Research Article

XiaoGuang Xu, Yue Guo, YongMin Fu, ZhengWei Wang, and XuDong Zhao*

Nonlinear discrete system model of tobacco supply chain information

https://doi.org/10.1515/nleng-2022-0029
received December 13, 2021; accepted February 27, 2022

Abstract: In order to understand the real environment and specific needs of China’s current tobacco industry, master the signal information in the tobacco supply chain, and timely discover the source of the tobacco supply chain, this paper puts forward the detection method of anti-counterfeiting at the source of the tobacco supply chain. Based on this, this article constructs a nonlinear discrete system model, which mainly studies the logistics information existing in the tobacco supply chain, utilizes the noise existing in the tobacco supply chain information obtained by EKF filtering, and combines it with Support vector machine data analysis method. The results showed that out of 450 sample tests, 0 real sample errors and 1 misuse of 49 false samples, with a total detection rate of up to 100% was achieved. The results show that the nonlinear discrete system model is better, has higher detection effect of tobacco supply source, and improves the detection accuracy.

Keywords: tobacco supply chain, nonlinear discrete system, model

1 Introduction

China is a country of large tobacco consumption. Regardless of its tobacco planting area, total production or consumption is first in the world, about 1/3 of total production or consumption in the world. In 2009, with about 350 million smoking people, tobacco industry throughout the country paid a tax of 513.111 billion yuan, accounting for more than 8% of the national tax revenue, which realizes taxes (including state-owned capital management income) of 416.34 billion yuan, which is the second largest industry of tax payment (second only to the petroleum industry). In 2011, China’s tobacco industry output value estimates were around 700 billion yuan. It can be seen that the tobacco industry has a very important status in China’s economic and social life to ensure a positive contribution to the national fiscal revenue. However, from the system, the Chinese tobacco industry still has a strong planning economy, which also leads to a series of problems caused by mechanisms and operations from planning system curing, especially some issues related to supply chain operations. For consumers, the demand is the main factor in the tobacco industry, mainly including the identification of the authenticity of tobacco products. As the tobacco industry is booming, the quality of tobacco products is also becoming increasingly visible. Through the statistics and research of tobacco industry in recent years, the integration trend of traditional tobacco industry and high-tech is increasingly obvious. The construction of informationization in tobacco industry is conducive to improving tobacco production efficiency and ensuring tobacco quality [1].

Tracing to build tobacco information is huge for the entire tobacco industry, which is conducive to achieving unified coordination and management of the entire tobacco industry. Traditional anti-counterfeiting means is generally achieved by special processes, such as discoloration inks, uneven print, adding watermarking, etc. Although these means have achieved anti-counterfeiting purposes to some extent, the cost is high and easy to copy. The information-based two-dimensional code cost is low, easy to carry, and share, and has high recognition rate, wide application range, and large development potential. Among them, the information-based QR code is more common in the mobile phone, and can effectively store and interpret information. In the tobacco industry, the main significance of the use of informationized QR code technology is: first to manage the
circulation channels and means of tobacco, and ensure standardization of production and processing in tobacco business; second, make consumers to participate in the process of tobacco quality supervision and management, consumers can query the authenticity and traceability of tobacco products at any time, to ensure the legitimate rights and interests of the consumers.

In the above context, it is urgent to detect the traceability of tobacco supply chain. However, the current tobacco supply chain traceability anti-counterfeiting detection method has the problems of poor denoising effect, low detection efficiency, and low detection accuracy. Therefore, this work proposes the tobacco supply chain traceability anti-counterfeiting detection method based on vector tracking.

2 Literature review

By using the tobacco supply chain industry as an object, and integrating the logistic business process between industry and commerce, there are two points in the realistic meaning of tobacco supply chain information: first, through research on tobacco supply chain integration, we can reduce logistics, information flow, and flow costs inside the supply chain, minimize the internal consumption and waste of supply chains, improve the operational efficiency and operational effect of the supply chain, and shorten the response speed of the supply chain to the demand market. Second, through breaking of the organization's boundaries, integration of industry logistics docking business processes to promote the integration of tobacco industry logistics information and can be achieved realizing seamless docking of logistics of tobacco industrial enterprises. This will build the core competitive structure of the tobacco supply chain to improve the competitiveness of the tobacco supply chain in the market.

