AN ESTIMATION OF THE DIFFUSION OF INTERNET: THE CASE OF HEILONGJIANG PROVINCE IN CHINA

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Abstract

Based on the theory of innovation diffusion, we use Bass, Exponential, Logistic and Gompertz models to analyse the Internet diffusion of Heilongjiang Province and try to compare and find a suitable model that can describe its current Internet diffusion state. The result shows that Gompertz model has the best performance in describing its current diffusion. We found that intimation effect is low in the Internet diffusion. Also we found that the Internet diffusion rate will continue to increase and the maximum rate of diffusion is predicted to appear around the year of 2035, and the diffusion will end with about 52.1% penetrated rate. We provide some suggestions for the decision of provincial communications agency (PCA), which will also have reference value for other similar regions.

Keywords: Internet, Innovation Diffusion, Growth Curve.
1 INTRODUCTION

Since China accessed the Internet officially on April 20th 1994, its number of Internet user had increased from five thousand to over eight million by the end of 1999 (Foster et al. 2000). The global Internet bubble crisis occurring in 2000 slowed down the Internet diffusion rate in China. In 2002, some Internet applications, such as online chatting, online gaming and Web-based short message services (SMS) emerged and enabled the speed of Internet diffusion to rise again. In 2004, China became the world’s second largest Internet market (94 million Internet users) following U.S. (Zhu & Wang 2005). By the end of June 2008, Internet user scale of China had exceeded U.S. to be the number one in the world, and its Internet penetration rate catching up and exceeding the global average level of 21.9% (CNNIC 2009). By the end of June 2010, the Chinese Internet users reached 420 million, Internet penetration rate rose to 31.8% (CNNIC 2010).

Internet is changing most people’s lifestyle with their diffusion as a booming communication technology. Many scholars studied Internet diffusion, since it is important to the society, economy, culture and other aspects. Some of them found out the factors which influence the diffusion speed by comparing Internet diffusion of different countries or regions. Researchers transformed the study from combining with social and economic factors to analyse the rules of Internet diffusion. By now, the models used in Internet diffusion are mostly Exponential model, classical S-shape growth curve model—Logistic model, Gompertz model, and Bass model (also called innovative products growth model proposed by Bass in 1969). Among them, Bass model has been widely used because it is easy to be expanded and its parameters have universal economic significance. Bass model has been used into medicine, education, agricultural, industrial technology, retail service, durable consumer goods, and other industries’ technology or product diffusion field.

Heilongjiang Province is located in the Northeast of China, and its Internet penetration rate is about 24% by the end of June 2010, which is great lower than the average level in China. This paper attempts to use different diffusion models to fit and predict the Internet diffusion of Heilongjiang Province, and choose the best model for analysing and predicting the current phase, which will provide suggestions for the decision of provincial communications agency (PCA). Heilongjiang Province is a typical city with developing heavy industry, studying about its Internet diffusion will also have references to other similar regions over the world.

The rest of the paper is organized as follows. In the next two sections, we propose some definitions after discussing the relevant literature. Innovation diffusion theory, growth curve and the market potential are illustrated. In Section 4, we present a research design framework and describe the data and the models. Section 5 presents the results and our analysis. Finally, we conclude managerial implications and directions for future research in Section 6.

2 LITERATURE REVIEW

Internet technology diffusion rules have been studied by many scholars. Goodman et al. propose that there is region developing unbalance on Internet technology diffusion because of the obstacles from culture, technology, policy, law and other respects (Goodman et al. 1994). Ferle et al. (2002) analyse the similarity and difference between Japan and U.S.’s Internet diffusion on culture consideration. Kiiski & Pohjola (2002), Zhao & Kim (2008) and Wunnava et al. (2008) all use cross-year cross-country Internet diffusion data to establish regression models to find the significant effect factors to Internet diffusion. Press et al. (1998) propose a six-dimension framework (pervasiveness, geographic dispersion, sectorial absorption, connectivity infrastructure, organizational infrastructure, and sophistication of use) to investigate the Internet diffusion, and analyse the different situations of 21 developing countries with the way of scoring. In 2000, Forster et al. (2000) analyse the Internet technology diffusion situation of China based on economic, politics, policy and the six-dimension Internet diffusion framework. Some other scholars try to interpret the Internet diffusion by applying innovation diffusion models. For example, Rai & Samaddar (1998) use Logistic, Gompertz and
Exponential models to fit and predict American Internet diffusion data in 1998, the result shows that Exponential model is better than contagion models (Logistic and Gompertz models), they also propose that contagion models always explaining the diffusion from the internal effect, but ignoring the external effects such as government policy, sponsorship, commercial sponsorship and technological developments. After analysing 20 information innovation technologies, Teng & Guttler (2002) choose Bass model from several diffusion models, and find that the external influence as represented by the coefficient of innovation is extremely small and the internal influence dominates the diffusions for all innovations. Dutta & Roy (2003) incorporate external factors from perspective of system dynamics in Exponential, Gompertz and Logistic models to fit the Internet diffusion data of United States and India, which provides a better Internet diffusion prediction result.

