Research on Traceability Modelling of Tobacco Production Quality Based on Information Synergy

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Abstract. To improve the quality of tobacco production accurate traceability, this paper is based on "Quality Information Resource Pool" formed by tobacco production management information system, constructing a causal traceability model of tobacco production quality, researching and development of traceability algorithm for tobacco production quality based on extended event graph. The quality traceability of raw materials, silk, tobacco and cigarette batches was realized successfully, the real-time and accuracy of quality tracing in tobacco production are improved.

1. Introduction
Product traceability is an effective technical scheme to control and solve the problem of product quality and safety, which can make consumers fully understand the detailed information of each link of product circulation. Tobacco through anti-counterfeiting traceability to show products, will undoubtedly let consumers have a deeper impression of the high quality of products. Liu Peng et al. (2020)[1] thought traceability is the basic idea of quality management and an important means to ensure the quality and safety of products. Zhong Lin et al. (2019)[2] used multi-block MICA-PCA method to fuse scheduling information, construct the structure model of tobacco quality traceability system, and realize the design of tobacco quality traceability system. Fan Haifeng (2019)[3] applied blockchain technology to the traceability of tobacco quality and safety to ensure the quality and safety of tobacco. Ling Jing et al. (2014)[4] proposed the method of tobacco anti-counterfeiting and tobacco quality traceability based on Internet of things, established the data model of tobacco anti-counterfeiting and quality traceability system, realized the monitoring and tracking of the production, circulation and sale of tobacco products, improved the level of tobacco anti-counterfeiting and realized the accurate traceability of tobacco quality. Shiqing Yao (2020)[5] built a game theory model to study the important role of traceability in combating product label misconduct. Kristín Óskarsdóttir et al. (2019)[6] identified possible traceability structures in the cold chain by identifying different types of technologies for cold chain traceability, and constructed a decision support framework (DSF) to select appropriate technical solutions. Changxiao Liu et al. (2018)[7] proposed the quality and process control model of Chinese herbal medicine products, and built the transmissibility and traceability system based on quality markers to improve the quality of Chinese herbal medicine products from the whole supply chain and production chain.
2. Causality Traceability Logic Model Based on Extended Event Graph Structure

The tobacco production quality event is expressed as an extended event graph, which is expanded according to the multi-level of tobacco processing production and logistics. In the quality problem event layer, the quality event cause layer, the business segment layer, and the business data layer, respectively uses the different forms of event graph structure, and according to the horizontal causality and vertical causality, Forming a pyramid-based causal traceability logic model for tobacco quality is shown in Figure 1.

![Figure 1. Causal traceability logic model for tobacco quality](image)

- The quality problem event layer represents the type of quality event that may occur for tobacco.
- The quality event cause layer represents the immediate cause events that lead to these quality problems.
- The business segment layer represents the quality events of each business link in the supply chain.
- The business data layer records the operational status of each business link.

3. Extension of Event Graph and Causal Edge Analysis

(1) Basic Composition of Event Graph

The vertices in the event graph act as the basic unit to describe the quality events, and the edges act as the basic unit to describe the state and behavior changes. The complex events and activities of tobacco quality are represented by the event graph.

(2) Event Graph Element Extension

The event graph uses vertices and edges to express each link of tobacco logistics to meet the basic requirements of causality in traceability modeling. But the time and relationship it describes is relatively simple, the information it describes is limited, and it is not a sign of causality. So we should extend the event graph and improve the algorithm.

Extended event graph elements consist of event nodes, causal edges and standard extended event graph structures.

Event nodes are described in six-element groups. The function can be expressed as:

\[ E = (id, attribute, causal, t_0, t, others) \]  

- \( id \) is identified as a unique event type, \( \forall E_i, i \neq j : E_i.id \neq E_j.id \);
- \( attribute \) represents the attributes of the event, is a limited collection, \( attribute = \{attribute_1, attribute_2, ..., attribute_n\}, n \geq 0 \);
causal = \{e_1, e_2, \ldots, e_n\} (n \geq 0) is a causal vector representing the set of reasons for the event; 

\( t_0, t_1 \) represent the start and end time of an event; 

\( \text{others} \) means other information. 

In the event graph, each causal edge is equivalent to a function, from one event node to another. According to the definition of causality and the characteristics of tobacco quality events, the factors can also have time characteristics, condition characteristics and probability characteristics. The function can be expressed as:

\[
Tr_{ij} = (N_i, N_j, \text{cond}_{ij}, t_{ij}, p_{ij})
\]  

\( N_i, N_j \) denotes the causal edge; 

\( \text{cond}_{ij} \) indicates the conditions under which causality occurs or activates; 

\( t_{ij} \) represents the delay time of node \( i \) event occurrence relative to node \( j \) event occurrence; 

\( p_{ij} \in (0,1) \) represents the probability relationship between node \( i \) events and node \( j \) events. It has two meanings, One is the causal probability, that is, when \( \text{Cond}_{ij} \) is the probability of triggering node \( j \) event after the occurrence of event node \( i \); The second is the causal strength, That is, the probability that the node \( j \) event occur and triggered by the node \( i \) event when the \( \text{Cond}_{ij} \) is true.

The extended event graph structure consists of a node set \( N \) and finite causal edge \( R \). Each node connects with each other through a directed edge to form a directed graph \((N, R)\), a set of nodes in a graph consists of a logical node representing an event node and a logical relation; Causal edge set \( R = \{Tr_{ij}\} \).

4. Quality Traceability Algorithm for Tobacco Production Logistics Based on Extended Event Graph

The main idea of cause-and-effect tracing is to find the path to obtain the maximum cause-and-effect intensity for a certain cause event from the outcome event that has occurred quality problems. The primary path can be thought of as backward inference, representing the maximum probabilistic path from a quality issue event to a business process operation event. At present, the most short-circuit algorithm is the classic Dijkstra algorithm. The extended event graph satisfies the premise that it does not contain non-directed loops with length, but sets the probability product between two nodes as the path length, and changes the shortest probability path to the maximum probability path.

Given quality problem event graph \( G(V, E) \);

\( \pi(u, v) \) indicates the causal probability between quality problem events \( u \) and \( v \), If there is no direct edge to edge connection between quality problem event \( u \) and business link event \( v \), then \( \pi(u, v) = 0 \);

\( \text{LABEL}(u) \) indicates the maximum causal strength when node \( u \) occurs;

\( \text{PREM}(u) \) indicates whether node \( u \) needs to be calculated ( \( \text{PREM}(u) = 0 \) indicates calculation required; \( \text{PREM}(u) = 1 \) indicates no need for calculation);

\( \text{POST}(u) \) indicates which node \( u \) gets the maximum strength from, So the main path from \( u \) to \( v \) is \( \text{POST}(u), \text{POST}(v), \text{POST}(v), \ldots, u \).

Input: Starting point node \( n_1 \) (quality problem event), Termination node \( n_2 \) (business segment), The cause and effect graph between them is \( G(V, E) \).

Output: The most possible path from quality problem event \( n_1 \) to business segment event \( n_2 \), Probability of business segment event \( n_2 \).

The algorithm is as follows:
Step 1: Given $n_1$, $n_2$;

Step 2: Let $\text{LABEL}(n_1) = 1$, $\text{PREM}(n_1) = 1$, $\text{POST}(n_1) = n_1$, For all $v \in V$, $v \neq n_1$, Let $\text{LABEL}(v) = 0$, $\text{PREM}(v) = 0$, $\text{POST}(v) = v$;

Step 3: Let $u = n_1$;

Step 4: For each node $v$ with $\text{PREM}(v) = 0$, do the following:

To calculate $\text{LABEL}(u)$ and update $\text{POST}(v) = v$.

Let $M = \max(\text{LABEL}(v), \text{LABEL}(u)) = M$, $\text{POST}(v) = u$.

Step 5: In all nodes with $\text{PREM} = 0$, Find the node with the maximum $\text{LABEL}$ value, Let $\text{PREM}(w) = 1$, $u = w$;

Step 6: If $\text{PREM}(n_2) = 0$, then go to step 4, otherwise go to step 7;

Step 7: Submit the most likely path for the results: $n_2$, $\text{POST}(n_2)$, $\text{POST}(\text{POST}(n_2))$, ..., $n_1$, and Probability of business segment event $\text{LABEL}(n_1)$.

Traversing the business segment events $\{n_2, n_3, ..., n_k\}$ associated with quality event $n_1$ in turn, Finding out the main paths and ranking them according to the probability. The ranking priority represents the traceability priority and scheme.

Based on the causal traceability of the event graph, the causal relationship between the events is established, the search space is greatly reduced, and the quality problem events and business links are together, the quality problem traceability is realized and the defect links can be found to improve.

5. **Traceability of Tobacco Production Quality Based on Information Collaboration**

Based on information collaboration, the quality traceability of Yunnan Zhongyan tobacco production mainly includes the whole process batch quality traceability of materials and finished tobacco. To realize the overall management of quality traceability can improve the quick response ability and quality management level of quality traceability, and realize the Lean quality management of enterprises. The main framework of quality collaborative management is shown in Figure 2.
Figure 2. The main framework of quality collaborative management

Quality traceability mainly includes: raw material batch tracking, silk making batch tracking, strip tobacco batch tracking, piece tobacco batch tracking.

1) