Prediction of soil moisture characteristic curve based on Internet of Things and enterprise e-commerce operation

Yifang Wang¹ · Dashan Niu²

Received: 2 June 2021 / Accepted: 19 July 2021 / Published online: 3 August 2021
© Saudi Society for Geosciences 2021

Abstract
E-commerce has an important influence on China’s economic and social development. The rapidly emerging Internet of Things and other emerging information technologies can promote the revolutionary innovation and development of e-commerce products and industries. Online direct sales channels fully apply the Internet of Things technology and e-commerce. The operations and channels have more power to apply the Internet of Things technology. If offline business operations have stronger advantages than online e-commerce operations, the Internet of Things technology and the diffusion process are incorporated into the database model; when the proliferation of the Internet of Things remains local, e-commerce operations can only obtain higher efficiency and benefits after applying the Internet of Things technology online, to closely integrate the new generation of information technology with traditional operating strategies. At the same time, government support policies have played an important role in promoting the application of a new generation of information technology. The particle gradation, stress status, dry density, etc., in the soil moisture characteristic curve prediction system may change with the operation of the soil in the atmosphere, and these influencing factors are important measurements that affect soil permeability and land water quality characteristics. The prediction of soil moisture characteristic curve, soil permeability, and soil erosion resistance are linked together, and the study of the influence of these influencing factors on soil permeability and soil moisture characteristics on soil water retention is useful for exploring the mechanism of soil erosion and soil erosion. Sexual control measures have very important guiding significance. Therefore, this paper uses the Internet of Things technology to conduct a detailed study on the prediction content of the soil moisture characteristic curve and the process of enterprise e-commerce operations.

Keywords Internet of Things · Soil · Moisture characteristic curve · E-commerce operation

Introduction
At present, the application of a new generation of information technology such as the Internet of Things in China’s e-commerce industries is emerging, giving birth to many models. Some e-commerce companies have introduced the Internet of Things and other related technologies in product sales and logistics to effectively reduce logistics time, innovate business models, and improve consumers’ online shopping experience (Alessio 2019). E-commerce has a major impact on China’s economic and social development. Currently, the rapid growth and development of new-generation information technologies such as the Internet of Things are promising (Arya et al. 2020), driving and promoting the independent innovation and development of China’s e-commerce industry. However, many e-commerce companies are currently exploring and applying the Internet of Things and other new-generation information technologies (Bowa and Xia 2019). There are still many difficulties and challenges, such as how to integrate the new-generation information technology (Feng et al. 2018), how to integrate the new generation of information technology with the company’s existing operating strategy closely, and how to make policies to drive the new generation of information technology to give full play to their effectiveness (Hao and Zhang 2019). This article starts systematic and scientific from the perspective of analyzing these issues in depth; from the perspective
of system science, the function of the system is affected by the surrounding environment and is determined by the structure of the system’s Internet of Things (Kamchoom and Leung 2018). To study in depth how new information technologies such as the Internet of Things directly affect the profitability and operating strategies of the entire e-commerce company, it is necessary to understand the supply chain architecture of e-commerce companies and how the Internet of Things technology affects the system structure and how the supply chain environment directly affects the decisive effect of the structure of the supply chain system on the function of the entire system (Karlis et al. 2018). For saturated soil, the main body of the seepage movement of the soil is liquid water; that is, we need to explore the law of the movement of water in the soil; the three phases of gas, liquid, and solid phases of the unsaturated soil must be available, not only the soil which contains the seepage movement of water but also the seepage movement of gas (Khanna et al. 2019). Therefore, the main body of the soil seepage movement of unsaturated soil is specially used to study the gas transfer seepage movement under the interaction of water and gas in the soil environment (Lan et al. 2020). The structure of this kind of gas is complex and changeable. Therefore, it is still difficult to study the main method of soil seepage movement in unsaturated soil (Li and He 2019). It explains in detail the basic definition of water force in the soil environment and reveals its influence on all water characteristic curves in the soil (Ma and Wang 2015), affecting the function and function characteristics. And from this, comprehensively put forward various soil seepage forces and stress property models under soil seepage, obtaining the basic analysis and calculation formula of seepage force in the soil environment and comprehensively demonstrating and analyzing the diameter and porosity of soil particles (Mulyono et al. 2018). The rate has a direct effect on the permeability and stress properties of sandy soil under soil saturation. The soil moisture characteristic curve directly reflects the law of the internal matrix potential of the soil changing with the soil moisture content, and it is an important measurement method for us to study the current soil hydrodynamics (Pan et al. 2020).

Materials and methods

Sample preparation and test equipment

The fine soil used in the experiment was mainly taken from a sandstone edge slope with a buried depth of 30-50 cm in a certain layer of a certain reservoir section. The soil is basically determined by the physical properties of the solid in the room, and its particle size is less than 2 mm, and the soil particles with a particle size greater than 0.07 mm account for about 79.5% of the total particle content, and the plasticity index is about 14.8. The physical indexes of soil in the natural state are shown in Table 1.