In China, Jianbin (2001) and Jianbin & Kete (2006) state and analyse the phenomenon of region disequilibrium of internet diffusion in China mainland, which is also called digital division. Combined with product diffusion impact factors, Zhang et al. (2002) use Bass model to do an empirical analysis on Chinese Internet access number, and predict the Internet diffusion the next few years. According to Zhu & Wang (2005), Chinese Internet user numbers in the 10 most developed provinces and cities (mostly eastern coastal cities) are three times more than the 10 least developed inland provinces, and more young people and college students use the Internet in developed provinces. Chen et al. (2007) also use Bass model to predict China's Internet user number.

Above all, most recent literatures on Internet diffusion focus on exploring Internet diffusion rules from the perspective of innovation diffusion. They use diffusion models to fit, predict and analyse Internet diffusion data, and establish the linear regression equation with different impact factors to fit, predict and analyse the diffusion data. They usually use countries or regions as research objects, and the data they collected are mostly the year, half a year or quarterly data. We attempt to explore the Internet diffusion of Heilongjiang Province through the monthly data, find out current diffusion's characteristics, and predict its future diffusion in this paper. We also promote some management advices to the communication industry of Heilongjiang. According to existing literatures, the regions of the same developing level in the same country have a certain similarity in the Internet development (Zhao et al. 2008); the research result will also have reference value to similar developing level regions and some related industries.

3 RELEVANT DEFINITIONS

Innovation diffusion theory: Innovation contains new products, new ideas, new methods, new systems and even new social entities (Chandrasekaran & Tellis 2007). Rogers (1983) from University of New Mexico proposes the famous diffusion of innovations theory in his book “Diffusion of Innovation”. Diffusion of innovation starts slowly, and when the adopters are accumulated to a certain number (critical point), the diffusion process accelerates suddenly, and goes into the take-off phase, this process will continue until the most potential adopters of the system adopt the innovation. Then the diffusion rate gradually decreases until it reaches saturation point. Through the whole diffusion process, the number of the accumulated adopters shows S-track over time. Rogers divided innovation adopters into four types: innovators, early adopters, early majority, late majority, and laggards. Diffusion process is influenced by four elements: innovation characteristics, communication channels, time elapsed since the innovation was introduced, and social systems.

Growth curve: Growth curve is also known as S-curve. Many communication products’ diffusion process follows growth curve, such as the number of fixed phone users, mobile phone users, and Internet users. Communication products which haven’t developed to the stagnation period could be fitted and predicted by growth curve. The development of most communication products meets the following procedure (GPDMII 2001) (see Figure 1.)

- Phase of entering (before A). When communication products first enter the market, due to lack of management, maintenance, costs, market demand and other factors, the supply capacity is insufficient, resulting in slow development of the business.
- Phase of growth (from A to B). As the level of management, network maintenance, marketing and other aspects continuously improve, market demand increases significantly, the business volume
grows rapidly, and the diffusion is accelerated. The inflection point C is between A and B, and it is the peak sale time when the cumulative sales is approximately one-half the market potential ($M$).

- Flat phase (after B). Finally, the market reaches the saturation point, the diffusion develops slowly, and the cumulative value is going to be stable.

![S-Shape Growth Curve](image)

Figure 1. S-Shape Growth Curve

The market potential ($M$): As described by growth curve, when product diffusion gets into the saturation stage, the diffusion is going to be stabilized, the accumulated amount of diffusion will stop in a relatively fixed number, and we call it the market potential. As the Internet industry is developing, many new applications have emerged, at the meanwhile their value-added features are widely recognized and used by people, it’s reasonable to assume that, if the diffusion is sufficient the market potential of Internet should be the number of all the households.