Research on the supply chain originates from research on logistics management, but most scholars in recent years have turned to research on the management of supplies from the research of logistics management. At present, foreign scholars' research on supply chain management is mainly focused on the following representative directions. Cuong in his published paper proposed “definition of supply chain quality management and its theoretical and practical analysis”: quality management should not be limited to the management of internal product quality, but should be quality management concepts from traditional single enterprises, focusing on quality management tools and technologies, based on supply chain, focusing on the communication and coordination of supply chain members, and the capacity of quality assurance system [2]. Ramesh et al. introduced game theory into the research of supply chain management in their papers “Game theory in supply chain management,” and research in the field can be divided into inventory game, production and pricing game, inventory, production, pricing, and other types of games such as comprehensive decision-making [3]. Game theory in supply chain management has proved to help solve the effectiveness of various problems in the supply chain, including inventory decisions, product pricing and product quantity, inventory, pricing, quality, advertising, etc., and competitive cooperation between supply chain members. With the complexity of the supply chain network, it is also necessary to use game theory to solve the problem of related networks. Silva analyzed the characteristics and distribution of tobacco industry logistics information resources, summarized the problem of tobacco industry logistics information resource management, and studied the integration mode of tobacco industry logistics information resources, and constructed SOA-based tobacco industry logistics collaborative information platform, and described the key technologies of the platform, the overall architecture, access mechanisms, and functional effects [4]. Balwicki et al. through the specificity of the tobacco industry and the analysis of tobacco supply chain structure, found out the reasons for the supply chain information of the tobacco industry, and then solved the information technology application, established a strategic partnership, designed a scientific sampling mechanism, etc., a series of corresponding countermeasures for the problem [5]. Maulidah analyzed the risk priorities in the tobacco supply chain and developed risk mitigation strategies for the tobacco supply chain by business process modeling methods. The analysis methods are the Delphi Law and the House of Risk (HoR). Business processes use the Supply chain operational reference (SCOR) model. The results show that the priorities of tobacco supply chain risk are: economic uncertainty, the unavailability of tobacco at the farm level, the location of tobacco ingredients away from production activities, rising product prices from customs, and a sharp increase in product demand. Strategies to mitigate supply chain risks include increasing the information flow in the tobacco supply chain, managing inventory/supply of tobacco raw materials and processed products, evaluating distributors' options, forming partnerships with tobacco farmers, implementing marketing portfolio strategies (product, price, location, and promotion), strengthening coordination with relevant governments, and management of information systems and technologies [6]. To explore how tobacco manufacturing companies can improve their sustainable performance through effective supplier relationship
management, Adesanya et al. provided insights into the various SRM methods used in the tobacco industry to ensure compliance and improve sustainability performance. However, further studies are needed to explore the generalizability of the conclusions we draw from individual case studies. The tobacco industry is an under-researched industry, particularly in sustainable operations and supply chain management practices. Our results also seem to apply to those comparable industries with strict regulation. Keywords—sustainability, supplier relationship management, and sustainability risk management [7]. Jianyong et al. identified nutrient soil composed of cake fertilizer, mushroom residue, cow dung, and calcium-magnesium phosphate fertilizer as an alternative to traditional flue-cured tobacco. According to the principle of feed crushing, mixing, and processing integration, cured tobacco nutrient soil processor was developed. The problem of mixing box blockage is solved by improving the grinding and mixing methods of the mixing system. Trials have been carried out trials for mechanized large-scale production and commercial supply of flue-cured tobacco nutrient soil, simplified the production process of flue-cured tobacco nutrient soil, reduced production costs, met the needs of the green development of tobacco production, and created good social and economic benefits [8].

3 Information denoising treatment based on vector tracking

Vector-tracked tobacco supply linked source anti-counterfeiting detection method extracts the logistics information present in the tobacco supply chain by vector tracking algorithm, and denoises the obtained information.