The collected moist soil is dried and crushed, and the soil is passed through a 2.5 mm standard sieve. The sieved concrete particles are spread evenly on a smooth pan, a small amount of distilled water was sprayed evenly with a spray bottle. The soil sample has a water content of w18%, and then, it was put in a sealed bag, set aside for 2 h before mixing evenly, and put it in a moisturizing tank to balance for about one day. The advanced dry layered sample preparation instrument can be used to prepare samples evenly divided into layers. The density condition is controlled as dry density 1.5 g/cm², initial sample void ratio is 0.79, the height is about 80 mm, and the size of the sample is about 80 mm in diameter. There are 35 reshaped specimens of 39.1 mm. The soil used is a remodeled purple soil, which has been subjected to a certain degree of disturbance, with reference to the natural state, combined with the test plan to prepare samples, and the influence of the disturbance is considered to a certain extent.

Calculation of soil permeability

Soil permeability test plan

Saturated sample Pick up the sample from the moisturizing cylinder, use the saturator to assemble the sample, and then put it into the vacuum saturation cylinder. After a period of time, take it out and reweigh the saturation m of the sample. The saturation Sr can be obtained by formula (1). If Sr=1, it is considered that the saturation has been completed. Through many experiments, the saturation duration of the purple soil sample is usually about 3 hours.

\[ S_r = \frac{w d_s \rho_d}{d_s p_w - \rho_d} \]  

(1)

In the formula, w is the water content of the soil (%), \( d_s \) is the relative density of soil particles, \( \rho_d \) is the dry density of the soil (g/cm³), and \( \rho_w \) is the density of water (g/cm³).

Triaxial penetration test For the stress setting of triaxial penetration, the overburden pressure is 0 kPa, 25 kPa, and 50 kPa;

| Proportion | Plasticity index | Liquidity index | Natural moisture content (%) | Natural density (g/cm³) |
|------------|------------------|-----------------|----------------------------|------------------------|
| 2.688      | 14.8             | 0.088           | 20.8                       | 1.68                   |

Table 1 Physical indicators of soil in natural state
the osmotic pressure is 20 kPa, 30 kPa, 40 kPa, and 50 kPa; the confining pressure is 50 kPa, 100 kPa, 150 kPa, 200 kPa, and 250 kPa; and the number and stress state are shown in Table 2.

At the beginning of using the sample or before starting to penetrate, thoroughly consolidate it. For the consolidation stability judgment basis, it does not exceed 0.063 cm³/2 h when its body shape changes and its rated displacement must be controlled within 0.012 cm³/2 h. After the completion of the consolidation test, certain axial stress is applied to the bottom. When the value of the axial stress reaches the specified stress value, the penetration stress test is started, and the count is automatically performed every 60 s. When the average water inflow at the bottom is equal to that at the top, the test work can be completely stopped after the average water flow rate is stable for a certain period of time.

Solving permeability coefficient

Based on Darcy’s law, according to the data of axial displacement, volume change, permeation duration, and permeation water consumption recorded in the actual test, the permeability coefficient of the sample is obtained by formula (2).

\[
k = \frac{Q \rho_w g H}{A \Delta T \rho_p} \times 10^{-6} \text{cm} \cdot \text{s}^{-1}
\]

Calculation of soil-water characteristic curve

For the discontinuously graded soil, the important variable to control its water-holding capacity is the discontinuous ratio \( G_r \). The discontinuity ratio is defined as

\[
G_r = \frac{d_{\max}}{d_{\min}}
\]

For soils with missing particle groups, the particle size is arranged in order from largest to smallest, defining the initial missing larger particle size in the missing particle size range as the discontinuity starting point and the last missing smaller particle size as the discontinuing end point.

In order to facilitate the analysis of the soil and water characteristics under the absence of particle groups, the weighted average particle size is introduced, and the weighted average particle size of the remaining particles of each sample is calculated as

\[
D_i = \frac{\sum_{j=1}^{n} d_i x_j}{\sum_{i=1}^{n} x_j}
\]

G. Fredlund and A. Xing models proposed according to the pore size distribution have wide applicability, and the accuracy of fitting the soil-water characteristic curve is very high. Therefore, this paper uses the F-X model to fit the data of each sample in the experiment. The model expression is

\[
\theta = \frac{\theta_s}{\ln \left( e + \left( \frac{\psi}{\alpha} \right)^m \right)}
\]

Results

Prediction of soil-water characteristic curve based on the effect of missing granular groups

Due to the lack of particles in the middle of the sample, the remaining particles of the missing sample are composed of the remaining large particle size group and the remaining small
particle size group. The particle size and relative size of the two remaining clusters in each sample have differences in content, so for samples with missing granule groups, a comprehensive index (weighted average particle size) should be used to characterize the particle size dispersion state, as shown in Table 3.