4 RESEARCH DESIGN

In this paper, we first collect the data, and then use the classic models in innovation diffusion field to fit the data and undertake predicting. Combined with the Heilongjiang Province’s situation, we select the best model based on the model fitting, prediction precision and parameters’ reasonability. Furthermore, we will try to reveal the rules of Heilongjiang Internet diffusion, and provide management advices for related management departments. The research framework is shown in Figure 2.

4.1 Data and Research Method

We use Internet access data of Heilongjiang Province provided by the Heilongjiang Provincial Communications Administration to undertake our research and try to find which model is suitable for describing the rules of Internet technology diffusion of Heilongjiang Province. We got 75 monthly Internet access numbers which are from Jan. 2005 to Mar. 2011. The curve of diffusion process is shown in Figure 3. Since the Internet access data of Heilongjiang Province first shown in the statistics of the year 1999, we assume that Jan. 1999 is the start point of Internet diffusion, and therefore our monthly data’s time is from 73 to 147.

From the original data curve, we can easily find that the diffusion curve of the number of Internet access in Heilongjiang is not very smooth, and in a few paragraphs there are obvious fluctuations. We carefully observe and find the following characteristics:
Figure 2. The Research Framework

- The 75 data points have an upward trend in overall.
- The 75 data display obviously linear in overall.
- At the end of one year, the data slow down, but at the beginning of the next year the data rise up again.
- The later few data show that the diffusion process is still increasing.

Figure 2. Monthly Data from Jan. 2005 to Mar. 2011

From the diffusion data, we are not sure whether the data contain the inflection point of the diffusion curve. So we try to use four candidate models, Bass model, Exponential model, Logistic model, and Gompertz model, to fit and predict the data. We use the first 69 data for model fitting, the last 6 data for predicting. We use three indicators: the parameters’ reasonability, index of goodness of fit \( (R^2) \) and the mean absolute percentage error \( (MAPE) \) to judge the models. \( MAPE \) is used to measure the predictive ability of a model (Dutta & Roy 2003), and the formula of \( MAPE \) is shown as below.

\[
MAPE = \frac{1}{k} \times \sum_{i=1}^{k} \left| \frac{x_i - \hat{x}_i}{x_i} \right| \times 100\%
\]  

(1)
Where, \( k \) is the number of time points that need to predict, \( x_i \) is the actual value at time \( t_i \), and \( \bar{x}_t \) is the predicted value at time \( t \).

4.2 Models Employed

As described in existing literatures, during the process of Internet developing, many researchers have tried to use a variety of growth curve models to explain the Internet diffusion. The diffusion models can be generally divided into three categories: the external diffusion model (e.g. Fourt-Woodlock model), the internal diffusion model (also known as contagion model, e.g. Logistic and Gompertz model), and mixed diffusion model (e.g. Bass and its extension models).

The communication product can be considered as the outcome of innovative technology, which also follows the law of contagion model of technology diffusion. So in the early stage, scholars who studied the diffusion of communication products were mostly concentrated on the internal diffusion model such as Logistic model and Gompertz model. While in the later researches, scholars found that external factors cannot be ignored in the diffusion process of communication products, therefore, Exponential model, Bass and its extension models were introduced. Among those models, Exponential model is better at fitting and predicting the diffusion which is in the stage driven only by innovation processes, and Bass model is better when the data includes the inflection point (Chandrasekaran & Tellis 2007). We chose Bass model, Exponential model, Logistic model and Gompertz model for the data analysis and forecasting.

4.2.1 Bass Model

Previous researches have shown that when the inflection point is contained in the diffusion data, Bass model is more reliable on forecasting (Chandrasekaran & Tellis 2007). According to Rogers’ classification of adopters, Bass made a few assumptions which can be summarized as follows (Bin 2002; Frank 1969):

- Only considering the case of initial purchase, that is, assuming repeat-purchases are excluded under the same level products, and one buyer only adopts one unit innovation product.
- The market potential remains unchanged over time.
- One innovation’s diffusion is independent from any others’.
- The innovation product’s performance remains unchanged over time.
- The geographical boundary of the social system does not change during the diffusion process.
- The diffusion only has two steps: non-adoption and adoption.
- One kind of innovation isn’t affected by marketing strategy.
- Supplying constraints do not exist.
- Adopters have no difference, that is, they are homogeneous.