Let $T$ describe the status update time; $X_k = [x, y, z, \dot{x}, \dot{y}, \dot{z}, \ddot{x}, \ddot{y}, \ddot{z}, b, d]^T$ describes the state vector, where $[x, y, z]$ describes the user’s three-dimensional position in the Earth-Center-Solid coordinate system, $[\dot{x}, \dot{y}, \dot{z}]$ describes the user’s velocity in the Earth-Center-Solid coordinate system, and $[\ddot{x}, \ddot{y}, \ddot{z}]$ describes the user’s acceleration in the Earth-Center-Solid coordinate system. $D$ stands for clock drift, and $B$ stands for clock deviation and builds a nonlinear discrete system model:

$$
\begin{cases}
X_k = \Phi X_{k-1} + W_{k-1} \\
S_k = d(X_k) + V_k.
\end{cases}
$$

In the formula, $S_k$ describes the observed vector, which is a vector that occurs during the actual observation process; $d$ describes the observable satellite number; $V_k$ is a observed noise vector; $\Phi$ describes a state transfer matrix; $W_{k-1}$ a is system noise vector.

The expression of the state transfer matrix $\Phi$ is as follows:

$$
\Phi = \begin{bmatrix}
I_{3 \times 3} & \frac{1}{2}T^2I_{3 \times 3} & 0.5T^2H_{3 \times 3} & 0_{3 \times 1} & 0_{3 \times 1} \\
0_{3 \times 3} & I_{3 \times 3} & TH_{3 \times 3} & 0_{3 \times 1} & 0_{3 \times 1} \\
0_{3 \times 3} & 0_{3 \times 3} & I_{3 \times 3} & 0_{3 \times 1} & 0_{3 \times 1} \\
0_{3 \times 3} & 0_{3 \times 3} & 0_{3 \times 1} & 1 & T \\
0_{3 \times 3} & 0_{3 \times 3} & 0_{3 \times 1} & 1 & 1
\end{bmatrix}
$$

The average value of the system noise vector $W_{k-1}$ is 0, and there is a formula:

$$
E[W_kW_k^T] = Q_k\delta_{kj}, Q_k \geq 0,
$$

$$
Q = \text{diag}([a_0^2, a_1^2, a_2^2, a_3^2, a_4^2]),
$$

where $[a_0^2, a_1^2]$ can be calculated by Allan variance parameter $Q_k, \delta_{kj}$.

The mean of observing the noise vector $V_k$ is 0, and there is a formula:

$$
E[V_kV_k^T] = R_k\delta_{kj}, R_k \geq 0,
$$

$$
R = \text{diag}([a_0^2, a_1^2, \cdots, a_3^2, a_4^2, a_5^2]).
$$

In the formula, $a_0^2$ describes the variance corresponding to $\Delta p_i$; $a_1^2$ describes the variance corresponding to $\Delta f_i$. According to the constructed nonlinear discrete system model, the information existing in the tobacco supply chain is extracted by the vector tracking method [9]:

$$
\begin{align*}
\sigma_D^2 &= \left(\frac{C}{R_C}\right)^2 \times \frac{2\eta\left(1 - \frac{d}{2}\right)^2 + 1}{8\eta\left(1 - \frac{d}{2}\right)^2 + 1^2} \times X_k \\
\sigma_F^2 &= \left(\frac{C}{f_c}\right)^2 \times \frac{1 + \frac{1}{\eta}}{\eta} \times Z_k, \\
\eta &= (C/N_0) \times T.
\end{align*}
$$

In the formula, $C/N_0$ describes the signal-to-noise ratio of the signal corresponding to the signal; the optical speed is described; $f_c$ describes the carrier frequency; $R_C$ describes the code rate corresponding to the C/A code.