It can be seen from Fig. 1 that when the start point of the discontinuity of the soil particles is the same but the end point is different, the impact on the soil-water characteristic curve is different. When the starting point of the discontinuity is the maximum particle size (2 mm) of the particle gradation and the end of the discontinuity is different, the suction is very small, and the water-holding capacity is not much different. At the middle stage, the water-holding capacity is significantly different, and when the suction is large, the difference gradually decreases.

When the start point of the discontinuity is the gradation intermediate particle size, and the end point of the discontinuity is different, for example, when both are 1 mm, the remaining particle composition at this time is a combination of large and small particle size groups. As the end of the discontinuity decreases, the difference of each sample of the remaining particles is composed of the same remaining large particle size group (2-1 mm) and different remaining small particle size groups.

The missing large particle size group and the small particle size group have different effects on the soil-water characteristic curve. The volume water content of the sample with the missing large particle size is greater than that of the continuous particle group (Fig. 2), and the water content of the continuous particle group is greater than that of the missing small particle diameter of the specimen.

**Prediction of soil-water characteristic curve based on dry density and continuous gradation**

It can be seen from Fig. 3 that the dry density has a greater influence on the soil-water characteristic curve. If the dry density is large, the soil-water curve is on the upper side as a whole. The volumetric water content under the same matrix suction is higher, indicating its water-holding capacity. The greater the dry density of the sample, the greater the matrix

| Missing range of particle size (mm) | Sample No. | Volume water content number | Weighted average particle size of the sample $D_i$ (mm) |
|------------------------------------|------------|----------------------------|-----------------------------------------------|
| Continuous granule group           | $D_0$      | $\theta_0$                 | 0.396                                         |
| 2-1                                | $D_{2-1}$  | $\theta_{2-1}$             | 0.291                                         |
| 2-0.5                              | $D_{2-0.5}$| $\theta_{2-0.5}$           | 0.172                                         |
| 2-0.25                             | $D_{2-0.25}$| $\theta_{2-0.25}$         | 0.118                                         |
| 2-0.075                            | $D_{2-0.075}$| $\theta_{2-0.075}$       | 0.038                                         |
| 1-0.5                              | $D_{1-0.5}$| $\theta_{1-0.5}$          | 0.313                                         |
| 1-0.25                             | $D_{1-0.25}$| $\theta_{1-0.25}$        | 0.299                                         |
| 1-0.075                            | $D_{1-0.075}$| $\theta_{1-0.075}$      | 0.472                                         |
| 1-0                                | $D_{1-0}$  | $\theta_{1-0}$            | 1.500                                         |

**Fig. 1.** Soil-water characteristic curves with the same start point and different end points
suction corresponding to the curve beginning to drop, indicating that the greater the matrix suction when starting to drain, the greater the inlet value, and the higher the residual volumetric water content at the end of the curve, finally the more stable the moisture content is.

It can be seen from Fig. 3 that in the entire matrix suction range, the difference in the initial volumetric water content caused by the dry density is more obvious. The sample with a smaller dry density in the early stage of matrix suction has relatively more pores, so its corresponding initial volume. If the water content is higher, as the matrix suction increases, the dry density becomes smaller, the sample displacement becomes greater, the difference gradually decreases, and the curves begin to intersect; in the middle stage of suction, the curves gradually separate and the dry density becomes higher. The higher the sample, the higher the corresponding curve and the greater the volumetric water content; in the later stage of suction, the difference of the curve begins to remain flat.

From Fig. 4, we can clearly see that the volumetric water content of each sample will decrease with the increase of the suction to the matrix. The initial water content corresponding to the small particle size is slightly higher than that of the larger particle size, and the smaller the particle size is. Under the same matrix suction, the particle size and volumetric water content will be higher, and the water-holding capacity will also change. On the contrary, under the same volumetric water content of the smaller the particle size, the greater the matrix suction and the difference in the transition section which is the most obvious difference, the boundary effect section is the second, and the unsaturated residual section has the smallest difference.

This test uses the F-X model to fit the data of each sample in the test. The details are shown in Table 4. Table 4 shows the fitting parameter values (a, m, and n) determined by the software Origin analysis.

It can be seen from the model fitting effect in Table 4 that the effect after fitting is very good, and the average value of $R^2$ must be greater than 0.9. It shows that the F-X model is suitable for fitting soil-water characteristic curve under the influence of different dry densities and different continuous gradations.

Dry density and continuous gradation have a certain effect on the model parameter values. The value changes most obviously, and the $m$ and $n$ values change little. Comparing the data in the table, it can be found that as the dry density increases, the value of $a$ gradually increases, and the value of $m$ and $n$ fluctuates; as the particle size increases, the value of $a$ gradually decreases, and the value of $m$ gradually increases as a whole, and the value of $n$ as a whole gradually becomes smaller.

