0.997 + 0.853)/(1 + 0.37 - 0.162 + 0.122) = 1.391$ .

It can be seen that the increase of Shenzhen Port container throughput has a catalytic effect on Hong Kong Port container throughput. This is consistent with the results of Fung (2001, 2002). Using the same approach, it can be calculated that the long-term impact of Hong Kong port monthly growth on Shenzhen Port is 0.143. It can be seen that the impact of Hong Kong Port on Shenzhen Port is small, but also positive.

### 3. Forecasting performance comparison

In this section, we first used the processed data to establish the four independent forecasting models of Shenzhen Port and Hong Kong Port (BP-ANN, SARIMA, PPR and PPR-GP) and Systematical Forecasting Model (SFM). Then, we compared the forecasting performance of the four independent forecasting models with that of SFM (Table 3).

From Table 3, we can obtain the following findings: firstly, the level prediction error (*NMSE* and *MAPE*) of the systematical forecasting model (SFM) to the two ports is smaller than the independent forecasting models (SARIMA, BP-ANN, PPR and PPR-GP), which means that the systematical forecasting model of container throughput is more accurate by considering the linkage between the two ports; secondly, the direction prediction accuracy (*CDFR*) of the association model is generally superior to the independent prediction models. But this advantage does not necessarily occur when the model and data changed. For example, the direction prediction error of PPR-GP on the Shenzhen port is less than SFM; thirdly, in general, the forecasting method proposed in this paper shows a significant advantage over the other referred models in the absolute prediction accuracy. The overall performance is better in the direction prediction accuracy.

Table 3 Independent forecasting model VS. systematical forecasting model

Hong Kong Port				Shenzhen Port		
Models	<i>NMSE</i>	<i>MAPE</i>	<i>CDFR</i>	<i>NMSE</i>	<i>MAPE</i>	<i>CDFR</i>
SARIMA	0.38	2.17	81.8	0.28	1.98	81.8
BP-ANN	0.28	2.33	81.8	0.15	1.91	81.8
PPR	0.24	1.97	72.7	0.23	1.89	81.8
PPR-GP	0.19	1.93	81.8	0.23	1.86	90.1
SFM	0.14	1.82	81.8	0.13	1.52	81.8



Notably, the forecasting method proposed in this paper also applies to container throughput analysis in other port groups, such as the Bohai Bayport group and the Yangtze River Delta port group.

#### 4. The future work

This paper analyzes a system of two related ports by constructing a univariate model. The future efforts are recommended to be concentrated on the systems of more related ports. Besides, more explanatory variables should be considered in the future.

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## CASTING DEVELOPMENTS FOR INDUSTRY 4.0.

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### ABSTRACT

If the casting industry in Thailand is to continue to move forward under Industry 4.0 then it must be committed to process and product developments through improved collection, integration and analysis of relevant data, and through increased use computer simulation and modeling, automation and robotics. However, to take full advantage of new technologies SME foundries in particular need to develop improved understanding through cause and effects analysis of the interactions between the various materials and production processes that they use in their production plants. This paper outlines the current state of casting technology in Thailand and then considers areas where improvements could be made.

**Keywords:** Casting. Thai Foundries. Industry 4.0. Improvement. New Technology.

### Introduction

Castings can be produced in a wide variety of shapes and sizes and with complex internal and external design features. Sizes can range from just a few hundred grams for small precision parts to up to 300 tonnes for the largest steel castings. The casting route provides near net shape production with a design freedom that cannot be matched by most other forming processes. A large selection of casting alloys is available to meet the varied and critical service demands that are placed on cast components in almost every engineering application, for example in air, sea and land transport, in industrial plant and equipment, in civil engineering, and in the electrical and electronics industries. Castings production has been and will continue to be a key integral part in the development of the automotive industry in Thailand.

Metallurgy in Thailand has its roots in cast metals. There is archaeological evidence that metals production began around 2000BC at Ban Chiang in N.E. Thailand with the casting of tin bronze into axe heads, spear tips and ornaments through technology transfer from the southern region of Siberia (White 2009). Much later, in the 1700s, at Coalbrookdale in England it was developments in melting and casting technology that contributed to rapid growth in mechanization through water and steam power during the Industrial Revolution, now termed Industry 1.0. The opening of the world's first bridge built from cast iron sections

over the River Severn at Ironbridge in 1779 provides an early example of design to make optimum use of the properties of a material. Cast iron, with flake graphite in the microstructure, is relatively weak under tensional loading but it is strong in compression, hence each section of the bridge was designed to be loaded only in compression. The bridge still stands today but is now restricted to pedestrians only. The considerable technological progress in casting production following Industry 1.0 has been compiled in the American Foundry Society (AFS) timeline (Staff report 2007). The period of growth in mass production through electrical power during the first half of the 20<sup>th</sup> Century (Industry 2.0) saw developments in moulding machine and moulding line technology and in electric arc and induction melting furnaces. From the 1980s continued advances in computer simulation and modeling of solidification, microstructures and residual stress distributions in castings, and the combination of CAE with rapid prototyping for tooling development provide examples from the era of automation, electronics & computing (Industry 3.0). With an emphasis on Thailand and the ASEAN region, this paper considers the role of the casting industry, current and future developments in casting technology, and the wider application of cast components towards the 4<sup>th</sup> industrial revolution of Industry 4.0. The paper asks the timely question: "Can Thai Foundries become "Smart Foundries?"

### **Current status of castings production**

Each year the AFS together with the publication "Modern Castings" conducts an annual census of world casting production volume with data collected from all of the member countries of the World Foundry Organization (WFO) and from a number of other important casting nations (Staff Report 2017). The latter group includes Thailand which is the only one of the ten nations in ASEAN that is included in the survey. The latest figures published are for 2016 and show that the total recorded annual casting production figure was 104.4 million tonnes, almost the same as the 2015 level, with the world top ten producers accounting for 91.6 million tonnes. The leading nation China produced 47.2 million tonnes, 45% of the world total. The AFS figures for the top ten, Thailand (21<sup>st</sup>) and the other two countries in Asia, Taiwan (15<sup>th</sup>) and Pakistan (22<sup>nd</sup>), are given in Table 1. The figures published for Thailand are in fact from the year 2015 and indicate a total of 316,400 tonnes, which is made up of 105,400 tonnes of aluminium base castings and just 130,700 tonnes for cast irons, with around 30,000 tonnes for steel castings, 26,000 for copper-base, and 24,000 for zinc-base. It is believed that the production figure for cast irons i.e. flake (FC), ductile (FCD) and alloy irons, underestimates actual production volume by about ten times, whilst the figure for Al-base seems accurate. There are no detailed production figures collected for casting output in Thailand but it is estimated (Bhandubanyong & Pearce 2016) that current capacity is around 1-1.2 million tonnes for ferrous castings and around 120,000 tonnes for non-ferrous, most of which consists of Al-base die-castings. Using these figures would give an estimated total of 1.3 million tonnes for Thailand. This puts the Thai casting

industry in terms of volume at least equivalent to that in Taiwan, i.e. about the 15th largest in the world, and behind only China, India, Japan and Korea in Asia (see Table 1). This assessment equates with Thailand's rank as 12<sup>th</sup> in the world list for 2016 vehicle production volume in that, as in Japan, it is estimated that about 70% of cast products are for auto-parts.

**Table 1.** Annual production figures for castings in 2016 taken from AFS Global Census (2017). Top ten producing nations listed together with rank position of other nations in Asia in the census. Thailand is the only member of ASEAN included.

Ranking	Country	Annual Production in million tonnes
1	China	47.2
2	India	11.35
3	USA	9.39
4	Japan	5.2
5	Germany	5.16
6	Russia	3.9
7	Korea	2.6
8	Mexico	2.56
9	Brazil	2.1
10	Italy	2.1
15	Taiwan	1.1
21	Thailand	0.32
22	Pakistan	0.24

The production of castings is complex and subject to the effects of a number of interacting material and production variables such that, in the minds of both design engineers and users, the casting route has always been associated with relatively high defect rates when compared to other forming methods. Over recent years, thanks to improvements in quality management systems and significant technological advances in the foundry industry, this "defect-ridden and unreliable" image of castings has, by and large, been overcome. However, there is still considerable scope for further improvements, especially in the non-automotive SME foundry sector in Thailand. Management in this sector still needs to be reminded that the production of accurate, fit-for-purpose defect free castings requires a scientific, rather than rule of thumb, approach to casting design and methods engineering

and that this must be followed by correct control of significant process variables at all stages of production.

In a survey to examine innovation in the Thai castings industry some 16 years ago it was noted that most of the technical progress and innovation had arrived via technology transfer from overseas notably from joint ventures with automotive or electrical/electronics companies mainly from Japan (Pearce & Bhandhubanyong, 2002).

This survey concluded that, for the non-joint venture Thai owned companies, innovation via industrial based R & D was needed to make better use of local raw materials such as sands, chemical binders, refractories and recycled materials such as reclaimed sands and secondary aluminium ingot. It was suggested that the Thai companies needed (a) to take advantage of the materials characterization techniques available in Thai universities and R&D centres (b) to make use of simulation & modeling to improve methods engineering and optimize processes (c) to pay more attention to energy efficiency, environmental and safety issues and, last but certainly not least, (d) to reduce scrap and rework and improve quality by using FMEA (Failure Modes & Effects Analysis) and SPC (Statistical Process Control) for the planning and control of their production processes. It was also recommended that Thai SME companies look at and learn from the best practices that were already in operation in the larger joint venture plants producing cast parts for the automotive and motor-cycle builders. These large automotive foundries have been world-class producers since the late 1990's (Mitchell, 1997).

In a more recent appraisal of the SME casting industry in Thailand (Bhandubanyong & Pearce, 2017) it was noted that, although some progress has been achieved, technical developments have been held back by a number of factors including limited investment, lack of applied R & D, inadequate testing and metrology services, and the country's general shortage of practical engineering skills together with limited training at the operative, craft and technician levels.

### **Technology Improvements and Industry 4.0 – Becoming Smart Foundries**

Over recent years, for foundries to stay competitive, the driving forces for improvements in castings production have included higher quality and reliability, cost reduction, increased energy efficiency, and meeting stricter environmental standards. The technical and performance demands on cast products have also increased particularly with respect to customer requirements for ready-to-use finished machined cast parts, tighter dimensional tolerances, optimum combinations of strength, ductility and toughness. There is also increasing demand for more complex, thinner-walled parts for automotive and aerospace applications. With the world-wide focus on "Industry 4.0" the casting industry is now paying more attention to how digital technologies can be integrated into all areas of casting production processes.

The larger JV automotive foundries and die-casters in Thailand are already "*smart*" in

that they have been making effective use of CAE and automation for quite some time and their processes already satisfy high environmental and health & safety standards. In compliance with exacting auto-industry quality standards they are well versed in the use of FMEA, SPC, DOE (Design of Experiments) and other analytical quality tools and techniques, and in the use of computer modeling and simulation in design and methods engineering. How can these foundries become "*smarter*"? For new product developments using other alloys, processes and treatments should always be examined as part of the materials and process selection stage. For example, the ferrous casting plants may need to consider producing parts in Compacted Graphite grades of cast iron (CGI) and Austempered Ductile Iron (ADI). Those in the Aluminium sector can look, for example, at counter-gravity filling of precision sand moulds to produce castings with greater reliability and fatigue performance, use of automatic high-pressure greensand box-less moulding for high-rate production of thin sectioned castings, semi-solid processing and, to reduce weight, substitution by magnesium base alloys, notably for automotive and aerospace parts. Mg base high pressure diecastings are important in producing parts for electronic equipment and computers but at present there is no recorded production of Mg alloys in Thailand.

In controlling their production, large auto-foundries generate a considerable amount of data. Much more use could be made of this information in the fine-tuning of compositions and processes to achieve optimum performance. For example, with existing common foundry alloys it has become increasingly difficult to achieve further improvements in properties but wider use of computer regression analysis and modeling to consider the interaction between composition and processing variables in predicting mechanical properties may allow precise trimming to optimize structure and properties. Melting and melt preparation is a key area to examine with respect to the interaction between charge materials, compositional ranges, impurity levels, dissolved gases, cleanliness, melting times, temperature, melt conditioning and final melt treatments before casting.

As robot and automation technology continues to develop so it is expected that the larger foundries will make wider use of robots in automatic handling, treatment and pouring of liquid metal, automatic mould and core production and assembly, and especially in the difficult areas (hot, dusty, noisy and dangerous) of knock-out, cleaning and fettling of castings, furnace lining replacement and plant maintenance. Flexible robotics will enable more thorough inspection of internal cavities in complex castings and also easier monitoring of production plant and equipment without the need for disassembly. Autonomous robotics allows robot production cells to be linked together with control systems via exchange of information or Internet of Things (IoT) allowing not only greater efficiency but also greater flexibility in production. Robots can use sensor technology to monitor work, can interchange information to make their own adjustments and can also link into supplier networks enabling automatic matching up of production scheduling with materials supplies to reduce

inventory.

In the SME sector in Thailand many improvements, as discussed in detail elsewhere (Bhandhubanyong & Pearce, 2017), are needed to enable foundries to remain competitive and move forward from an Industry 2.0 situation. By making better use of computer-based manufacturing systems small foundries can improve their organization, planning, procurement, production, customer service and sales. For some years foundry-specific software has been available to manage all technical and commercial foundry operations. It is likely that it is more cost effective for small foundries to license such software (with associated technical support) rather than try to develop their own programs or modifying software that is designed for mass production assembly.

Via such production control, foundries can improve the timing of their raw materials purchasing, schedule production efficiently and deliver products on-time while coordinating production data etc. with their Quality Management system. For example, melting schedules can be correctly arranged to prevent contamination between successive melts avoiding the need for wash-out melts, and core-production can be matched to mould production to avoid excessive core storage times or lack of cores at the moulding line. Process modeling and simulation are also now more easily available as bureau services in Thailand. By using such services, or investing in basic simulation software, foundries can solve running & feeding problems before pattern equipment or tooling is made. This improves casting yield by avoiding oversized systems and reduces defects such as shrinkage porosity, mis-runs, and oxide films & inclusions from turbulent filling. For both large JV plants and SME foundries factory locations, layouts, production lines and their operation can all be simulated so that time- and cost-effective design of new plants can be achieved. Such virtualization modeling would be most applicable in SME foundries seeking to modernize their plant layout to improve space utilization, ergonomics and work flow.

Although many SME foundries operate a Quality Management system most of them need to make more effective use of FMEA studies and SPC methods. This observation applies across the general SME manufacturing sector in Thailand (Pearce & Bhandubanyong, 2017). Without any basic cause & effects analysis and statistical control it is highly unlikely that manufacturers, including foundries, will have a clear picture of variations in their processes and the factors that affect these variations, their process capability, and the quality of their products. Without such knowledge and understanding of what they are doing foundries will continue to solve problems by a "fire-fighting" approach. As such they make changes to processes for the sake of change, and quite often do not even record the details of such changes or indeed their effects on the process. It is a waste of time and money to embrace Industry 4.0 if a foundry does not understand the science and technology involved in all of its operations, does not recognize "out of control" situations, does not collect accurate production data, does not have clear work instructions, does not train operators,



etc.

Plant and equipment in all foundries has to operate under arduous conditions e.g. heat, dust, vibration, etc. It is therefore important that, in all foundries, the condition, performance and efficiency of this production hardware is carefully monitored by suitable condition monitoring as part of a Total Productivity Maintenance (TPM) system. Improvements in sensor technology and data collection now enable the pulse of equipment to be instantly taken and analyzed. New equipment suppliers can offer remote monitoring and condition control services via a cloud-based system. Foundries should take into consideration the provision of remote support when making decisions about the purchase of new production equipment.

All foundries can also take advantage of reduction in pre-production time by use of rapid prototyping via additive manufacture (AM) methods. Polymers can be used to produce patterns for sand moulding via Fused Deposition Modeling (FDM) giving advantages of time saving and cost when compared to machined aluminium patterns. Where only one or two castings are required, 3D printing enables "pattern-less" casting production. Sand moulds and cores for actual production of a casting and sand models of a casting for prototyping can be produced directly from CAD information. Broken or worn-out parts of equipment can be 3D scanned and the moulds to produce replacements made using binder jet 3D printing to minimize any downtime (Valunaraya et al. 2017) As for casting simulation, SME foundries can benefit from the design freedom advantages of 3D printing by making use of bureau service from specialist companies, e.g. to supply mould assemblies and cores for small series casting production of designs which are difficult to produce by conventional means.

### **EEC and the role of government on promotion of Thai industry**

The government of Thailand started the promotion of the new mega project called "Eastern Economic Corridor" or EEC during 2016. It is envisaged that EEC will be the prime mover for revival of economic growth in the same manner as the predecessor "Eastern Sea Board" had been nearly 4 decades ago. The target industries are 1) First S-curve or five existing industrial sectors which can be developed by adding value through advanced technologies ( i.e. Next-Generation Automotive, Smart Electronics, High-Income Tourism and Medical Tourism, Efficient Agriculture and Biotechnology and Food Innovation) and 2) New S-curve or five sectors which can serve as growth engines to accelerate Thailand's future growth ( i.e. Automation and Robotics, Aerospace, Bio-Energy and Bio-chemicals, Digital and Medical and Healthcare).

The Board of Investment (BOI), which is the principal government agency for encouraging investment, has been focusing on attracting foreign investment, particularly in the high-tech sector. The total new investment value under the BOI stood at THB 144 billion (USD 4.05 billion) up to August 2016 in the 10 targeted industries under Thailand 4.0, accounting for 48% of total investment.

During the past two years, a number of laws have been amended and drafted to improve the ease of doing business by eliminating hurdles and improving the public sector's services. Recently, the Prime Minister, Prayut Chan-o-cha, presented a five-pronged policy approach to attract increased investments from the private sector: 1) **Technology**: To enhance capacity in core technologies where Thailand has potential, such as biotechnology, and agricultural, food, energy, and health-related and medical technologies; 2) **Human resource development**: To promote "Thai 4.0" and attract talent from overseas; 3) **Infrastructure**: To develop physical infrastructure, connectivity infrastructure, intellectual infrastructure, and social infrastructure; 4) **Enterprises**: To empower entrepreneurs and enterprises of all levels, promote startups, to uplift SMEs from the original equipment manufacturer (OEM) to the original design manufacturer (ODM) and the original brand manufacturer (OBM), and encourage large-scale corporations to help develop local suppliers; and 5) **Targeted industries**: To promote investment in the 10 S-curve and new S-curve industries, especially in the Eastern Economic Corridor (EEC). (PriyankaBhunia, 2017)

Very interesting policy approaches are items number 2) to promote "Thai 4.0" and number 4) to empower entrepreneurs and enterprises and to uplift SMEs from OEM to ODM and OBM. These two approaches, if tackled correctly, could really benefit Thai Foundries and propel them to become "Smart Foundries" within 5-10 years.

For example, at the implementation level, the Department of Industrial Promotion or DIP, supported by the Japanese Government, has been setting up the "Center of Robot Excellence" or CoRE to develop the seriously needed "System Integrators" or SI to help facilitate SMEs in the application of automation and robotic systems in manufacturing processes. The "Industrial Transformation Center" or ITC is also being established at the Industrial Service Center premises in Bangkok and in provincial areas to demonstrate a model automation and robotic line for Thai SMEs. Henceforth, the combined activities of CoRE and ITC could help in automatization and/or robotization of Thai Foundries with the application of IoT and even AI where appropriate.

### Concluding Comment

Thai Foundries have come a long way from being a traditional village industry producing simple tools and handicraft to become strong partners in the supply chain of the first and new S-Curves industries. However, prior to the application of automation, robotics, IoT, and AI, basic improvements in terms of data control, control of process variables, correct application of statistical tools such as FMEA, FTA, Cause and Effect Analysis, etc., must be done to build a strong foundation for the application of the advanced technologies. The policy of the Thai government and operation of various implementation units could facilitate technology transfer and applications. However, it is only the belief and understanding of Top Management and an adequate supply of qualified, well-trained human resources that could help the Thai Foundries actually realize the "Smart Foundries" vision in

a suitable period of time.

#### **Response to comments from reviewer.**

##### **Should add more charts & related information:**

The paper is already 10 pages long which is the maximum length allowed (?) hence in the draft submitted it was felt that the inclusion of diagrams or charts would take up space that could be more fruitfully used for detail & discussion in the text. As such it is intended that diagrams and pictures etc. be included in the slides for oral presentation. These might include: examples of the design capability of castings, some new casting processes, scope for CGI, ADI, Mg alloys, thin-walled castings, castings for auto-bodies and EV, robots in foundries, 3D sand printed moulds, etc.

##### **Should show process of thinking/methodology behind paper:**

We believe that the rationale for the paper is self-evident and is outlined in the last 5 lines of the Introduction. The methodology is based on the personal observations and related experiences in the castings industry by the authors.

##### **Clarify outputs of work**

This is covered in the Concluding Comments section at the end. The paper is not based on experimental work so conventional conclusions are not relevant. If the reviewer wishes a specific comment on outcome then perhaps the following could be added at the end of the Concluding Comments section.

*"This paper has attempted to provide a critical but constructive overview of castings production in Thailand and has indicated areas where improvements and further developments are needed. It is hoped that the outcome of this work would be to encourage all sectors of the Thai Castings Industry to join together in preparing a "vision" or "roadmap" for the industry such that it can continue to grow and be sustainable under Industry 4.0."*

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## EXPLORING THE INFLUENCING FACTORS ON CONTINUANCE USAGE AND INFORMATION SHARING INTENTIONS FROM ONLINE RESTAURANT REVIEW PLATFORMS

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### ABSTRACT

Online reviews have considerably impacted on the hospitality industry, because of the intangible characteristics of experience, products and services. Consumers rely heavily on other customers' reviews in order to evaluate service quality prior to consumption. The empirical evidence claimed that online restaurant review platforms help customers gather information regarding restaurant experiences from the prior experiences of other customers. Besides, they can provide restaurant managers to understand customers' preferences, needs, and reactions. This study aims to know the factors that can enable the Internet users to keep on using online restaurant review platforms and share the information based on the uses and gratifications theory (UGT). The 30-item scale has been developed based on literature and validated by six experts. This study utilized the partial least square analysis (PLS) to investigate the interrelationships of usage motive of online restaurant review platforms, continuance usage and restaurant information sharing intentions. The results indicated that information seeking motive and entertainment motive have significantly positive impact on continuance usage intentions; information seeking motive and relationship maintenance motive has a significantly positive impact on information sharing intentions. These findings provide suggestions on the design and management of online restaurant review platforms. Managerial implication and future research are also discussed.

**Keywords:** Online restaurant review platforms, UGT, Continuance usage intentions, Information sharing intentions

## Introduction

According to a survey conducted by the Planning Department of the Republic of China Executive Yuan, as many as 93% of Taiwanese people now have the habit of eating out. Among them, 33.74% of the population even dine out for more than 4 days a week (Executive Yuan, Republic of China, 2017). Besides, the MasterCard Survey on Consumer Purchasing Priorities – Dining for 2017 showed that many Taiwanese consumers carefully browsed customers' reviews of restaurants before going out to eat, with 64 percent of them reading online review comments from other consumers, which is the highest level in the Asia-Pacific region (MasterCard, 2017). As the importance of online reviews increases, several online restaurant review platform (e.g., Yelp, TripAdvisor, Google Map) offering consumers' comments have become the primary information references for customers in the hospitality industry (Liu & Park, 2015).

For consumers, compared to the promotional information provided by a restaurant, the opinions and comments provided by the authentic consumer experiences are more convincing and credible (Ayeh, 2015). The more commentators make comments, the more representative information can be used as reference to reduce inconsistent expectations. Luca (2016) asserted that for every additional star rating, restaurant revenue will increase by 5-9%. The study by Kim, Li, and Brymer (2016) also claimed that the number of online reviews has a significant positive effect on restaurant performance. Therefore, online reviews are important for consumers and restaurateurs, it is essential to study the factors in which customers continue to use the restaurant's online review platforms. However, few studies have investigated the reasons for the continuous use and the willingness to share restaurant information of restaurant online review platforms.

Hence, it could be the objectives of this first attempt to identify the influencing factors of sharing information and continuous use in the restaurant online review platform from the customer perspectives. Literature Review

This study explored the influencing factors of continuance usage on online restaurant review platforms and restaurant information sharing intentions by the uses and gratifications theory (UGT).

UGT was proposed by Katz, Blumler, and Gurevitch (1973), it is an important theoretical framework for investigating media use motive and behavior. Based on social and psychological needs, it is believed that users actively choose the media to meet their specific needs and motives rather than passively obtain information from the media (Gao & Feng, 2016). Recent research has applied this theory to online media in order to understand the motive of consumers continually selecting the type and use of Internet media (Gao & Fe

ng, 2016; Ku, Chu, & Tseng, 2013; Whiting & Williams, 2013), and to explore the impact of user motive on behavioral intentions (Hur, Kim, Karatepe, & Lee, 2017; Ifinedo, 2016; Lee & Ma, 2012).

As shown in Table 1, UGT was applied to the online media related papers, it could be found that most of the usage motives used in information seeking, entertainment, and relationship

Maintenance. They are also significant influences on the behavior intentions (e.g., Hur et al., 2017). Thence, this study established the usage motives of the restaurant's online review platforms based on previous research results, which were information seeking motive, entertainment motive and relationship maintenance motive.

**Table1:** The literature of usage motive underpinned by the UGT on online media.

Author	Population	Medium	Motives	Results
Hur et al., 2017	Korean users	Social media	information seeking, relationship maintenance, entertainment	Information seeking motive, entertainment motive and relationship maintenance motive positively influence the continued use intentions and information sharing intentions.
Ifinedo, 2016	American university students	Social networking sites	purposive value, self-discovery, entertainment value, social enhancement, maintaining interpersonal interconnectivity	self-discovery, entertainment value, social enhancement, and maintaining interpersonal interconnectivity have positive impacts behavioral intentions

According to extant studies, behavior Intention can be used to predict the actual behavior of consumers. When consumers produce positive behavioral intentions, the likelihood of actual behavior is higher (Venkatesh & Agarwal, 2006). The continued use of products and services is more important than the initial use of consumers because the success of products and services depends on continuous use (Bhattacharjee, 2001; DeLone & McLean, 2003). In response to the development of Internet technology and the habits of people using social media, the continuance usage and information sharing intentions on using social media and online tools received research attention. In this study, the continuance usage intention is defined that online users continue to use online restaurant review platforms in the future; information sharing intentions are the intent to share restaurant information with others (Hur et al., 2017).

Low, Goh and Lee (2010) shows that people could predict the potential information needs of themselves or others and share relevant information for future searches. Lee and Ma (2012) stated that information seeking motive triggered the intention to share the latest news on social media. Hur et al. (2017) found that information seeking motive, entertainment motive and relationship maintenance motive positively influence the continued use intentions and information sharing intentions of social media. This paper established the following hypothesis based on the above literature:

H1: Information seeking motive positively influence (a) continuance usage intentions and (b) restaurant information sharing intentions.

H2: Entertainment motive positively influence (a) continuance usage intentions and (b) restaurant information sharing intentions.

H3: Relationship maintenance motive positively influence (a) continuance usage intentions and (b) restaurant information sharing intentions.

## **Methods**

The 30-item scale has been developed based on literature and validated by six experts. This paper utilized the purposive sampling. The targeted survey viewers are people who are required to have experiences using and submitting the online restaurant reviews. In order to confirm the respondents having published restaurant-related reviews, this study used two review platforms including Google Map review and Yelp.com.tw, which could view the reviewers' pages and invite them to complete the online questionnaire. Even though providing a lucky draw as an incentive to fill in the questionnaire, receiving responses from reviewers tended to be a tough challenge. The population of the purposive samples is uncertain because we cannot predict how many people had already published restaurant-related reviews. We had done our best to collect the survey. A total of 273 questionnaires



were issued, 62 valid questionnaires were collected, and the valid response rate was 23%. Because of the limitation for collecting the valid questionnaire, this paper used the partial least square analysis (PLS) to investigate the interrelationships of information seeking motive, entertainment motive, relationship maintenance motive, continuance usage intentions and restaurant information sharing intentions.

## Results and Discussion

### Model test results

The results in table 2 indicated that information seeking motive and entertainment motive have significantly positive impact on continuance usage intentions; information seeking motive and relationship maintenance motive have significantly positive impact on restaurant information sharing intentions.

**Table2: The result of PLS analysis.**

Endogenous		
Continuance usage intention	0.662	
Restaurant information sharing intention	0.516	
Hypothesis	Path Coefficient	
Information seeking motive→Continuance usage intention	0.313	**
Information seeking motive → Restaurant information sharing intention	0.521	***
Entertainment motive→Continuance usage intention	0.548	***
Entertainment motive→Restaurant information sharing intention	0.044	
Relationship maintenance motive→Continuance usage intention	0.094	
Relationship maintenance motive → Restaurant information sharing intention	0.253	*

Note: \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

### Theoretical implications

The hypothesized relationships developed based on the theoretical framework of UGT (Katz et al., 1973) received support from the empirical data. This empirical findings indicated that the information seeking and entertainment motive enhanced online users' continuance usage intentions for online restaurant review platforms; information seeking and relationship maintenance motive enhanced restaurant information sharing intentions. These findings are consistent with UGT (Katz et al., 1973) and obtain support from the empirical studies, although limited in number in the recent literature. These findings come to heel the

study of Hur et al. (2017), Ifinedo (2016) and Lee and Ma (2012).

### **Managerial implications**

The results could benefit a lot for the restaurateurs and review platform management executives. The restaurateurs could be possible to focus on their own Google Maps reviews and furthermore reviews on Facebook because there are over 80% respondents would use these two review platforms. In addition, the restaurateurs need to manage the online reviews. Consumers are more likely to patronize restaurants with positive reviews, but if the reviews are negative, consumers' willingness to consume at this restaurant could probably be reduced (Resnick, Kuwabara, Zeckhauser, & Friedman, 2000). For the reason that, restaurant managers could probably encourage the customers to write positive online reviews for their restaurants by discounting prices or giving light refreshments. When a negative comment appears, using the "reply" feature as much as possible to remedy negative reviews (Kim, Li & Brymer, 2016)

As mentioned previously, the increases and updates of online restaurant reviews will benefit the restaurants and online restaurant review platforms (Kim, Li, & Brymer, 2016; Luca, 2016). Therefore, how to encourage users to continue using the restaurant's online review platforms and to post and share comments is noteworthy. Based on this research results, the restaurants' information on the online review platforms must be correct and updated, such as business hours, so that can increase users' information seeking motive.

Xu, Chen, & Santhanam (2015) mentioned that compared to text format, video format reviews has a significant positive influence on consumer perceptions and their intentions to purchase. The restaurateurs could encourage publishers to upload photos, video format reviews. Furthermore, the restaurateurs and review platform manager can add fun buttons or games on the online review pages, increasing activity linked to users' friends to encourage continued publication of restaurants' comments.

### **Conclusions and future research**

Online reviews have impacted on the hospitality industry. Consumers made decisions depending heavily on other customers' reviews. This paper examined the determinants of continuous usage and information sharing on the online restaurant review platforms based on the UGT theory. The 30- item scale has been developed based on literature and validated by six experts. The empirical finding through the PLS indicated that information seeking motive and entertainment motive have significantly positive impact on continuance usage intentions; information seeking motive and relationship maintenance motive has a significantly positive impact on information sharing intentions.

There are some limitations that lead to commands for future research. First, the questionnaire respondents of this study came from two online review platforms. The future research could be extended through including more diversified review platforms. Second,

the users of online review platforms have different viewpoints based on their nationalities and cultural background. This research is currently focused on the reviews of Taiwanese and Chinese languages. Using cross national data would extend the database in the online review research.

Finally, the effect of the use of motivation for behavior intention, user involvement may be a moderator (Bano & Zowghi, 2015). Online users will be willing to spend more time and frequently use restaurant online review platforms when they think it is in line with their own needs and satisfaction. Hence, the effect of the information seeking, entertainment and relationship maintenance motive, and continuance usage and information sharing intentions may vary depending on the level of users' involvement.

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## HIGH SENSITIVITY MEMS-BASED EXTRINSIC FIBER-IOPTIC FABRY-PEROTULTRASONI SENSOR

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### ABSTRACT

Fiber optic extrinsic Fabry-Perot interferometric (EFPI) sensors are ideal candidates for measuring a wide range of chemical and physical parameters due to inherent advantages compared with traditional electronic sensors. To date, the sensitivity is still a barrier for EFPI sensors to further expand their practical application fields. In this work, we present the recent research achievements in our group on EFPI ultra sonicsensors and their potential application for detecting the weak partial discharges (PDs). The main concerns lie in improving the response sensitivity of vibrating diaphragm by employing the micro electromechanical systems (MEMS) technology.

**Keywords:** Fiber-optic, Fabry-Perot, ultrasonic sensor

### Introduction

Due to good directionality, strong penetrating ability, easy to obtain concentrated sound energy and long distance in water, the ultrasonic waves are now widely used in medicine, military, industry and agriculture. Thus, the detection of ultrasonic waves is indispensable in our society today. Currently, the ultrasonic detection is commonly achieved by using the piezoelectric transducers (PZTs) (Levassort F. and team, 2007:375-381). However, the material of PZT is sensitive to electromagnetic interference (EMI) that causes signal distortion due to the electrical loading effects. As a result, the PZT sensors are difficult to detect ultrasonic waves in the complex environments such as the transformer stations due to the performance degradation of sensors.

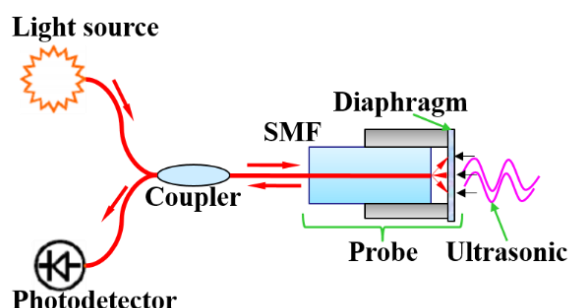
Fiber optic extrinsic Fabry-Perot inter ferometric (EFPI) sensors are ideal candidates for measuring a wide range of chemical and physical parameters due to inherent advantages compared with traditional electronic sensors, such as immunity to electromagnetic interference (EMI), high frequency response, small size, light weight, and remote sensing

capability, and thus it has become an ideal candidate for ultrasonic detection. However, to date, the sensitivity is still a barrier for EFPI sensors to further expand their practical application fields. In order to improve the sensitivity of EFPI sensor, various materials and their processing methods for vibrating diaphragm of EFPI sensors have been proposed. Zhu et al. proposed an EFPI ultrasonic sensor based the micro electromechanical systems (MEMS) technology with the SU-8 photoresist diaphragm (Zhu J. and team, 2015: 2087-2090). Ma et al. proposed an EFPI sensor using multi layer grapheme as the diaphragm material (Ma J. and team, 2013: 932-935). Liu et al. proposed an EFPI sensor based on the large-area silver diaphragm (Liu B. and team, 2016: 50-54). However, due to the immature micro fabrication processing technology, it is difficult and cockamamie to fabricate the vibrating diaphragm using these materials. Currently, due to the mature processing technology in micromachining and good mechanical behavior, silicon is commonly used as diaphragm materials for fiber optic EFPI sensors (Yu B. and team, 2003: 3241-3250), and thus it is urgently needed to fabricate the ultra thin and large-area silicon diaphragm, since that will result in a larger diaphragm deformation under the same ultrasonic pressure, thus making a higher sensitivity of the ultimate sensors (Gong Z. and team, 2017:1-1; Fu C. and team, 2017: 593-604).

In this paper, an EFPI ultrasonic sensor with ultrathin and large-area silicon diaphragm based on the MEMS technology is designed, fabricated and tested. The testing results show the sensor has a higher sensitivity and signal-to-noise ratio (SNR) compared with its conventional commercially available PZT counterpart.

### Design and operational principle

Picture 1 is the schematic illustration of the EFPI ultrasonic sensor that comprises of a light source, a coupler, a probe, and a photo detector. As shown in the picture 1, the light is launched into a coupler and then propagates into the probe, which consists of a single mode fiber (SMF) and a vibrating diaphragm. Henceforth, a Fabry-Perot interferometer (FPI) is formed between the SMF end and the internal surface of diaphragm. Finally, the light is reflected back to the coupler, and collected by a photo detector.



**Picture 1:** The schematic illustration of the fiber-optic extrinsic Fabry-Perot interferometric (EFPI) sensor

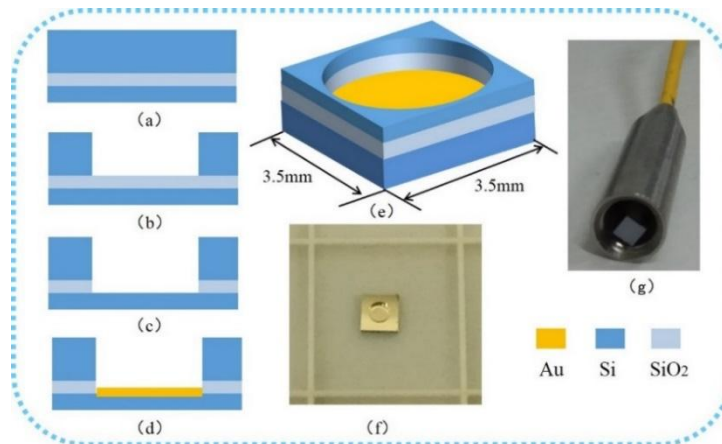
As an important sensing element, the diaphragm plays a decisive role in the sensitivity of EFPI sensors. When the ultrasonic pressure  $p$  is applied, the central deformation of circular diaphragm can be given by:

$$y(p) = \frac{3(1-\mu^2)p}{16Eh^3} R^4 \quad 1)$$

Where  $R$  and  $h$  are radius and thickness of the circular diaphragm, respectively.  $E$ ,  $\mu$  are the elastic modulus, Poisson's ratio of the diaphragm material, respectively.  $p$  is ultrasonic pressure. According to Eq. (1), as smaller thickness and larger area will result in a larger diaphragm deformation. In general, the ultrasonic waves with the frequency of 20~300 kHz are widely applied. Therefore, in this work, a silicon diaphragm with the natural frequency of 30 kHz is designed through the ANSYS (Ver. 14.5). The diaphragm thickness is 5  $\mu\text{m}$ , better than the previously reported EFPI ultrasonic sensors with more than 20- $\mu\text{m}$ -thick vibrating diaphragm (Fu C. and team, 2017: 593-604), and its diameter is 1600  $\mu\text{m}$ .

### Fabrication

The fabrication process of diaphragm is shown in picture 2. To accurately keep the diaphragm thickness, a commercially available silicon-on-insulator (SOI) wafer (device layer 5  $\mu\text{m}$ , box layer 1  $\mu\text{m}$  and handling layer 500  $\mu\text{m}$ ) is used to fabricate the diaphragm (Picture 2(a)). Firstly, a deep hole with the diameter of 2.5 mm and depth of 500  $\mu\text{m}$  is etched in the handling layer of SOI wafer by using the deep reactive ion etching (DRIE) process (Picture 2(b)). Then, the oxide layer at the bottom of the deep hole is completely etched via the buffered oxide etching (BOE) process (Picture 2(c)). Next, a 30-nm-thick gold film is sputtered onto the inner surface of the device layer (Picture 2(d)). Pictures 2 (e) and 2(f) show the processed diaphragm and its three-dimensional structural design, respectively. When the sensor is assembled, a fiber optic patch cord (type: straight tip, corning: SMF-28e, outside diameter: 2.5 mm) is inserted into the deep hole, and a spectrum analyzer is applied to determine the cavity length between the fiber and diaphragm. Finally, when the cavity length is determined, the fiber is fixed by the epoxy (353ND). The fabricated sensor probe is shown in picture 2 (g).



**Picture2:** The fabrication process for the diaphragm of the fiber-optic EFPI sensor: (a)silicon-on-insulator (SOI) wafer, (b) etching a deep hole in the handling layer of SOI wafer, (c) removing the oxide layer, (d) sputtering the gold film, (e)the three-dimensional structural design of diaphragm, (f) the processed diaphragm, (d) the assembled probe

### Experimental tests

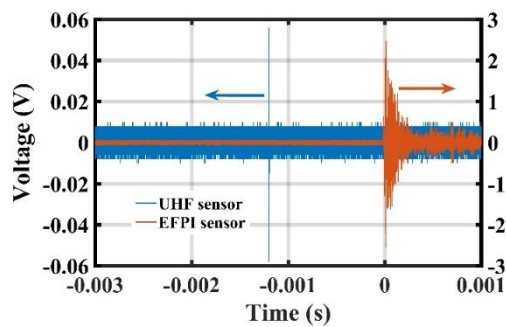


(b)

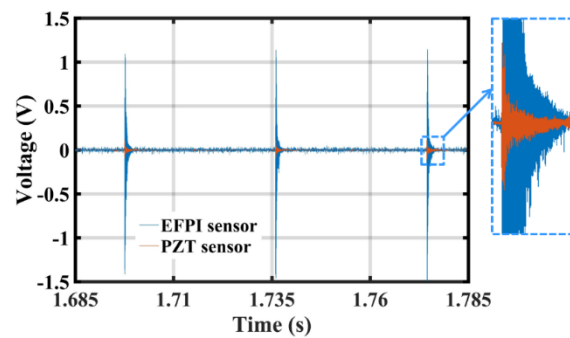
**Picture 3:** (a) The image of comparative test of EFPI sensor and UHF sensor, (b) The pulse discharge gun

Partial discharge (PD) detection is one of the main applications of ultrasonic sensors. Thus, to validate the EFPI ultrasonic sensor proposed in this research, the ultrahigh frequency (UHF) sensor that is commercially available sensor of PD detection and the EFPI sensor are utilized to detect PD at the same time as shown in picture 3(a), and a pulse discharge gun is fired to simulate the PD and emit the ultrasonic signals as shown in picture 3(b). Picture 4 shows the ultrasonic signals picked by both sensors. The testing results show the signal-to-noise ratio (SNR) of EFPI and PZT sensors are 15dB and 7 dB, respectively, which means the EFPI sensor with the higher SNR is very promising to detect the weaker PD events compared with UHF sensor.





**Picture 4:** The ultrasonic signals picked by the EFPI sensor and the UHF sensor



**Picture 5:** The ultrasonic signals picked by the EFPI sensor and the PZT sensor

In addition, a commercially available ultrasonic PZT sensor is also employed to validate the EFPI sensor. The testing results show that the EFPI sensor can recognize the ultrasonic signal easily within the distance of 3 m from the pulse discharge gun, while the PZT sensor can only pick up the ultrasonic signals within the distance of 0.8 m. Picture 5 shows the ultrasonic signals picked by both sensors at the distance of 0.8 m from the pulse discharge gun. According to picture.5, when the SNR of PZT sensor is almost 0 dB, the EFPI sensor still has the SNR of 15 dB, which means the EFPI sensor can detect the ultrasonic signals at a greater distance. The result further indicates the EFPI sensor can identify the weaker ultrasonic signal compared with the commercially available PZT sensor since the attenuation of ultrasonic wave is very serious during propagating, and in other words, the EFPI sensor shows the higher sensitivity compared with its conventional commercially available PZT counterpart.

## Conclusion

In this paper, a fiber-optic EFPI ultrasonic sensor is designed, fabricated and tested. The testing result shows the EFPI sensor based on MEMS technology can recognize the weaker ultrasonic signals easily compared with the UHF and PZT sensors due to the higher sensitivity and SNR. As a result, it is very promising to detect the weak PD events successfully, and exploit the application fields of fiber-optic EFPI ultrasonic sensors further.

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## MODELLING OF THE VALUE NETWORK IN SMART MANUFACTURING BASED ON FUZZY ANALYTIC HIERARCHY PROCESS AND SOCIAL NETWORK ANALYSIS

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### ABSTRACT

The rapid development and integration of cloud computing and industrial Internet of things have stimulated the transformation of traditional manufacturing into manufacturing services with higher added value. By analyzing the modelling of the value network, this work creates a generalized method for the dynamic integration and collaboration of resources in different parts of the value network. A self-organizing mechanism was adopted to cluster the distributed resources. The fuzzy analytic hierarchy process and the ontology modelling technique were adopted for the resource configuration under complex environment. Besides, the method of the social network analysis was used for the service collaboration and exception-handling in manufacturing. Therefore, the issues of the delayed interactions among resources, the collaboration with low efficiency, the late response to market changes, etc. can be solved. An analysis was also conducted to verify the feasibility of the proposed models in integrating multiple resources and promoting collaborations among services. The result showed that the method can improve the efficiency, reduce the cost, and stimulate the collaborative innovation among the studied factory, and the models may also support the improvement of many small and medium enterprises.

**Keywords:** value network, resource modelling, fuzzy analytic hierarchy process, smart manufacturing

### Introduction

Nowadays, the manufacturing industry is facing the challenge of how to increase their competitiveness [1]. The fast development of technology and the fierce competition in the market have changed the industry fundamentally. Manufacturers need to pay more attention to the value creation of their business through innovative production modes, such as the product-service system [2]. At the same time, the industrial structure has turned into a demand-oriented, highly responsive and flexible one that can handle the large-scale personalized customization well. The new structure has shifted the focus of production value-chain from the primary-level operations (i.e. the manufacturing processes) to the

upper-level applications (e.g. the customized designing, the service-oriented manufacturing, etc.). To achieve the long-term innovation and development, it is imperative that enterprises of the value chain coordinate closely with each other, especially in terms of some commercial information and business models, so as to realize the sharing of related resources and to achieve advantageous complementarities.

Individual companies no longer compete as independent entities but an integral part of the supply chain links [3]. As a result, the value chain of collaborations in industrial product-service systems grip the extensive attention from foreign and domestic institutions, universities and well-known enterprises. However, few research have been done to deepen the mechanism of collaborative service modeling in the value chain. The work then proposes an architecture for different manufacturing resources based on the fuzzy analytic hierarchy process (FAHP) and social network analysis, which is shown in Fig. 1. The architecture integrates all kinds of roles (e.g., the suppliers, consumers, sellers, etc.) with a smart platform which aims to achieve the real-time information exchanging, the highly effective collaboration, and the responsive mechanism, among the different roles. Besides, through the study of the dynamic value network, the work provides some theoretical and technical support on the business service integration, which may contribute to the collaboration and reconstruction of the dynamic value network in different industries.

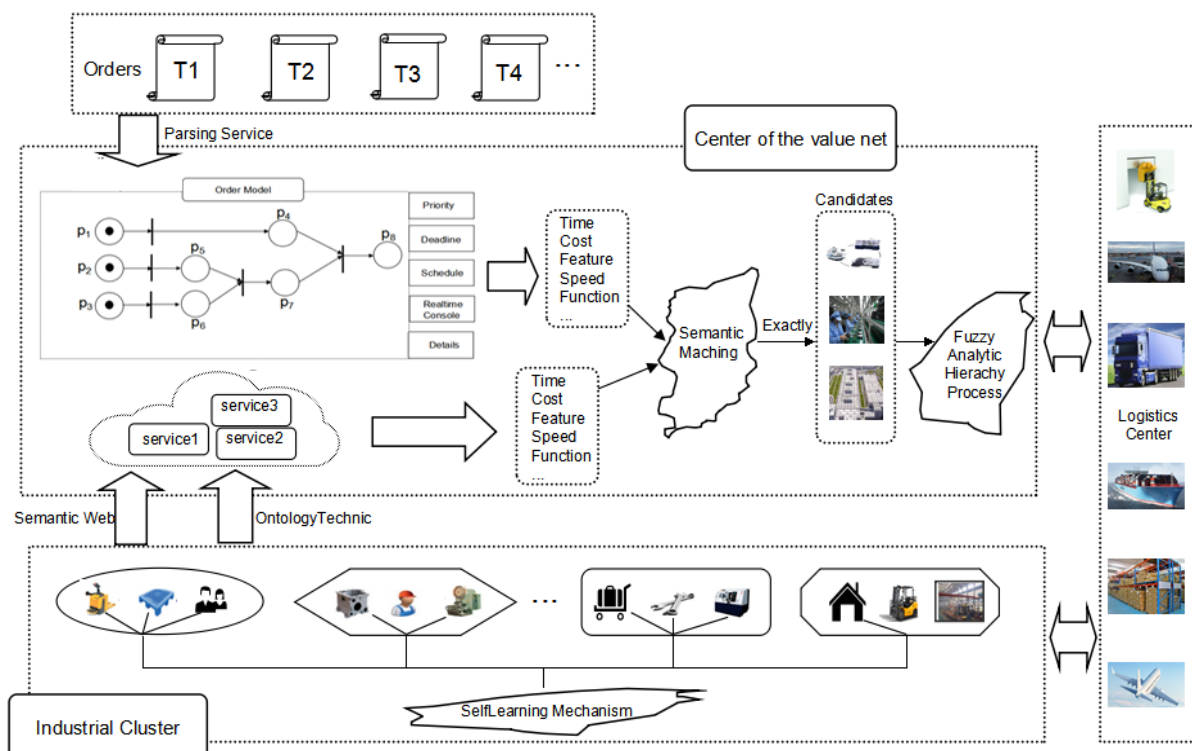


Fig. 1 The overall framework of the value network in smart manufacturing

## 2. Analysis of the model

As shown in Fig. 1, the core components of the designed industrial ecosystem are integrated at the center of the value network, including the customer orders, various plants and corporations which consist of industrial clusters, logistics centers, etc. As a useful tool for the system modelling [4], the Petri net is introduced in this paper to map the manufacturing process more precisely.

The model builds an industry chain or a network with relevant resources, making it possible for the resource invocation with higher efficiency and effectiveness. Each role taking part in the network can operate autonomously based on the resource matching and self-learning mechanism. The semantic web service technology is applied to standardize and unify the functions and services of different hardware platform before the services are registered and become accessible in the value network. The universal cloud service enables the effective management and realizes the flexible invoking of manufacturing services.

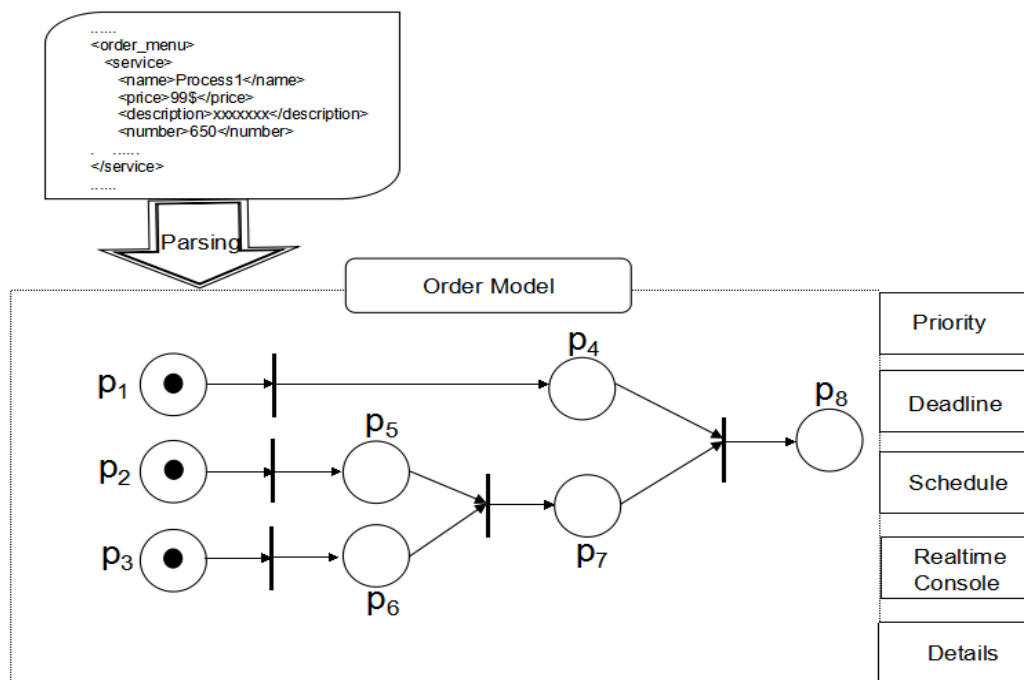


Fig. 2 Modeling of the order processing using Petri net and semantic web

As is shown in Fig. 2, the customers just need to place the order and specify their requirements. With the help of the professional knowledge of the value network, the parsing mechanism can provide a detailed process specification using the Petri net on the bases of many production constraints, such as the task priority, the desired due time, the resource plan, deadline, etc., which gives a specific guideline to the subsystems on how to produce a product. The order is a key element to the model which acts as a token. Depending on the different configuration of resources (e.g. the location of logistics centers and the availability

of the manufacturing services, the orders may commute between relevant companies instructed by the Petri net. As to each process or the transitions in the Petri net, the model uses the technology of ontology and the semantic similarity measuring to compare the requirement with the properties in service pool, picks up the proper services and forms a candidate set for the further selection of resources. Instead of simple information orientation, the semantic similarity measuring can truly understand the task description and improves the search quality of resources, especially in the case of big data.

By means of the quantitative and qualitative analysis and the top-down architecture, FAHP balances the various criteria with different weight. After making the optimal decision from the candidate set, the order model will invoke the chosen services and their corresponding physical devices, instructed by the designed workflow which is interpreted from the customers' orders. At the same time, the value network will also inform the logistics center to transport the semi-manufactured products from the previous process to the next place. Driven by the real-time order which incorporates the dynamic Petri net and other business information, the chosen plants or other entities will arrange the raw material, the semi-manufactured products, and other resources from the upstream nodes in the value network. After finishing the task, the Petri net is updated and the progress of the scheduled task can be calculated and reported to the customers and other entities in the network.

Generally, the production using the service network and the logistics system may cause the dynamic orders created by the parsing mechanism moving back and forth within the value network until they are finished. To reduce the pressure of the network and improve the performance, the self-learning subsystem is introduced where the smart production entity (e.g. a machine, a plant, a warehouse, etc.) is designed to keep an 'experience list'. Whenever an order or a process is executed, the smart production entity will collect the upstream and downstream resource configuration and their corresponding production performance. If the same or similar situations occur next time, the entity can query the knowledge base, inform the logistic center automatically, plan the manufacturing route and arrange the production autonomously. The decentralized subsystem can undoubtedly reduce the rerouting of tasks and the number of decision makings of resource matching, thus improving the efficiency and reliability of the whole value network.

### **3 The key mechanisms**

In order to implement the above-mentioned theories to the real production environment, several key mechanisms need to be realized.

### 3.1 Fuzzy Analytic Hierarchy Process

To evaluate the services provided by semantic matching service, the paper puts forward a fuzzy analytic hierarchy process. FAHP has been widely used to deal with decision-making problems involving multiple criteria evaluation/selection of alternatives [5]. The reason why analytic hierarchy process (AHP) is not directly applied in this paper is that it has some natural limitations as follows. Firstly, in general processes, the fuzziness of subjective judgment is out of consideration when constructing the comparative matrix. Secondly, the threshold that judges a matrix whether it has consistency (e.g. the 'CR<0.1' standard in AHP) lacks sufficient scientific support.

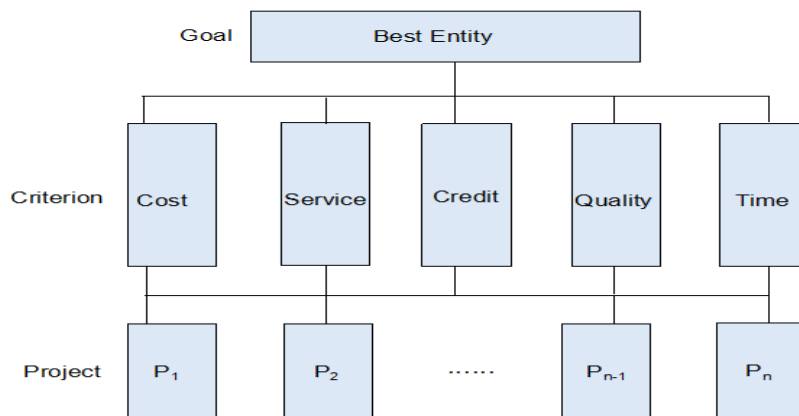


Fig. 3 The three-layer structure of the analytic hierarchy process for resource selection. The paper builds three layers to simulate the actual situation when choosing the optimal resource, as is shown in Fig. 3. Through comparing the importance of two factors from the lower layer (such as cost and service), three sets of the fuzzy number in (1) are chosen by customers. By using the average method, formula (1) is turned into formula (2). Other factors could be handled similarly, then we could get a fuzzy matrix. Thus, a comprehensive fuzzy number of the number  $k$  sector could be calculated through (3).

$$(a_1, b_1, c_1) \quad (a_2, b_2, c_2) \quad (a_3, b_3, c_3) \quad (1)$$

$$\left( \frac{a_1 + a_2 + a_3}{3}, \frac{b_1 + b_2 + b_3}{3}, \frac{c_1 + c_2 + c_3}{3} \right) \quad (2)$$

$$D_i = \sum_{j=1}^n a_{kj} / \sum_{i=1}^n \sum_{j=1}^n a_{ij} \quad (3)$$

Since (1) is a triangular fuzzy number, defuzzification also should be solved by triangular fuzzy function shown in (4). The last step, calculating the minimum data by formula (5). Each factor and its relative weight is done which could clearly reflect the influence of the upper layer and help to pick up the best choice.

$$p(M1 \geq M2) = \begin{cases} 0 & \text{otherwise} \\ \frac{a_2 - c_1}{(b_1 - c_1) - (b_2 - a_2)} & b_1 \leq b_2, c_1 \geq a_2 \\ 1 & m_1 \geq m_2 \end{cases} \quad (4)$$

$$d(M \geq M_1, M_2, \dots, M_k) = \min p(M \geq M_i), i=1, 2, \dots, k \quad (5)$$

### 3.2 The self-learning mechanism

As is stated above in Section 2, the self-learning mechanism is an innovative method to improve the efficiency of the model, which could reduce the frequency of calling fuzzy analytic hierarchy process and the semantic service. At the same time, it could help to build a network in the value chain. Every entity in value net keeps a list which makes an order record that it has done. The flowchart is shown in Fig. 4. When a new order is completed, the entity will compare characters shown in Fig. 5 with orders history recorded in the database. If it is matched exactly, the mechanism will locate the downstream firm from the list, send relevant information to it using web service interface and call the logistics center without the intervention from the head of the system. If not, this new order will be recorded in the database as a new table in Fig. 5. Through tables stored in the database (DB), relevant resources could be linked logically, like making a new friend in a social way. But at the expense of time, it has to be sent back to the center to find next downstream firm according to the Petri net. Depend on the distributing idea, some of the services such as rerouting has been “push down” into lower level nodes which improve the robustness and reduce the degree of coupling. With more and more users using and exercising the model, the database will be richer. By means of learning, all nodes could build a close connection with each other and form a social community. Every entity on the net could commute with others automatically in case some emergencies happen so the mechanism plays a significant role in preventing error propagation and cooperative working.



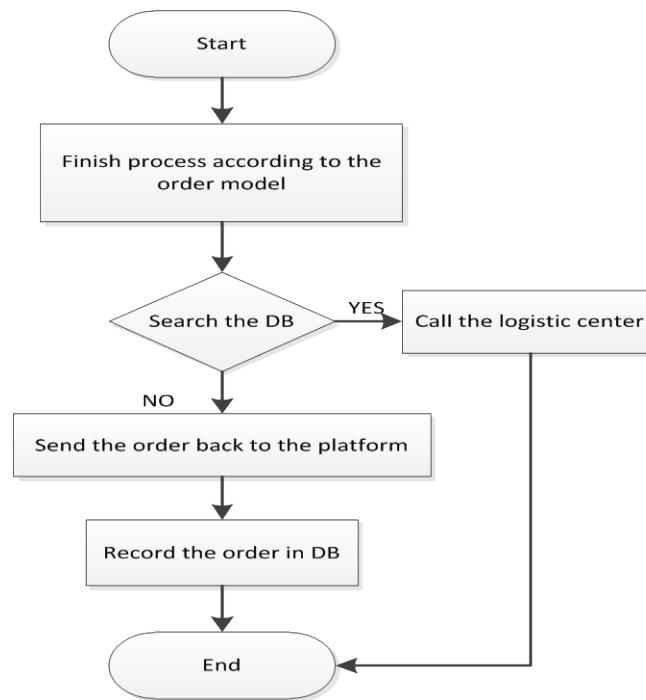


Fig. 4 The flowchart of the self-learning subsystem

Items	Description
Order ID	Order_1
Order Characters	Petri net,schedule,priority,deadline
Downstream Firm Location	(X1,Y1)
Downstream Firm Interface	string callService1(string argv);
Upstream Firm Location	(X2,Y2)
Upstream Firm Interface	string callService2(string argv);

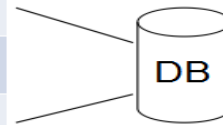


Fig. 5 An example of the self-learning logic

#### 4. Conclusion

This paper introduces a modelling technique for the value network in smart manufacturing where production resources can be pooled and allocated based on the fuzzy analytic hierarchy process and social network analysis. By this model, a dynamic and automatic industry ecosystem which supports the plug-and-play, extensibility and cross-platform ability of services are emerging. The collaborative optimization can further promote the innovation, performance, cost-saving ability, and core competitiveness of the manufacturing-related enterprises through the core value network which represents the networked idea [6]. Therefore, the industrial value chain together with the product-service system is enjoying great potential and promising prospects with potential users existing in the market.

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# OPPORTUNITY FROM THE USER-GENERATED CONTENT: USING BIG DATA TO ANALYZE THE DETERMINANTS OF ON-LINE POPULARITY OF LANDSCAPE RESTAURANTS

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## ABSTRACT

The magnificent growth of big data including click-through-rate, mobile transactions and the user-generated content (UGC) on the Internet has motivated the development of the so-called big data analytics to identify the critical success factors in the hospitality industry. However, the literature gap existed in the restaurant industry because the extant research focused on the hotel industry. The paper aims to identify the determinants of on-line popularity of landscape restaurants. This paper retrieved 558 valid data from 750 observed landscape restaurants from the Ipeen platform. Through the literature review, this paper identified influencing factors of page views of landscape restaurant including food rating, service quality rating, environment rating, number of posting, score given, overall rating and average spending in the review platform. Using the truncated regression with 2000 bootstrapped procedure to explore the significant impact factors of on-line popularity of landscape restaurants. The empirical results indicated that service quality rating and score given had significantly positive impact on the page views. This result had argued that the beautiful environment and delicious cuisine could not get more page views in the landscape restaurants in contrast to the service quality. The viewers who are willing to give the rating are the major browsers. The managerial implication and future research are also discussed.

**Keywords:** Landscape Restaurants, Page View, Big Data Analysis, Environment Rating, Service Quality Rating.

## Introduction

The magnificent growth of big data including click-through-rate, mobile transactions and the user-generated content (UGC) on the Internet has motivated the development of the so-called big data analytics to identify the critical success factors in the hospitality industry. However, the literature gap existed in the restaurant industry because the extant research focused on the hotel industry. Even though the landscape restaurants in Taiwan demonstrated diversified themes with a good scenic spot and offered the delicious cuisines

in order to attract more customers, however, there are many landscape restaurants failed within three years (from 2015 to 2017) according to the research from Ipeen (Ipeen, 2016). Parsa, Self, Njite and King (2005) indicated that the percentages of independent restaurants transferring their ownership within three years are 61.36%, relatively higher 4.14% than those of restaurant chains. There are 754 landscape restaurants in Taiwan (Ipeen, 2017) and this obviously increased year by year. However, there is very little research to investigate the determinants of popularity of the landscape restaurants. Therefore, this paper using the secondary data from Ipeen to examine the influencing factors for the number of page view of the landscape restaurants.

## Literature Review

The increasing of social media and magnificent volume of UGC on the review platform had offered the affluent first-hand experiences sharing and comment from the travelers or customers (Marine-Roig & Clavé, 2015). Researchers claimed that the social media could be divided into blog, review platform, media sharing platform, FAQ website, social media, social news and wiki (Gandomi & Haider, 2015; Marine-Roig, 2014). Furthermore, Koltringer and Dickinger (2015) found that UGC had been full of rich and diversified information and user opinions. Phang, Tan, Sutanto, Magagna and Lu (2014) proposed that Chinese tended to have collectivism cultural perspective which means Chinese consumers would commonly share their purchasing experiences in the social media because of this collectivism culture leading sharing behaviors. Vuylsteke, Wen, Baesens, and Poelmans (2010) argued that Chinese consumers generally much more believed the on-line massive opinions instead of few expert comments than the consumers from the western people. Meanwhile, the modern consumers tend to like ranges of different theme restaurants with different, diversified and creative dining experiences (Lego, Wood, Mcfee, & Solomonm, 2002; Weiss, Feinstein, & Dalbor, 2004). However, there is a paucity of research to identify the impact factors of attracting customers in the hospitality industry. Wang and Hung (2015) had examined the influencing factors of customers' satisfaction and behavior intention in the most popular travel platform in China – Ctrip. They summarized seven key factors – environmental atmosphere, room facility, other amenities, service quality, location, cleanliness, value for money and empirically claimed that these key factors had the positive impact on the satisfaction and behavioral intention in the Ctrip platform. Based on the literature review, this paper investigated the impact of food rating, service quality rating, environment rating, number of posting, overall rating, score given with a control variable of average spending on page views of landscape restaurants.

## Methods

Due to the dependent variable of page view having the characteristics of left censored with zero, the traditional multiple regression could not fit this data. Hence, this paper used the truncated regression model with the bootstrapped procedure to investigate the determinants of number of page views for landscape restaurants. Fig. 1 illustrated one example of the user generated contents for one observed restaurant from Ipeen website including number of photo posting, overall rating, food rating, service quality rating, rating for environmental atmosphere, number of collection, number of posting, number of score given, number of page views, location to Mass Rapid Transit (MRT) station, average spending, number of seats (however, there are very few restaurants having this data, hence, this paper eliminate this control variable.).



Figure 1. One example UGC retrieved from Ipeen.

This paper used average spending as the control variable. There are 750 landscape restaurants from the Ipeen platform. 558 valid restaurant UGC data are collected. This paper utilized the regression method from Zhang, Ye, Law & Li (2010). However, due to the left censored of page view, this paper used the truncated regression with the bootstrapped procedure to identify the influencing factors of page view in the following equation (1):

$$\ln(\text{Page\_views}) = \beta_0 + \beta_1 \text{Food}_i + \beta_2 \text{SQ}_i + \beta_3 \text{ENV}_i + \beta_4 \text{Score}_i + \beta_5 \text{Rating}_i + \beta_6 \text{Post}_i + \beta_7 \text{AvgS}_i + \beta_8 \text{NOC}_i + \beta_9 \text{Loc}_i + \beta_{10} \text{Photo}_i + \varepsilon_i \quad (1)$$

Where *Page\_views* is the number of page view, *Food*, *SQ*, *ENV* and *Rating* are the ratings for food, service quality, environment and overall rating, respectively; *Score* is number of score given, *Post* is number of posting, *Loc* is the walking time from the

landscape restaurant to the nearest MRT station, *AvgS* is the average spending, *NOC* is the number of collection for landscape restaurants, *Photo* is the number of photo posting,  $\varepsilon_i$  is the error term.

Figure 2 shows the research structure indicating the dependent variable (page view proxy for popularity), independent variables (the ratings for food, service quality, environment and overall rating, respectively; number of score given, number of posting, the walking time from the landscape restaurant to the nearest MRT station, the average spending, the number of collection for landscape restaurants, the number of photo posting and control variable (average spending)

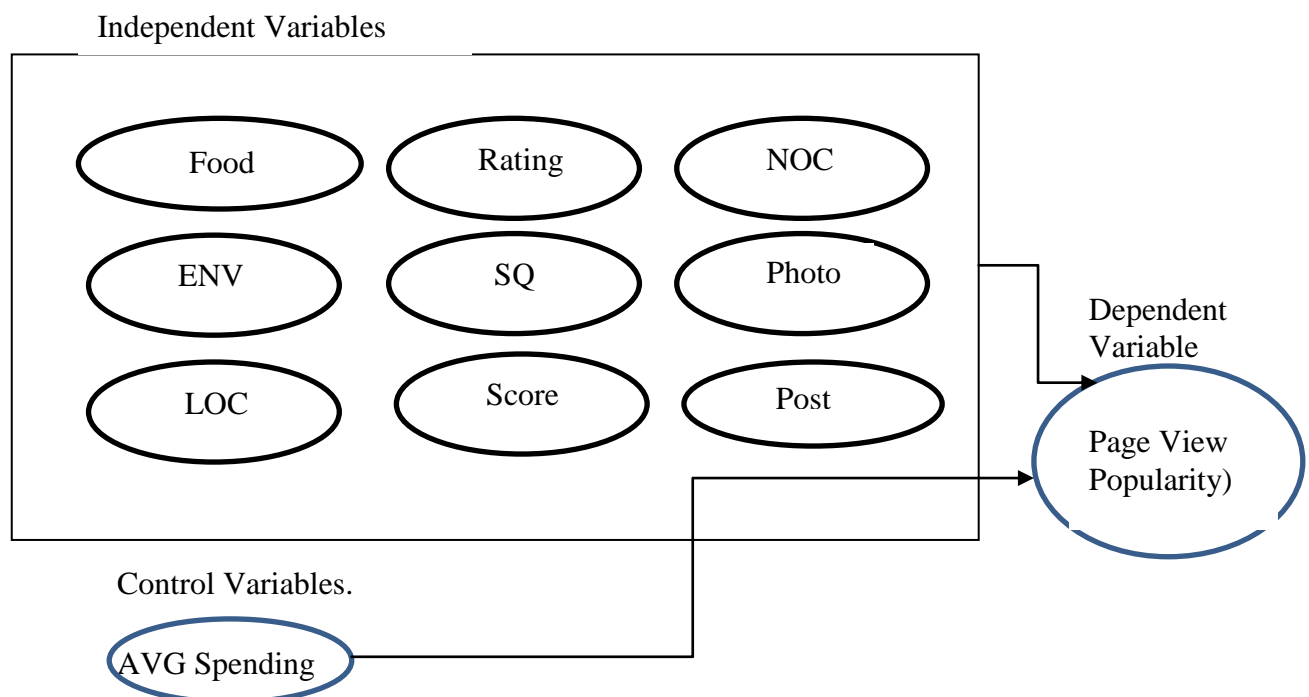


Figure 2. The research framework

## Results and Discussion

### Descriptive statistics

Table 1 shows the descriptive statistics. It indicates that the number of page view is ranging from 153 to 17,500,000 revealing the extremely different popularity within these observed landscape restaurants. The average spending in the observed landscape restaurants is NT\$429 with the 558 observed samples. Regarding the viewers' rating, the average overall rating is 3.32. The rating for environment is 3.26, which is the highest average rating among the other two ratings indicating the consumers more satisfied with the environment in the landscape restaurants compared to the food and service quality.