The accumulation expression of Bass model is as follows:

\[
N(t) = M \times \frac{1 - e^{-(p+q)t}}{1 + \frac{q}{p} e^{-(p+q)t}}
\]

(2)

Where \( N(t) \) means the accumulate number of adopters at \( t \) moment, \( p \) is the innovation coefficient, which is also known as the coefficient of external influence, inferring to the impact of advertisement, government policy etc.; \( q \) is the imitation coefficient, also known as the coefficient of internal influence, mainly aimed at the impact of technology diffusion from adopters’ words-of-mouth to the non-adopters. \( M \) is the value of the market potential. \( p \)'s and \( q \)'s values are between 0 and 1. The inflection point, which is also called the peak sale time, appears round the moment \( T^* = 1/(p + q) \ln(q/p) \), and if an interior maximum exists, \( q > p \) (Frank 1969).
4.2.2 Exponential Model

As described in the previous article, when \( q \) is zero, Bass model reduces to an exponential function assumed driven only by innovation processes. It can describe the situation the diffusion increases rapidly (Bernhardt & Mackenzie 1972; Fourt & Woodlock 1960). The Exponential model is as follows.

\[
N(t) = b \cdot e^{ar}
\]

(3)

Where \( a \) is rate of product’s diffusion, and \( b \) determines the curve’s position on the timeline.

4.2.3 Logistic Model

In Bass model, when \( p \) is zero, external factors are not considered. And the diffusion of products is driven only by words-of-mouth from adopters to non-adopters. This pure imitation model (or called the model containing internal impact only) is suit for the case that the innovation’s features cannot be easily identified or the case of strong network externalities. At the meanwhile, the model is also called a logical curve (Logistic) model.

\[
N(t) = \frac{M}{1 + b \cdot e^{-at}}
\]

(4)

Where, \( a \) indicates the imitation coefficient, \( b \) is a constant, which determines the S-curve’s position on the timeline. In Logistic model’s curve, the biggest diffusion rate, also is the inflection point, is at 50% of the saturation level (Rai et al. 1998). The inflection point appears round the time \( b/a \).

4.2.4 Gompertz Model

As one of the classical contagion models, Gompertz model is widely used in innovation diffusion models fitting and predicting, the model’s expression is as follows.

\[
N(t) = M \cdot e^{-b \cdot e^{-at}}
\]

(5)

Where, \( a \) and \( b \) are the same meanings as the ones in Logistic model. The difference is, in this model curve, the inflection point \((b/a)\) appears at 37% of the saturation level (Rai et al. 1998).

4.3 Parameter Estimation

As for estimation algorithm of the model parameters, researchers have used ordinary least squares (OLS), nonlinear least squares (NLS), genetic algorithms (GA), the maximum likelihood estimation (MLE), the global search algorithm based on genetic algorithms (GA-NLS), ant colony optimization (ACO), cellular automata algorithm (CA), Kalman filtering method and so on. According to whether the parameters are changing over time or not, estimation methods can be divided into time-invariant and time-varying methods. The basic idea of time-varying estimation method is the estimation value of the parameters will be constantly revised with more available diffusion data (Zhenhua, 2009). The main purpose of this paper is to do theoretical research of Internet diffusion in Heilongjiang Province and give some management advice, so we don’t concentrate on time-varying estimation method which is more complex and still in the exploratory stage, but mainly consider using the time-invariant estimation methods.

Currently, time-invariant estimation methods mainly include ordinary least squares (OLS) and nonlinear least squares (NLS), but the OLS may cause multicollinearity between variables, is easy to produce self-relevant values, and its poor robustness will lead to considerable error around the inflection point. Some scholars try to use genetic algorithms (GA) to solve the local convergence problem in NLS, but research findings are inconsistent between different products. So we choose nonlinear least squares (NLS) algorithm to estimate the parameters.
5 RESULTS AND ANALYSIS

We use SPSS software to fit the data. According to the data from National Bureau of Statistics of China (NBSC), by the end of 2007, the total number of households in Heilongjiang Province was about 12.88 million. As the annual statistics of households change slightly, we use this household number as the market potential M’s initial value. The fitting results of 75 monthly data are as follows. Since the data show linear characteristic, we fit the linear regression as well.