---

**Fig. 2.** Soil-water characteristic curves with the same discontinuous end points and different starting points

**Fig. 3.** Soil-water characteristic curves under different dry densities

---
Prediction of soil-water characteristic curve based on the effect of earth pressure

It can be seen from Fig. 5 that at the beginning, the greater the increase in overburden pressure, the lower the initial water content of the sample. This is mainly because the increase in overburden pressure changes the soil structure of the sample and compresses the volume of the entire sample. The total pores of the sample have also become tighter. The pores between the particles have become narrower, and the contact between the particles has become more compact, so that the total pore capacity of the sample has decreased after dehumidification. The moisture is discharged under the pressure of the overburden, so after the completion of the preconsolidation, it corresponds to an initial period. With the increase of the suction of the overburden, the dry density gradually increases, but the moisture content decreases, but we can clearly see from the curve that the higher the pressure of the overlying soil matrix, the higher the compression of the pores. With the increase of the matrix suction, the soil-water characteristic curve decreases more slowly and the water content decreases accordingly. The ratio between the water content of the larger earth pressure sample and the water content of the smaller earth pressure sample gradually decreases, and there is a tendency to gradually overlap or exceed, which means that they are affected by the earth pressure and have smaller pores. The stronger the water-holding capacity, the lower the dehumidification rate.

It can be seen from Fig. 6 that as the overburden pressure and matrix suction increase, the mass moisture content of purple soil gradually decreases. During the dehumidification and moisture absorption process, the trends of the curves are similar. Related studies have shown that the water content under the same suction will gradually increase with the increase of the bearing pressure, but Fig. 6 shows that the initial water content of the purple soil sample is lower under higher overburden pressure. With the further development of the suction path, the decrease in water content has been significantly eased. This is mainly because under capillary overburden, the original pore structure and supporting water-holding channels gradually shrink and become uniform, which more fully

![Graph of soil-water characteristic curves under different continuous gradations](image)

**Table 4** Fitting parameter values

| Sample No. | a (kPa) | m     | n     | R²     | Sample No. | a (kPa) | m     | n     | R²     |
|------------|---------|-------|-------|--------|------------|---------|-------|-------|--------|
| 1#         | 0.279   | 0.382 | 1.035 | 0.965  | 13#        | 0.320   | 0.348 | 1.365 | 0.986  |
| 2#         | 1.171   | 0.486 | 0.693 | 0.987  | 14#        | 1.097   | 0.295 | 1.578 | 0.990  |
| 3#         | 3.13    | 0.397 | 0.696 | 0.994  | 15#        | 3.268   | 0.392 | 0.798 | 0.990  |
| 4#         | 25.319  | 0.330 | 1.131 | 0.999  | 16#        | 19.858  | 0.368 | 1.026 | 0.990  |
| 5#         | 0.269   | 0.406 | 0.690 | 0.915  | 17#        | 2.122   | 0.610 | 0.730 | 0.996  |
| 6          | 0.784   | 0.508 | 0.471 | 0.932  | 18         | 4.003   | 0.442 | 0.917 | 0.995  |
| 7          | 15.907  | 0.908 | 0.368 | 0.965  | 19         | 10.304  | 0.388 | 1.017 | 0.999  |
| 8          | 190.040 | 1.189 | 0.493 | 0.996  | 20         | 28.520  | 0.245 | 1.579 | 0.998  |
| 9          | 0.217   | 0.290 | 1.502 | 0.952  | 21         | 6.833   | 0.435 | 1.568 | 0.998  |
| 10         | 0.486   | 0.364 | 0.804 | 0.974  | 22         | 11.227  | 0.342 | 1.595 | 0.989  |
| 11         | 1.110   | 0.383 | 0.553 | 0.973  | 23         | 19.246  | 0.209 | 3.083 | 0.997  |
| 12         | 26.746  | 0.498 | 0.659 | 0.997  | 24         | 43.874  | 0.144 | 3.075 | 0.975  |
plays a role in capillary upward lifting. Therefore, with the development of suction, the rate of decrease of water content becomes more moderate.

It is worth noting that during the dehumidification process in Fig. 6, the soil-water curve of the AF3 and AF4 samples at the suction 10 kPa position is approximately a horizontal line segment, that is, the second boundary effect area, and the effect of the AF4 sample is more obvious than that of the AF3. The phenomenon of this second platform is called the bimodal effect, and the samples with lower overburden pressure did not show such characteristics.