**Table 1 : Descriptive statistics**

Variable	Obs	Mean	Std. Dev.	Min	Max
No of collection	750	61.36	131.83	0	996
No of photo	629	6.76	6.72	0	24
AVG spending	558	428.92	387.52	20	4050
Score given	750	9.65	16.60	0	128
No. of posting	750	7.65	13.15	0	111
Overall rating	750	3.32	1.84	0	5
Page views	750	194613.30	1015640.00	153	1.75E+07
Rating for SQ	728	2.77	1.71	0	5
Rating for Env.	737	3.26	1.89	0	5
Rating for Food	717	2.73	1.70	0	5

### Result from the truncated regression

The truncated regression with 2000 bootstrapped procedure is to examine the influencing factors of numbers of page view. The more page views show the more popularity of the landscape restaurants. The empirical results in table 2 indicated that service quality rating, score given had significantly positive impact on the page views. This result had argued that the beautiful environment and delicious cuisine seems not to get more page views in the landscape restaurants, in contrast that it might be suggested that the service quality of the landscape restaurant would probably attract the viewers' attention.

**Table 2 : Truncated regressions with 2000 bootstrapped procedure - Dependent variable: Page view**

IV	Coefficients		Bootstrap	Normal-based	
			Std. Err.	[95% Conf. Interval]	
No. of collection	-826.31		746.20	-2288.84	636.23
Location to MRT	1355.98		1254.41	-1102.61	3814.57
No of photo	13536.86		40181.65	-65217.72	92291.45
AVG spending	-101.83		100.77	-299.34	95.69
<b>Score given</b>	<b>43803.04</b>	*	22623.22	-537.65	88143.74
No. of posting	-30077.21		25023.61	-79122.58	18968.17
Overall rating	-104602.10		112833.60	-325752.00	116547.80
<b>Rating for SQ</b>	<b>139173.70</b>	**	69989.01	1997.76	276349.60
Rating for Env.	-78505.83		63410.22	-202787.60	45775.92
Rating for Food	55155.38		40844.56	-24898.48	135209.20
Constant	-85493.75		146375.70	-372384.80	201397.30
Sigma	1035644.00		339496.80		

Log likelihood = -6520.0648, Wald chi2(10) = 34.22;

\*\* p-value <0.05, \* p-value < 0.1

## Discussion and conclusions

### Theoretical Implication

The current study provides a thorough understanding of factors influencing the on-line popularity of the landscape restaurants. This paper suggests that number of score given from the customers and perception of service quality in the landscape restaurants had the significantly positive impact on the on-line popularity in Taiwan. Due to the perception of landscape restaurants, the on-line viewers preferred to focusing on the service quality rather than the stereotype impression on the environment and food quality. This empirical findings proposed that the landscape restaurants with beautiful natural attractions should put emphasis on the service quality and initiate the incentives for viewers willing to give score to the website in order to increase number of page views.

### Managerial Implication

This empirical result suggested that the restaurateurs need to launch the incentives or reward programs to motivate the viewers to grade the landscape restaurants after they had a dining experience. The more viewers who had scoring given lead to more viewers to browse their website. Meanwhile, even though the characteristics of the landscape restaurants are scenic spots, the service quality in the landscape restaurants are the primary driver of the viewers to browse the website. However, due to the remote distance of the landscape restaurants, how to recruit the qualified staff and enhance the service quality are the two essential factors for the landscape restaurateurs.

### Conclusion and future research

This paper collected the UGCs from 750 landscape restaurants in the Ipeen review platform. Compared to the beautiful environment and delicious food, the service quality is empirically proved to be the first essential factors to attract viewers' attention in the landscape restaurants. The future research could include more review platforms to generalize this empirical result to ranges types of restaurants.

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## THE IMPACT OF CONSUMERS' PURCHASE INVOLVEMENT ON CONSUMPTION OF USING O2O: THE APPLICATION OF UTAUT2

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### ABSTRACT

As information technology advances, the popularity of mobile devices and massive wireless access points, consumer purchasing habits have gradually changed. Consumers have enjoyed offline experiences after booking and paying via online to offline/offline to online (O2O). The O2O business model has become the prevailing e-commerce business model in the hospitality industry. However, there is still not enough research to investigate the determinants of consumers' intention and usage in O2O.

This study aims to understand consumers' use intention for O2O on the extended Unified Theory of Acceptance and Use of Technology (UTAUT2) by adding Social Network Services Acceptance Model (SNS). Furthermore, this study also added "product involvement" as a moderator in order to predict their use intention for O2O more precisely.

This study utilized the structural equation modeling (SEM) to analyze the factors of consumers using O2O through smart PLS 3.0. The results from 82 collected samples indicated that facilitating conditions and privacy risk had significant and positive effects on the use behavior of O2O; habit had significant and positive effects on the behavior intention of O2O. The hedonic motivation has a significant positive effect on consumers' intentions of using the O2O, and are moderated by product involvement. The future research and managerial implication are discussed.

**Keywords:** UTAUT2, SNS acceptance model, O2O, product involvement

### 1. Introduction

According to statistics from the Taiwan Network Information Center (2017), the proportion of Taiwan's population who had previously accessed the Internet over the age of 12 has increased from 77.3% to 83.4% from 2012 to 2017. In addition, there are currently more than 500 cities in the world that are covered by Wi-Fi wireless network hotspots, of which Taipei City has the highest coverage (over 90%) and has more than 5,000 wireless access points (Strachan, 2014). Especially in the tourism industry, the ratio of people using the Internet has increased significantly because consumers can not only obtain information

on the Internet and compare price, but also have on-line transactions (Kim, Chung, & Lee, 2011).

The most popular Online to Offline/Online (O2O) platform in Taiwan, such as Gomaji, 17life, KKday are more welcomed by consumers. With the convenience of mobile devices and Wi-Fi, the development of O2O has gradually matured. Consumers can not only make online reservations and pay, but also go offline (physical stores) to personally enjoy the experience. Merchants can use the O2O platform to attract the potential customers to induce physical store sales (Phang, Tan, Sutanto, Magagna & Lu, 2014); they can also develop their own official website or APP to manage customer loyalty. After the actual experience, consumers can post comments and share with other inexperienced consumers in the O2O platform. Phang et al. (2014) have pointed out that the popularity of mobile phones, networks, and social media will make O2O profitable. Many studies had used various theoretical models to analyze individuals' acceptance of or use of information and communication technologies. Some of the most important theories are the Technology Acceptance Model (TAM) (Davis, 1989), Theory of Planned Behavior (TPB) (Schifter & Ajzen, 1985) and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis & Davis, 2003). The extended unified theory of acceptance and use of technology (UTAUT2) was developed by Venkatesh, Thong, and Xu (2012) from the original UTAUT, combining the advantages of TAM and TPB, and was especially used to explain consumer acceptance. UTAUT2 include performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), hedonic motivation (HM), price value (PV) and habits (HB). This study refers to Kondrat (2017)'s research on ICT acceptance and the Social Network Services Acceptance Model integrating constructs of privacy risk (PR), perceived technology security (PTS), and attitude (A) that were not addressed in UTAUT2. This study further included the degree of product involvement (Laaksonen, 1994).

## 2. Literature Review

### 2.1 The extended unified theory of acceptance and use of technology, UTAUT2

Schifter and Ajzen (1985) indicated that attitudes, subjective norms, and perceived behavioral control jointly determined the behavioral intentions, and that behavioral intentions determine individual behaviors. The UTAUT is developed by Venkatesh et al. (2003) and aims to explain the factors influencing employees' acceptance and use of ICTs. Figure 1 demonstrated the difference between UTAUT2, TAM, TPB and UTAUT.

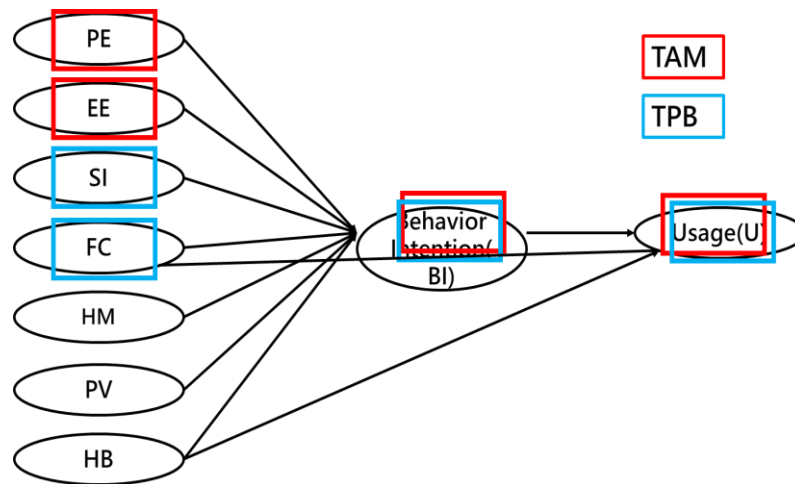


Figure 1. UTAUT2 v.s. TAM, TPB, and UTAUT

## 2.2 Social Network Services Acceptance Model, SNS

In the ICT environment, trust has been proven to be one of the factors that strongly influence usage (Acemyan & Kortum, 2012). Shin (2010) proposed a new model for the study of trust, security, and privacy, and measured 323 users of Facebook and Myspace using AMOS for Structural Equation Model (SEM) analysis. The results showed that the perceived privacy and perceived security are SNS. The main determinants of trust. The basics of this model are related to TAM features: usefulness, ease of use, and enjoyment. Kondrat (2017) used the SNS acceptance model proposed by Shin (2010) in addition to 7 constructs in UTAUT2 to explore college students' acceptance of ICT.

## 2.3 Product Involvement

Lastovica and Gardner (1979) argued that different consumers have different levels of product involvement. Zaichkowsky (1985) believes that product involvement is based on the individual's need, values, and interests. Many scholars have proposed different ways of measuring the degree of involvement. The most commonly used are the RPII proposed by Zaichkowsky (1985) and the CIP of Laurent & Kapferer (1985). The degree of product involvement is based on Zaichkowsky's (1985) empirical study.

## 2.4 Hypotheses Development

Venkatesh et al. (2012) collected 1,512 valid questionnaires and analyzed by structural equation model (SEM). The results showed that Hong Kong consumers' "performance expectancy", "effort expectancy", "social influence", "facilitating conditions", "hedonic motivation", "price value", and "habits" have a significant and positive effect on "behavioral intention" in the use of mobile networks.

Martín and Herrero (2012) used a quota sampling procedure to collect 1,083 valid questionnaires with a random sampling, and then confirmed by regression analysis that the "performance expectancy" and "effort expectancy" of Spanish consumers had significant

and positive effect on the “behavioral intention” of online purchase of rural tourism.

Escobar-Rodríguez and Carvajal-Trujillo (2014) used the theory based on UTAUT2 which proposed by Venkatesh et al. (2012). Using partial Least Square, (PLS) Smart PLS version 3.0 to test the ability of the model. The results showed that the “behavioral intention” of consumers using new technology (low-cost-airline e-commerce websites) is influenced by “performance expectancy”, “effort expectancy”, “facilitating conditions”, trust, consumer innovation and “price value”.

Harsono and Suryana (2014) invest Line users in Bandung, Indonesia, aged between 19 and 24, collected 419 valid questionnaires, and use SEM to confirm that the “performance expectancy”, “effort expectancy”, “social influence”, and “facilitating conditions”, "hedonic motivation" and "habit" have a significant and positive effect on the use of social media's "behavioral intention".

Baptista and Oliveira (2015) used UTAUT2 as a model to examine the “performance expectancy”, “hedonic motivation”, and “habit” of 252 African users through SEM, which has a significant and positive impact on “behavioral intention” on the use of mobile banking.

Hew, Lee, Ooi and Wei (2015) collected 288 valid questionnaires in Malaysia and tested their "performance expectancy", "effort expectancy", "social influence", "facilitating conditions", "hedonic motivation", "price value", and "habit" have a significant positive effect on the "behavioral intention" of using mobile apps by SEM.

Slade, Dwivedi, Piercy, and Williams (2015) collected 288 valid questionnaires and used SEM to make sure that "performance expectancy" and "social influence" have a significant and positive effect on "behavioral intention" of using mobile payment.

Bhatiasevi (2016) collected 272 valid questionnaires from two universities’ students, consumers from department stores, and bank customers in Thailand through convenient sampling. With AMOS path analysis, there is a significant positive effect on “performance expectancy”, “effort expectancy”, and “social influence” to “behavioral intention” of mobile banking.