<table>
<thead>
<tr>
<th>Models</th>
<th>M (10^6)</th>
<th>p</th>
<th>q</th>
<th>R^2</th>
<th>a</th>
<th>b(const)</th>
<th>Inflection point(T*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liner</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.989</td>
<td>3.134**</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Bass</td>
<td>533.480**</td>
<td>0.0014**</td>
<td>0.0218**</td>
<td>0.988</td>
<td>—</td>
<td>—</td>
<td>119.826</td>
</tr>
<tr>
<td>Exponential</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.971</td>
<td>0.015**</td>
<td>39.44**</td>
<td>—</td>
</tr>
<tr>
<td>Logistic</td>
<td>—</td>
<td>a</td>
<td></td>
<td>0.988</td>
<td>0.02752**</td>
<td>24.99**</td>
<td>908.140</td>
</tr>
<tr>
<td>Gompertz</td>
<td>670.658**</td>
<td>—</td>
<td>a</td>
<td>0.989</td>
<td>0.01312**</td>
<td>4.751**</td>
<td>362.119</td>
</tr>
</tbody>
</table>

** Significant level at 5%

Table 1. Models’ Fitting Results

According to Table 1, all model’s parameters have high significant level. As we have seen in Figure 2, the Internet diffusion data obviously fit the linear regression (R^2=0.989). We thought it is because the diffusion data belong to the right segment of the S-shape curve, which appearing linear shape. Since we know the Internet diffusion can be described by the innovation diffusion models, focusing on the linear regression parameters is valueless. So we don’t analyze the linear shape any more. In Bass model, the external diffusion coefficient p (0.0014) is lower than the internal diffusion coefficient q (0.0218), this result is correspond with the common sense that in one innovation diffusion, imitation coefficient is always much bigger than the innovation coefficient (Frank 1969). Logistic model and Gompertz models’ imitation coefficients are 0.02752 and 0.01312. The three models’ imitation coefficients, in larger extent, are all much smaller than China’s telecom industry product imitation coefficient (0.16~0.48), which is measured by large number of scholars (Andrés et al. 2010; Pengfei & Xinmei 2009). Therefore, we can conclude that for the current Internet diffusion in Heilongjiang Province, although word-of-mouth is mainly promotes the diffusion, it is still much lower than the China’s telecom industry level.

From the views of fitting ability (R^2), although the four models are all good, Exponential model is the worst, and Gompertz model is the best. Exponential model can fit the exponential growth phase of S-shape growth curve effectively, because the data appear similarly to the exponential shape due to the small imitation coefficient. Furthermore, Bass model can be used to depict the Internet diffusion of Heilongjiang Province. One of the original assumptions of Bass model requires that fitting data contain the inflection point of S-shape growth curve. According to Bass model, the inflection point appears at the moment T*=119.826 (Jan. 2009). In Logistic model, T*=908.140 (Oct. 2080), which means the inflection point appears in 69 years and 7 months later. While in Gompertz model, T*=362.119 (Apr. 2035), which means the inflection point appears in 24 years and 1 months later.

And next, we use the first 69 monthly data (from T=73 to T=141) to fit and predict the last 6 monthly data (from T=142 to T=147). The four models’ predicted values are as follows. From the Table 2, we find that the four models’ MAPE are all within 10%, they all can predict effectively. Bass, Logistic and Gompertz models’ MAPE are all within 5%, they are all better than Exponential model. Among them, Gompertz has the best prediction effect. The predicted values of Bass, Logistic and Gompertz models are all lower than actual level. On the contrary, the predicted values of Exponential model are all higher than actual level. That’s because the last few ones of the 69 data points are nearly to the year-ending data, as we observed, the data slow down when it is close to the end of a year, which may affects the models’ predicting trend.
<table>
<thead>
<tr>
<th>Models</th>
<th>T</th>
<th>142</th>
<th>143</th>
<th>144</th>
<th>145</th>
<th>146</th>
<th>147</th>
<th>MAPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual value(AV)</td>
<td></td>
<td>321.9</td>
<td>328.0</td>
<td>326.6</td>
<td>337.3</td>
<td>339.9</td>
<td>347.9</td>
<td>—</td>
</tr>
<tr>
<td>Bass(PV)</td>
<td></td>
<td>314.2</td>
<td>316.7</td>
<td>319.2</td>
<td>321.7</td>
<td>324.1</td>
<td>326.5</td>
<td>3.91%</td>
</tr>
<tr>
<td>Exponential(PV)</td>
<td></td>
<td>344.8</td>
<td>350.2</td>
<td>355.7</td>
<td>361.2</td>
<td>366.9</td>
<td>372.7</td>
<td>7.49%</td>
</tr>
<tr>
<td>Logistic(PV)</td>
<td></td>
<td>313.4</td>
<td>315.8</td>
<td>318.2</td>
<td>320.5</td>
<td>322.8</td>
<td>325.1</td>
<td>4.25%</td>
</tr>
<tr>
<td>Gompertz(PV)</td>
<td></td>
<td>315.3</td>
<td>318.1</td>
<td>320.8</td>
<td>323.5</td>
<td>326.2</td>
<td>328.8</td>
<td>3.41%</td>
</tr>
</tbody>
</table>