Under different matrix suction (as shown in Fig. 7), the difference in moisture content of the sample is apparent. The size of the hysteresis loop of the soil sample under high suction is significantly smaller than that of the soil sample under low suction, and the hysteresis loop reaches the maximum at 0. Because in the process of moisture absorption of the sample, a certain number of closed bubbles will be generated, and the sample cannot be fully saturated after one time of moisture absorption and stability. Under 0 kPa suction, the difference between AF1 and AF2 and the moisture content of the sample is 13.29% and 14.64%, respectively. Generally, the difference between AF1 and AF2 is greater than AF3 and AF4, indicating that the difference between the different covering of soil is deep; the hysteresis effect of purple soil is quite different.

When the suction is 5 kPa, the difference between the moisture content of the AF1 and AF2 samples is 4.82% and 5.52%. At this time, the difference in the moisture content of the AF3 and AF4 samples is 3.09% and 0.35%, which is also less than AF1 and AF2; this shows that the overburden pressure has a certain effect on the hysteresis curve. The greater the overburden pressure, the lower the hysteresis effect. As shown in Fig. 8, under the same matrix being sucked, its moisture content is relatively low.

In the process of soil moisture absorption, the interaction of soil hydrophobic particles and part of the pore water thickens
the soil combined with the hydrophobic membrane, which expands the moisture-absorbing soil particle skeleton and further changes the structure. In the process of strong moisture absorption, the strong combination of water film action results in a relatively low moisture content of the strongly absorbed matrix under the same moisture-absorbing matrix state.

Discussion

Analysis of the interaction between the diffusion of Internet of Things technology and the performance of enterprise e-commerce channels

New types of information science and technology such as the Internet of Things are entering the field of retail products and have received great attention from the Chinese government and the industry. For example, the application and promotion of RFID technology in warehouse inventory management can greatly improve the efficiency of logistics. Retailers can greatly improve consumers’ online shopping experience by using virtual reality/real Augmented Reality technology. However, the emergence and application of the Internet of Things technology have also brought us some problems. For example, people are generally concerned about personal privacy issues and network health issues. From this perspective, customers still have a great duality in IoT technology, and they will still be skeptical about IoT devices, so that consumers can accept that the application of IoT technology in the field of e-commerce will not happen overnight. Let consumers have a slow process of acceptance. This brings us a challenge. The application of the Internet of Things is recognized by many consumers as a long evolutionary process and a proliferation process. Therefore, in-depth exploration of the application and proliferation process of the Internet of Things in consumer groups has a great impact on the decision-making and profitability of retail enterprises. Figure 9 shows the interaction mechanism structure between the proliferation process of the Internet of Things and the profit and decision-making of retail enterprises.

As shown in Fig. 9, two issues are specifically studied:

Question 1: currently studying the pricing behavior of online retailers and their impact on the rapid proliferation of the Internet of Things. The specific impact mechanism is mainly manifested in the following: online retail prices will directly affect whether consumers can consume through online channels when buying IoT products, which will also directly affect whether consumers can perceive IoT applications online. According to the Bass diffusion theory, whether consumers are willing to accept the Internet of Things is mainly affected by Internet media, advertising, and publicity on one hand, and friends around them on the other hand. If a person has used the application of the Internet of Things, he is likely to recommend the application of the Internet of Things to his friends around him, and those consumers recommended come to accept this application. Therefore, the retailer’s pricing behavior will directly affect the expansion and proliferation of the Internet of Things among consumers. Question 1 is mainly used to study the direct impact of the functional expansion and psychological diffusion of commercial Internet of Things applications in the overall psychological process of consumers on retailers’ marketing decisions. In order to analyze and study these two key issues in depth, we specially designed an embedded virtual diffusion simulation processing model. The market mechanism of the simulation model is mainly based on the market framework of fierce price competition with product retailers, and the Yoo-Lee model is used as the evaluation benchmark. The basic model mainly includes two basic aspects. One part is mainly by describing a dynamic price-driven mechanism based on the automatic adjustment of retailer commodity prices, and the other part is mainly by describing a microscopic diffusion based on the depth of the Internet of Things network.
The mechanism is based on the Bass diffusion model system as the main theoretical basis. The actual adoption of new technologies often takes into account all the latest technology and environmental-related elements contained therein.

**Analysis of the influence of channel structure on enterprise e-commerce subsidy strategy under the environment of Internet of Things**

The formation of China’s agricultural informatization and its corresponding implementation of the rural economic revitalization strategy are of great significance, and rural e-commerce is an important link in agricultural informatization. Many local governments have formulated subsidies and support policies for rural e-commerce companies in accordance with local actual conditions.

In addition, a new generation of information technology is also increasingly promoting the vigorous development of China’s e-commerce and has attracted widespread attention from local governments, enterprises, and consumers. The Ministry of Commerce, the Office of the Cyberspace Administration of China, and the National Development and Reform Commission jointly issued the “Thirteenth Five-Year Plan for E-Commerce” that clearly emphasizes the application of new information technologies such as the Internet of Things, big data, and cloud computing.

Regarding the importance and supporting role of e-commerce, logistics companies usually use express order query services to improve the consumer experience; in addition, the US Amazon company has obtained the patent of “preorder shopping” by using this big data technology. Commercial operations in Amazon can effectively reduce the waiting time required by users in logistics services. This shows that the introduction of a new generation of information technology will have a great impact on the decision-making of e-commerce companies.

Therefore, this article analyzes the decision-making interaction between e-commerce and traditional media, government subsidies, and other e-commerce channel organization members through the established game model (Reddy et al. 2018). It mainly includes two aspects: the first is to analyze the current implementation effects of the current e-commerce subsidy policies formulated by the local government from the two dimensions of the subsidy target and the channel structure; the second is to analyze the subsidy under the background of the emerging information science and technology era (Takashi et al. 2018). What will happen to the effect of considering that the use of this new information technology in the market will directly stimulate consumers’ herd mentality, which will directly affect consumers’ purchase and herd behavior; this article needs to further study by establishing a model system that can be simulated. In the case of herd consumers in the market, the channel structure and subsidy objects will directly affect how they affect consumer herd behavior.

This article mainly focuses on the basic structure of DM and PIM and analyzes the relevant subsidy policies of local governments in the development of the e-commerce network industry, and its influence on the development of the main channel operation, and analyzes the current electronic information network technology in depth (Thomas et al. 2002) and the promotion and use in the operation of the enterprise and its influence on the implementation of the enterprise subsidy policy.

Research and analysis: (1) The effect of subsidies on the overall economic benefits and decision-making of sales channels is mainly affected by the decision-making structure of sales channels. Compared with other independent sales product channels, direct sales channels often have a kind of mutual coordination (Thomas et al. 2004). When making decisions, online sales channels tend to be more willing to give a larger proportion of government subsidies directly to consumers, which directly results in a clear difference in the decision-making structure of the two sales channels; (2) The significant effect of subsidies is mainly affected by some new sciences. The impact of the promotion of information technology and some new scientific information technologies such as the Internet of Things and big data can promote the effective use of online network operators from the promotion level of these scientific information technologies and promote the business interaction between the government and private enterprises. Also, there are nonscientific functions to enhance the overall effect of business interaction between the government and private enterprises (Touil et al. 2008).

The research in this article is mainly aimed at the actual development of enterprises with certainty and special needs, and in the case of uncertainty and special needs, subsidies to enterprises are likely to directly reduce the risks they generate, so it is also very important. It may cause large differences in the effects of the subsidy structure for different objects.

**Analysis of channel intrusion on enterprise e-commerce product quality decision-making in the Internet of Things environment**

**The introduction of product quality issues in enterprise e-commerce**

The advancement of the Internet of Things technology has promoted the tracking capabilities of food storage and food distribution in the retail distribution link (Triantafyllou et al. 2016). Therefore, compared with the past, companies in all aspects of the retail industry have innovated in the application of cold chain technology and other Internet of Things technologies. The innovative investment of these companies can...
effectively improve the performance of food and reduce the deterioration and obsolescence of food. This status quo has brought many reforms and changes to the quality management of the supply chain of the company: that is, it is not only the manufacturing process that determines the quality of the company’s products but also the retail link. Most of the current scenarios are that product quality is only affected in its manufacturing process. Therefore, we will focus on two aspects. One is mainly to discuss how to affect product quality in the retail industry and product quality in traditional markets. There are differences between the decision-making of the Internet; considering that Internet e-commerce can make it easier for manufacturers to open their own direct sales channels, another hot topic is the impact of channel intrusion on all aspects of retail and its decision-making on product quality.

Analysis of enterprise e-commerce product quality

With the widespread application of Internet of Things technology, especially cold chain technology, the decision-making issues of various aspects of the retail industry regarding product quality and many other factors have become clearer. However, the channels of previous research approaches have invaded the assumption of the content of quality decision-making. Product quality is only affected by the manufacturing process. Therefore, this article mainly studies the impact of channel intrusion on product quality decision-making in a market economy that may affect product quality in the retail link.

First of all, the market economy environment that affects the product quality of the enterprise in the retail link is compared with the traditional market economy environment that only affects the product quality of the enterprise in the manufacturing link. For the improvement of the product quality of the enterprise, there are both disadvantages and possibility of bringing the good side. The good side is mainly that since most of the decisions are made by multiple parties and their decisions are closely related to each other, under certain conditions, one party may be unwilling to improve himself in this way. Product quality activities will make other participants lose the motivation to improve the quality of their products, which will have a negative impact on consumers. But on the other hand, because these beneficiaries are constantly participating in the judgment and decision-making of product quality, the sum of the total product quality thresholds of the enterprise can be increased, thereby adding more room for development of the product quality and production efficiency of the enterprise. Finally, by means of numerical simulation, the influence of channel erosion on the product quality of manufacturing enterprises in each link of manufacturing and production is analyzed. The analysis results found that when the substitutability between channels is obviously too large or too small, the intrusion of channels will enhance the quality efforts of manufacturing enterprises in all aspects of production and sales. On the contrary, this kind of channel intrusion will reduce the quality of manufacturing enterprises in the production and sales links.