The error corresponding to the observation vector is calculated by the acquired tobacco supply chain information:

$$
Z_{c,k} = H_k\hat{X}_{c,k} + V_k.
$$

In the formula, $\hat{X}_{c,k}$ described is an estimate error corresponding to the state vector; $Z_{c,k}$ described is an error corresponding to the observation vector; $H_k$ describes a linear observation matrix, its expression is as follows:
\[
H_k = \begin{bmatrix}
-\hat{a}_1 & 0_{1 \times 3} & 0_{1 \times 3} & 1 & 0 \\
-\frac{\partial \hat{a}_1}{\partial \hat{u}} & -\hat{a}_1 & 0_{1 \times 3} & 0 & 1 \\
-\frac{\partial \hat{a}_2}{\partial \hat{u}} & -\hat{a}_2 & 0_{1 \times 3} & 0 & 1 \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
-\frac{\partial \hat{a}_N}{\partial \hat{u}} & -\hat{a}_N & 0_{1 \times 3} & 0 & 1 \\
\end{bmatrix}.
\]

In the formula, \( a_i = [a_{xi}, a_{ri}, a_{zi}] \) describes the direction cosine corresponding to the unit vector, and a deflection process is performed:

\[
\frac{\partial \hat{a}_1}{\partial \hat{u}} = -\hat{s}_i - \hat{u} + \frac{(s_i - \hat{u}) \times \hat{a}_i}{R_i} \times \hat{a}_i.
\]

In the formula, \( R_i \) describes a geometric distance; \( u \) describes a three-dimensional position in a coordinate system; \( \hat{s} \) describes the user’s speed in coordinates; \( s \) is a three-dimensional coordinate; \( \hat{\xi} \) is the speed of the satellite in the coordinate system. The EKF filtering process is usually as follows:

\[
\hat{A}_{i|f-1} = \Phi \hat{A}_{i|f-1},
\]

\[
P_{i|k-1} = \Phi P_{i|k-1} \Phi^T + Q,
\]

\[
k_f = P_{i|f-1} H^T (H P_{i|f-1} H^T + R_f)^{-1},
\]

\[
\hat{A}_f = \hat{A}_{i|f-1} + K_f [Z_{c, f} - \{h(\hat{A}_{i|f-1}) - \hat{Z}_f\}],
\]

\[
P_f = (I - K_f H_f) P_{i|f-1}.
\]

In the formula, \( K_f \) describes a filter gain matrix; \( P_f \) describes an estimated error covariance matrix \([10,11]\).

With EKF filtering, the noise existing in the obtained tobacco supply chain information is treated, and the calculation formula for tobacco supply chain stroke source anti-counterfeiting detection accuracy is as follows:

\[
\hat{Z}_c,f = [h(\hat{A}_{i|f-1}) - \hat{Z}_f] + H_f \hat{Z}_{c,f}.
\]

### 4 Tobacco supply chain stroke source anti-counterfeiting detection method

Based on the above information denoising treatment, the support vector machine (SVM) method is used to detect the supply of tobacco supply.

Setting \( \psi \) as a non-linear mapping between the input space and the output space, and the data present in the sample set \((x_i, y_i)\) and \((x_0, y_0)\) are mapped to high dimensional space \(f\) through non-linear mapping \( \psi \). Linear regression in the feature space by the following linear functions:

\[
f(x) = w \cdot \psi(x) + s, \, \psi : \mathbb{R}^n \rightarrow F, \, w \in F,
\]

where \( S \) is described as the threshold. Since nonlinear mapping \( \psi \) is fixed, the high dimensional space flat \(|w|^2\) and the sum of experience risks will have an impact on \( W \), namely:

\[
R(w) = \frac{1}{2} ||w||^2 + \sum_{i=1}^{l} \varepsilon(f(x_i) - y_i).
\]

In the formula, \( l \) describes the total number of samples; \( \varepsilon() \) is a loss function, its expression is as follows:

\[
\varepsilon(f(x_i) - y_i) = \begin{cases} 0, & f(x_i) - y_i | < \varepsilon \\ |f(x_i) - y_i | - \varepsilon, & \end{cases}
\]

Try to make the linear regression function flat, control the complexity of the function, and minimize the ease field \(|w|^2\) of corresponding \( W \).

The main minimization target function is used to calculate the \( W \) and \( S \), which minimizes the formula:

\[
\begin{align*}
&y_i - w \cdot \psi(x_i) - s \leq \varepsilon + \xi_i \\
&w \cdot \psi(x_i) + s - y_i \leq \varepsilon + \xi_i^* \\
&\xi_i, \xi_i^* \geq 0.
\end{align*}
\]

Construct a Lagrangian equation by the above analysis:

\[
L(w, b, a, \xi) = \frac{1}{2} ||w||^2 + C \sum_{i=1}^{l}(\xi_i + \xi_i^*) - \sum_{i=1}^{l} a_i (\varepsilon + \xi_i - y_i + w \cdot \psi(x_i) - s) \\
- \sum_{i=1}^{l} a_i^*(\varepsilon + \xi_i^* + y_i - w \cdot \psi(x_i) - s) \\
- \sum_{i=1}^{l}(\lambda_i \cdot \xi_i + \lambda_i^* \cdot \xi_i^*).
\]

In the formula, \( a_i, a_i^*, \xi_i, \xi_i^* \) represent the Lagrangian multiplier, set the deflection of the parameter \( w, s, \xi_i, \xi_i^* \) to zero, and obtain the minimum value of the above formula, namely:

\[
\begin{align*}
\frac{\partial L}{\partial w} = 0 \\
\frac{\partial L}{\partial \xi_i} = 0 \\
\frac{\partial L}{\partial \lambda_i} = 0 \\
\frac{\partial L}{\partial \lambda_i^*} = 0.
\end{align*}
\]
Combined with the above formula, obtain a dual optimization problem:

\[
\begin{aligned}
\sum_{i=1}^{l} (a_i - a_i^*) &= 0 \\
C_{0}, 0 \leq a_i, a_i^* &\leq C.
\end{aligned}
\tag{24}
\]

The number of functional regressions of the SVM can be used, and \(W\):

\[
w = \sum_{i=1}^{l} (a_i - a_i^*)\psi(x_i).
\tag{25}
\]

The minimum solution of \(R(w)\) is \(a_i, a_i^*\). Solving the linear regression function by \(a_i, a_i^*\), to obtain abnormal data:

\[
f(x) = w \cdot (x_i) + s \\
= \sum_{i=1}^{l} (a_i + a_i^*)[\psi(x_i) + \psi(x)] + s \\
= \sum_{i=1}^{l} (a_i - a_i^*)K(x, x_i) + b.
\tag{26}
\]

The specific testing steps of the anti-counterfeiting detection method based on vector tracking tobacco supply chain are as follows [12,13]:

1. Constructing the support vector regression estimation model by the data processing by vector tracking algorithm.

2. If \(a_i = C\) or \(a_i^* = C\) is consistent, the residual corresponding to the sample point is calculated by the model:

\[
E_i = |y_i - \hat{y}_i|.
\tag{27}
\]

In the formula, \(\hat{y}_i\) describes the actual measurement value, and \(y_i\) describes the regression estimate.

3. Set constant \(\sigma\) according to the requirements of the measurement data and the actual requirements, set \(\sigma = [-1,1]\), when \(\sigma = 0\), the detection result is optimal.

When \(E_i > \sigma\), the \(y_i\)th sample is abnormal data, and the tobacco supply is retroactive anti-counterfeiting detection.

In combination, the detection flow chart of the anti-counterfeiting detection method based on vector tracking tobacco supply is shown in Figure 1.

5 Results and analysis

An internal network Linux server and MATLAB software were used to test this work.

5.1 Extract tobacco supply chain information

Extract tobacco supply chain information, which contains genuine information and fake information.

5.2 Denoising treatment

Since there is some noise in the tobacco supply chain information, the detection result is interfered, and the noise present in the tobacco supply chain information is processed using a vector tracking tobacco supply. On the basis of vector tracking tobacco supply, the signal is denoised by vector tracking, and the signal frequency fluctuation is obtained. The signal tends to stabilize, indicating that vector tracking tobacco supply linked source anti-counterfeiting detection method can effectively remove noise in the signal [14,15].

5.3 Detection effect

Based on the above, the method of supplying the tobacco supply chain is used, and the test results are shown in Figure 2.
According to Figure 2, when $\sigma = 0$, the vector tracking method is used, and the accuracy of the tobacco supply chain source anti-counterfeiting is 100%, the detection effect is optimal.

5.4 Detection time

The detection time and test results of monitoring tobacco supply chain with and without vector tracking method are shown in Figure 3.

It can be seen from Figure 3 that the detection time is very small when the vector tracking method is applied and not applied to monitor the tobacco supply chain. When the iteration time exceeds 60, the detection time after applying the vector tracking method is lower than that before applying the vector tracking method [16]. It is because the vector tracking tobacco supply is detected before the anti-counterfeiting detection method is detected, and the noise signal existing in the tobacco supply chain is removed, eliminating the interference caused by the noise signal in the source anti-counterfeiting detection process of tobacco supply, shortening the tobacco supply chain. The time used by anti-counterfeiting detection has increased detection efficiency [11].

5.5 Detection accuracy

450 samples were tested before and after the application of the vector tracking method. The detection results are shown in Table 1.

According to the analysis, 430 genuine samples were accurately detected, and 20 genuine samples were accidentally detected as fake. In the fraud sample, 45 samples were accurately detected, 5 samples were wrongly detected as genuine, and the total detection accuracy was 95.56%. After the application of vector tracking method, 450 authentic samples were accurately detected, 0 authentic samples were misused, and in the fraud sample, 49 samples were accurately detected, while 1 sample was wrongly detected. The total detection accuracy rate was 100%, the detection accuracy

| Methods                          | Category   | Detected as genuine | Detected as fake | Total |
|----------------------------------|------------|---------------------|------------------|-------|
| Before applying the vector tracking method | Count/a    | Genuine             | 430              | 20    | 450   |
|                                   |            | Fake                | 5                | 45    | 50    |
| accuracy/%                       |            | Genuine             | 95.56            | 4.44  | 100   |
|                                   |            | Fake                | 11.11            | 88.89 | 100   |
| After applying the vector tracking method | Count/a    | Genuine             | 450              | 0     | 450   |
|                                   |            | Fake                | 1                | 49    | 50    |
| accuracy/%                       |            | Genuine             | 100              | 0     | 100   |
|                                   |            | Fake                | 2.22             | 97.78 | 100   |
was relatively high. It is because the vector tracking tobacco supply chain trace source anti-counterfeiting detection method combined with vector tracking algorithm and SVM to detect tobacco supply linked source anti-counterfeiting, and improved the accuracy of the test results.

5.6 Detection effect

In order to verify the detection effect of this method, under multiple iterations, the tobacco supply chain before and after application of vector tracking method was applied, using the anti-counterfeiting detection, the extracted tobacco supply chain information is subjected to anti-counterfeiting test, and the test results are known. In the application of vector tracking method, the tobacco supply chain information is omissible in the anti-counterfeiting test results, reducing the detection effect, and the application of vector tracking method after application vector tracking method is accurate improves the detection effect [12].

Vector tracking method was used to extract logistics information in the tobacco supply chain, and EKF filter was used to deal with the noise in the obtained tobacco supply chain information, which eliminated the interference of noise signal in the detection process. SVM method was used to carry out regression estimation, and residual errors corresponding to sample points were calculated to obtain the abnormal data, so as to achieve traceability and anti-counterfeiting detection of tobacco supply chain. The experimental results show that the method proposed in this article has higher traceability and anti-counterfeiting detection efficiency, better detection effect, and improved detection accuracy.

6 Conclusion

This article describes the necessity of the system simulation used in the tobacco supply chain distribution center. The counterfeiting and traceability information of tobacco products in the market is unknown. Using the nonlinear discrete system model to analyze, we can quickly query tobacco products, and improve the detection effect of tobacco supply chain. No special case considerations were taken into account during this development. In the process of our system development, there are still deficiencies in the analysis of cigarette categories and characteristics. At present, we only completed the general discussion in a simple way. However, in the actual operation process, there may be some differences in the way of operation for different types of cigarettes, which also needs to be analyzed in terms of warehouse management.