Table 2. Four Models’ Predicting Results

Considering the three indicators, the fitting effect, predicting effect and parameters reasonability, we can see, although Exponential model can be accepted to depict current stage of the Internet diffusion of Heilongjiang Province, it is the worst in the four models, partly due to the diffusion is already not the phase of exponential shape. According to Logistic model, the inflection point appears in 2080, which is too long time and unreasonable. So we removed Exponential and Logistic models from candidate models. According to Bass model, the inflection point has been appeared in 2009, it is earlier than China’s Internet diffusion inflection time (around the year 2021) (Jingjing et al. 2007), which is not according with the fact that the level of Heilongjiang development is always lower than China’s average level. However, due to the actual meaning of its parameters and model’s scalability, we can use the Bass model to give further description on more completed diffusion stage, such as in the stage the diffusion has already reached the inflection point.

Figure 3. Four Models’ Fitted Curves

So we choose Gompertz model as the best model to describe the current Heilongjiang Internet diffusion. According to it, the inflection point will appear around the year 2035. With the current rate, this province’s Internet diffusion’s ultimate penetration rate is only nearly 52.1%1. The intimation coefficient is only 0.01372, that means word-of-mouth effect to Internet diffusion is not strong in this province. Low penetration rate and low intimation coefficient both indicate that the province’s low education level and economic level prevent the Internet’s diffusion from growing better. Poor income

1 \[ M(\text{Gompertz})=670.658, 670.658/1288=52.1\% \]
level makes non-adopters have no money to afford the PCs to access to the Internet. Poor education level may let them feel no need to access to the Internet. These reasons also reduce some diffusion’s network external effect. The government should pay more attention on the education and the interaction between Internet and economic level. Besides, they should encourage the electronic business and electronic government’s development, enforce the broadcast of the Internet and make sure the access price is proper. These all may increase the rate of diffusion from internal and external effects.

6 CONCLUSION

In this paper, we use innovation diffusion theory to analyze Internet diffusion rule of Heilongjiang Province China. Bass model, Exponential model, Logistic model and Gompertz model were used to fit and predict the monthly data of Internet adopters in Heilongjiang Province. We found that for the current stage of Heilongjiang Province Internet, Gompertz is the best model to describe its diffusion. And in the next few years, the diffusion rate of the Internet will continue to grow. Around the year of 2035, the inflection point will appear, and the diffusion will reach the peak sale point and after that the Internet diffusion rate will decrease gradually. We also found that Heilongjiang Internet diffusion intimation effect and ultimate penetration rate are very low, which should be higher. We speculate that when the diffusion reaches the inflection point, Bass model will be more suitable to fit the data.

As mentioned previously, the diffusion of Internet technology is more influenced by social factors, the “soft power” such as economic level and education level, and other factors. That is to say, in a more developed regions, a variety of development needs will push lots of potential adopters to use the innovative technology. Diffusion will be driven by word-of-mouth from adopters to non-adopters. In Heilongjiang Province, economic growth is still mainly driven by the development of heavy industry, and its economic level is relatively backward, the Internet diffusion cannot proceed spontaneously by the internal communication as the dominant driving force. In the future we will consider social factors, such as household income, economic development conditions and education level in the diffusion process, which will provide more detailed advices and recommendations.

Acknowledgements

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