Kondrat (2017) used SEM to analyzed 402 Polish undergraduates, showing that “performance expectancy”, “facilitating conditions”, and “habit” have a significant impact on the “behavioral intention” of using ICTs.

Based on the above references, the following hypotheses are established:

H1. Performance expectancy have a significant and positive effect on the behavioral intention of using O2O.

H2. Effort expectancy have a significant and positive effect on the intention to use O2O.

H3. Social influences have significant and positive effects on behavioral intentions using O2O.

H4a: Facilitating conditions have a significant and positive effect on the intention of using O2O.

H5: The hedonic motivation has a significant and positive effect on the intention of using O2O.

H6: The price value has a significant and positive effect on the intention of using O2O

H7a: Habits have significant and positive effects on behavioral intentions using O2O.

Kondrat (2017) used SEM to analyzed 402 Polish undergraduates, showing that “facilitating conditions” has a significant impact on the “usage” of ICTs; Baptista & Oliveira (2015) stated that a series of facilitating conditions (such as the online teaching of mobile banking or the support of chat functions) will make users have greater willingness to use new thing, so the following hypothesis is made:

H4b: Facilitating conditions have significant and positive effects on the usage of O2O.

Habits have a direct influence on the use of technology, and habit has strong impact on behavioral intention because strong habits will ignore conscious intentions (Limayem et al., 2007); Harsono and Suryana (2014) invest Line users in Bandung, Indonesia, aged between 19 and 24, collected 419 valid questionnaires, and use SEM to confirm that the "habit" has a significant and positive effect on the “usage” of social media. Escobar-Rodríguez and Carvajal-Trujillo (2014) used Smart PLS 3.0 to test model’s ability. The results showed that the behavior of consumers using low-cost-airline e-commerce websites is significantly affected by habit, so this hypothesis is established:

H7b: Habits have significant and positive effects on the use of O2O.

Harsono and Suryana (2014) invest Line users in Bandung, Indonesia, aged between 19 and 24, collected 419 valid questionnaires, and use SEM to confirm that the "behavioral intention" has a significant and positive effect on the “usage” of social media. Bhatiasavi (2016) collected 272 valid questionnaires from two universities’ students, consumers from department stores, and bank customers in Thailand through convenient sampling. With AMOS path analysis, there is a significant positive effect on “behavioral intention” to “usage” of mobile banking. Kondrat (2017) used SEM to analyzed 402 Polish undergraduates, showing that “behavioral intention” has a significant impact on the “usage” of ICTs, so this hypothesis is established:

H8: Behavioral intention using O2O has significant and positive effects on the use behavior of O2O

In addition, this study will collect relevant research literature using UTAUT2 in the past five years, as shown in Table 2, in order to facilitate comparative analysis after the event.

**Table 2.** Literature review of UTAUT2

references	industry	country	PE	EE	SI	FC	PV	HM	Habit
Baptista and Oliveira (2015)	Mobile banking	Africa	S	NS	NS	NS	NS	S	S
Escobar-Rodríguez & Carvajal-Trujillo (2014)	Low-cost Airline booking website	Spain	S	S	NS	S	S	N/A	NS
Harsono & Suryana (2014)	Social media	Singapore	S	S	S	S	NS	S	S
Hew, Lee, Ooi, & Wei (2015)	APP	Malaysia	S	S	NS	S	NS	S	S
Justyna Kondrat (2016)	ICT	Poland	S	NS	NS	S	NS	NS	S
Venkatesh, Thong, & Xu (2012)	Mobile internet	Hong Kong	S	S	S	S	S	S	S

\*S, significant effect; NS, no significant effect; N/A, untested.

Privacy Risk (PR) is strongly related to users' perceptions of their personal information (Metzger, 2006). According to users' belief that ICTs protect their privacy, their overall view of privacy risks is more positive, so privacy risks positively influence behavioral intention and usage (Shin, 2010),

The more an individual can feel the security of ICT, the more he or she will have more behavioral intention and usage of technology (Cheng, Lam, & Yeung, 2006).

Attitude positively influence “behavioral intentions” of use. It is important that attitudes are malleable (Ajzen, 2005), as it may change over time (Foltz, Newkirk, & Schwager, 2016)

Shin (2010) conducted a structural equation model analysis 323 Social Network Services (SNS) users and found that “privacy risks” and “perceived technological security” has a significant impact on the “behavioral intention” and “usage” of SNS.

Kondrat (2017) used SEM to analyzed 402 Polish undergraduates, showing that “privacy risks”, “perceived technological security”, and “attitude” has a significant impact on the “behavioral intention” and “usage” of ICTs. Therefore, hypotheses are proposed:

H9a: Privacy risks have a significant and positive impact on the behavioral intention of using O2O.

H9b: Privacy risks have a significant and positive impact on the usage of O2O.

H10a: Perceived technological security has a significant and positive impact on the behavioral intention to use the O2O.

H10b: Perceived technological security has a significant and positive impact on the usage of the O2O.

H11a: Attitude has a significant and positive effect on the behavioral intention to use O2O.

H11b: Attitude has a significant and positive impact on the usage of O2O.

Verbeke and Vackier (2004) believed that a highly involved individual will actively collected relevant information. Chen and Huang (2013) in the study of factors affecting consumers' willingness to purchase fast food, analyzed 435 subjects with the structural equation model, and found that the higher the degree of involvement, the more uncertainty that it can reduce the individual's perception of the food tracking system, so this study establish the following hypotheses:

H12a: Performance expectancy has a significant positive effect on consumers' behavioral intention to use the O2O, and will be moderated by product involvement.

H12b: Effort expectancy has a significant positive effect on consumers' behavioral intention to use O2O, and will be moderated by product involvement.

H12c: Social influence has a significant positive effect on consumers' behavioral intention to use O2O, and will be moderated by product involvement.

H12d: Facilitating conditions has a significant positive effect on consumers' behavioral intention to use O2O, and will be moderated by product involvement.

H12e: Hedonic motivation has a significant positive effect on consumers' behavioral intention of using O2O, and will be moderated by product involvement.

H12f: Price value has a significant positive effect on consumers' behavioral intention to use O2O, and will be moderated by product involvement.

H12g: Habit has a significant positive effect on consumers' behavioral intention of using O2O, and will be moderated by product involvement.

### 3. Methodology and Research Model

The survey was used a convenient sampling and distributed 92 questionnaires on the internet through Gomaji FB Fans club and gave them a lucky draw chance. Most of the scales were adapted from Venkatesh et al. (2012). The items in the scale were modified to fit the O2O context. All the items were measured using a seven-point Likert scale with the anchors strongly agree to strongly disagree.

Structural equation modelling (SEM) using PLS3.0 was utilized to analyze collected data. The instrument demonstrates evidence of composite reliability (values>0.070 in all occasions). The figure 2 below comes out of the research model of this research.



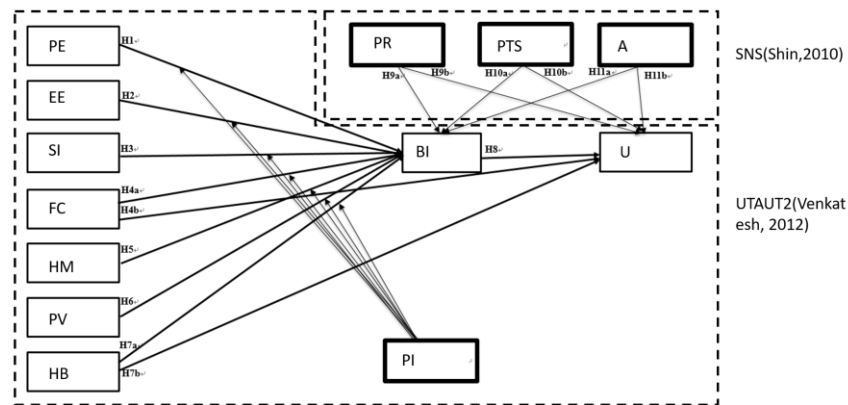


Figure 2. Research model

## 4. Results and Discussion

### Results

Finally, we collected a total of 82 valid questionnaires (89.1% response rate), which included 56 women and 26 men; 9 people under the age of 20 (11%), 52 people in 21-25 (63.4%), 8 people in aged 26-30(9.8%), 7 people in aged 31-35(8.5%), 3 people in aged 36-40(3.7%), and 2 people in aged 41-45(2.4%), 1 people over the age of 51(1.2%). Apart from students, they are mostly Public servant.

The results in table 3 indicated that “facilitating conditions” have significant and positive effects on the usage of O2O; Habit has a significant and positive effects on behavioral intention of using O2O; Privacy risks have a significant and positive impact on the usage of O2O. The results supported H4b, H7a, H9b, and H12e.

### Managerial Implication

The empirical findings of this research provide useful implications for practitioners. Understanding the constructs in the proposed research model is crucial for O2O retailers in Taiwan, as well as emerging economies, so that consumers can trust and adopt O2O.

For facilitating conditions, the manager should keep promoting good image and rich benefits that use of ICT brings along. Individuals indicated that the feeling they have around websites and platform attracts them to O2O (Kondrat, 2016). The manager should also educate and promote types of actions to customers to increase the support given to users as facilitator condition, as well as on-line help provided in an easier way and available to the users (Zhou et al., 2010).

For habit, when consumers face a changing environment, consumer habits have a major impact on the use of personal technology (Venkatesh, 2012). In the launch of the O2O business model, when advertising is released, it can be emphasized that consumption in this way has become the mainstream of the contemporary. The practitioners can release the advertisement that make consumers believe that O2O is the trend of the sociality.

For privacy risk, O2O retailers need to provide social support to people, which may

reduce their perceived risk and help in building self-assurance toward O2O. A recent study has also found that addressing concerns of risk is likely to enhance usage (Lian and Yen 2014). The practitioners should maintain their online information system periodically to make sure the safety of the data maintenance.

**Table3.** The results of PLS analysis

Hypothesis	Path coefficient
H1. PE>BI	0.180
H2. EE>BI	0.133
H3. SI>BI	0.125
H4a. FC>BI	0.085
H4b. FC>U	0.267*
H5. HM>BI	0.238
H6. PV>BI	-0.240
H7a. HB>BI	0.455**
H7b. HB>U	0.063
H8. BI>U	-0.038
H9a. PR>BI	0.059
H9b. PR>U	0.312**
H10a. PTS>BI	-0.090
H10b. PTS>U	-0.081
H11a. A>BI	0.094
H11b. A>U	-0.029

Note: \*p<.05, \*\*p<.005, \*\*\*p<.001

The results in table 4 indicated that the hedonic motivation has a significant positive effect on consumers' behavioral intentions of using O2O, and will be moderated by product involvement. It means that people nowadays would like to spend times on looking for something for fun. The practitioners should design the websites or APP more interesting or provide unique and unexpected service.

**Table 4.** The results of product involvement moderate

Hypothesis	Moderated coefficient
H12a.	-0.206
H12b.	0.101
H12c.	-0.052
H12d.	-0.040

Hypothesis	Moderated coefficient
H12e.	0.246*
H12f.	-0.152
H12g.	0.037

Note: \*p<.05, \*\*p<.005, \*\*\*p<.001

## 5. Conclusions and future research

O2O has infiltrated into the life of the Taiwanese people unconsciously. Many people actually do not know that they are already using the O2O in their daily lives. By filling in the questionnaire, the participants are more aware of the decisions they make in their daily lives. This research is aimed at the hospitality and tourism industry, and discusses consumers booking restaurants, hotels or purchases of tours, SPAs, gyms, movies, concerts, catering, tourism, and entertainment, etc on the O2O platforms, websites, apps, and the official websites. The results and discussions could give some advices to merchants themselves, as well as the platforms practitioners.

Jack Ma, founder and chairman of e-commerce behemoth Alibaba Group Holdings Ltd put forward the new form of e-commerce, new retail. New Retail is a term that roughly indicates a combination of the best in physical and online retail. It is making the distinction between physical and virtual commerce obsolete. The future research could explore more about the quality or acceptance of new retail.

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