The synergistic impact of traceability and channel intrusion on enterprise e-commerce product quality decision-making in the Internet of Things environment

The Chinese government has issued a new strategy for revitalizing the rural economy, which has had a profound impact on the development of China’s agricultural industry. The strategy for the revitalization of the rural economy involves many projects such as the revitalization of the agricultural economy. Among them, rural e-commerce and the quality and traceability system of agricultural products are the key projects. All three have a great influence on the practice of the agricultural economy. Rural e-commerce has completely changed the traditional supply chain structure; with the help of rural e-commerce, agricultural product manufacturers can more easily build a direct sales channel outside of traditional channels, that is, channel intrusion. Changes in the channel structure will undoubtedly directly affect the decision-making on product quality, and solving the problem of agricultural product quality will undoubtedly become one of the most important issues in the development of China’s modern agricultural economy. It is difficult for ordinary consumers to accurately evaluate the quality of agricultural products, because it is difficult for consumers to fully grasp the business behavior of many agricultural companies. Therefore, traceability is considered to be an advantageous means to regulate corporate behavior. The USA and Europe have established sound food safety traceability systems and have issued relevant laws requiring all foods to be traceable to the entire production process. China’s food quality and safety traceability system is also being further established and perfect. In summary, there is an interaction between rural e-commerce, the quality of agricultural products, and the tracking system. However, there are still some problems with the three in Chinese practice. The specific explanations are as follows.

For China’s rural e-commerce companies, due to the relatively weak agricultural foundation in China, many agricultural producers and manufacturers lack experience in the operation and management of e-commerce, and because the development of e-commerce requires them to invest a lot of human resources and network operating costs, whether to adopt a channel intrusion strategy is undoubtedly a key issue that must be carefully considered for Chinese agricultural producers.

For the traceability system, the construction of the quality and safety traceability system requires a lot of manpower and capital, and the cooperation of enterprises must also be required. Therefore, for the local people’s government and its
affiliated rural agricultural committees, the construction of a quality, safe, and reliable tracking information system is time-consuming and labor-intensive. It looks perfect but is difficult to implement. In some places where financial funds are not sufficient, quite a few people often pay attention to the investment in rural e-commerce, but they are relatively indifferent to the construction of quality and safety traceability systems.

Since the quality of Chinese agricultural products is affected not only by the production and manufacturing links but also by the retail links, based on this, this paper constructs a broad game model in the design to in-depth study the impact of the retail manufacturing links on the quality of agricultural products, namely, in the retail manufacturing process, and how channel intrusion and traceability are jointly used as decisions affecting the quality of agricultural products. In the research process of this model, various functions of channel traceability characteristics are analyzed.

This paper models the factors such as the utility of consumers, the income of producers, and the income of retail enterprises. The researchers found the following: (1) In the case of channel intrusion, traceability can increase the quality cost threshold between the retail industry production link and the manufacturing production link at the same time, which means that traceability can increase the manufacturing and retail enterprises. With regard to the desire to improve the quality of its products, traceability to a large extent encourages enterprise manufacturers to adopt excellent quality in all aspects of production to make efforts. (2) When the product has traceability, channel intrusion cannot change the quality cost threshold of the producer in the manufacturing process. However, their influence on the brand image and competitive advantage of the retail enterprise in the production and operation of the retail enterprise has a relatively clear significance. Therefore, the intrusion of channels can promote the high-quality efforts of retail enterprises to provide them with high-quality services. (3) When the channel difference is relatively large, if the cost of product quality effort is relatively low, put in low-quality effort, and put in high-quality effort when the cost of product quality effort is relatively high.

Conclusion

With the popularization of new technology platforms such as the mobile Internet, various emerging technologies continue to appear and are widely used in the operation of the mobile Internet, which can not only improve the operation efficiency of the entire industrial chain but also more importantly improve. At the same time as the platform’s operational capabilities, risk control and prevention capabilities have also been strongly improved. Taking the soil of a certain section as the object, the influence of the lack of particle group, dry density, and particle gradation on the soil-water characteristic curve was analyzed and compared. The soil-water characteristic test of the soil pressure was carried out to study the influence of the soil pressure on the soil-water characteristics. The soil-water characteristic curve of the sample with missing particles is S-shaped. As the weighted average particle size of the sample gradually decreases, the pore continuity and the number of pores gradually increase, but the pore radius gradually decreases and the water-holding capacity becomes stronger. The F-X model was used to fit the soil-water characteristic curve in the sample with missing granular group, and the model fitting parameters were obtained. The analysis shows that the greater the overburden pressure, the smaller the pores and the stronger the water-holding capacity, which shows that the dehumidification rate is lower. The greater the pressure when covering the soil, the more obvious the bimodal characteristics of the soil; the pressure of the covering has a certain effect on the hysteresis curve, and the higher the pressure of the covering, the effect of the hysteresis will be weakened. The increase of overburden pressure and matrix suction will gradually reduce the porosity ratio of the soil sample; the decrease of the porosity ratio during dehumidification should be much higher than the increase of the porosity ratio during moisture absorption. In the scenario where the Internet affects product quality, the structure of e-commerce and e-commerce operations has an impact on corporate quality decisions. Regardless of the structure of e-commerce operations, Internet intrusion has not changed the quality cost threshold of product manufacturers in the production process; that is to say, Internet intrusion has not changed the quality decision of product manufacturers in the production process.

Declarations

Conflict of interest The authors declare that they have no competing interests.

Open access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution, and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

References

Alessio P (2019) Spatial variability of saturated hydraulic conductivity and measurement-based intensity-duration thresholds for slope
Arya IW, Wiraga IW, Dwipa IGAGS, Pramana IMW (2020) Effect of pore water pressure on soil crack against safety factor of slope stability. J Phys Conf Ser 1450:012014

Bowa VM, Xia Y (2019) Influence of counter-tilted failure surface angle on the stability of rock slopes subjected to block toppling failure mechanisms. Bull Eng Geol Environ 78(4):2535–2550

Feng SJ, Chen ZW, Chen HX, Zheng QT, Liu R (2018) Slope stability of landfills considering leachate recirculation using vertical wells. Eng Geol 241:76–85

Hao W, Zhang P (2019) Numerical simulation of pore water pressure variation of building foundation in shallow coastal waters. J Coast Res 93:257–263

Kamchoom V, Leung AK (2018) Hydro-mechanical reinforcements of live poles to slope stability. Soils and Foundations -Tokyo 58(6):1423–1434

Karlis K, Jean-Frank W, Tomas S, Philip B (2018) Physically based hydrogeological and slope stability modeling of the Turaida castle mound. Landslides 15:2267–2278

Khanna R, Datta M, Ramana GV (2019) Influence of core thickness on stability of downstream slope of earth and rockfill dams under end-of-construction and steady-state-seepage: a comparison. Int J Geotech Eng 13(1–2):25–31

Lan H, Wang D, He S, Fang Y, Chen W, Zhao P, Qi Y (2020) Experimental study on the effects of tree planting on slope stability. Landslides 17(4):1021–1035

Li J, He X (2019) Simulation for frost heaving damage of concrete lining channels by using XFEM. J Coast Res 93:264–273

Ma XJ, Wang W (2015) Composite model for dynamic pore water pressure developing process of soft soil under cyclic loading. J Mech Eng Res Dev 38(2):12–17

Mulyono A, Subardja A, Ekasari I, Lailati M, Sudirja R, Ningrum W (2018) The hydromechanics of vegetation for slope stabilization. Iop Conference 118:012038

Pan Z, Zhang P, Luo Z, Yang H (2020) Research on WSN low energy routing algorithm based on geographic location. Computer Simulation 37(6):305–309

Reddy KR, Kumar G, Giri RK (2018) System effects on bioreactor landfill performance based on coupled hydro-bio-mechanical modeling. Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management 22(1):04017024.1–04017024.15

Takashi O, Sumio M, Otto LJ, Shih A, Kazutoki A (2018) The response of pore water pressure to snow accumulation on a low permeability clay landslide. Eng Geol 242:130–141

Thomas SJ, Chevallier LP, Gresse PG, Harm CP, Eglinton BM, Armstrong RA, De Beer CH (2002) Precambrian evolution of the Sirwa Window, Anti-Atlas Orogen, Morocco. Precambrian Res 118:1–57

Thomas RJ, Fekkak A, Ennih N, Erramdouk SC, Gresse PG, Chevallier LP, Liégeois JP (2004) A new lithostratigraphic framework for the Anti-Atlas Orogen, Morocco. J Afr Earth Sci 39:217–226

Touil A, Hafid A, Moutia J, Leboukhari A (2008) Petrology and geochemistry of the Neoproterozoic Sioura granitoids (central Anti-Atlas, Morocco): evolution from subduction-related to within-plate magmatism. Geological Society, London, Special Publications, vol 297:265–283

Triantafyllou A, Berger J, Baele JM, Diot H, Ennih N, Pieters G, Monnier C (2016) The Tachakoucht–Iriri–Tourtit arc complex (Moroccan Anti-Atlas): Neoproterozoic records of poly phased subduction-accretion dynamics during the Pan-African orogeny. J Geodyn 90:81–103