The current coordinated operation of the supply chain is one of the very serious problems. Because there are more upstream and downstream enterprises in the supply chain, and more competition between them. For example, cigarette production enterprises mainly complete cigarette manufacturing, and cigarette sales are carried out by commercial companies, which leads to the division of procurement costs in the process of applying RFID technology, including purchasing RFID background system, RFID label, and wireless communication equipment.

Funding information: The authors state no funding involved.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest: The authors state no conflict of interest.

References

[1] Khan Z, Huque R, Sheikh A, Readshaw A, Eckhardt J, Jackson C, et al. Protocol: compliance of smokeless tobacco supply chain actors and products with tobacco control laws in Bangladesh, India and Pakistan: protocol for a multicentre sequential mixed-methods study. BMJ Open. 2020;10(6):e036468.

[2] Cuong TN, Kim HS, Nguyen DA, You SS. Nonlinear analysis and active management of production-distribution in nonlinear supply chain model using sliding mode control theory. Appl Math Model. 2021;97(4):418–37.

[3] Ramesh G, Thotappa C, Gnaneshwari GR. Efficient information management in technical education system supply chain using data integration system (DIS). Int J Inf Syst Manag Res Dev. 2019;9(1):37–44.

[4] Silva R, Mattos C. Critical success factors of a drug traceability system for creating value in a pharmaceutical supply chain (psc). Int J Environ Res Public Health. 2019;16(11):1972.

[5] Balwicki U, Stoklosa M, Balwicka-Szczyrba M, Drope J. Legal steps to secure the tobacco supply chain: A case study of Poland. Int J Environ Res Public Health. 2020;17(6):2055.

[6] Maulidah S. Risk mitigation of tobacco supply chain: business process model. Habitat. 2020;31(3):149–60.

[7] Adesanya A, Yang B, Iqadara F, Yang Y. Improving sustainability performance through supplier relationship management in the tobacco industry. Supply Chain Manag. 2020;25(4):413–26.

[8] Jianyong Li, Wang J, Peng M, Li L, Zhao J, Liu L, et al. Development of customized production machine for flue-
cured tobacco formula nutritional soil. Asian Agric Res. 2021;13(5):5.

[9] Marsoof A, Chen L, Kim HK. Plain packaging and tobacco trade marks: a constitutional and empirical study from singapore. Eur Intellect Property Rev. 2019;41(9):555–63.

[10] Ar A, Nmm B, Pk C, Bs D. Analysis of a dyadic sustainable supply chain under asymmetric information. Eur J Operational Res. 2021;289(2):582–94.

[11] Abdeljawad R, Bahri N, Ltaief M. Stabilization of discrete nonlinear singularly perturbed system with time-delay represented by a coupled multimodel. Energy Procedia. 2019;162:191–200.

[12] Cen Y, Wang H. Design and application of flavors composite scheduling system based on dynamic safety stock. IOP Conf Ser: Earth Environ Sci. 2019;252(5):052103.

[13] Mousavi BA, Azzouz R, Heavey C, Ehm H. A survey of model-based system engineering methods to analyse complex supply chains: a case study in semiconductor supply chain. IFAC-PapersOnLine. 2019;52(13):1254–9.

[14] Wang HT, Wen XY. Modulational instability, interactions of two-component localized waves and dynamics in a semi-discrete nonlinear integrable system on a reduced two-chain lattice. Eur Phys J Plus. 2021;136(4):1–43.

[15] Li M, Yue X, Xu T. Asymptotic behaviors of mixed-type vector double-pole solutions for the discrete coupled nonlinear Schrodinger system. Eur Phys J Plus. 2021;136(1):62.

[16] Rofin TM, Mahanty B. Equilibrium analysis of dual-channel supply chain under retailer’s greening cost information asymmetry. Int J Inf Syst Supply Chain Manag. 2020;13(4):22.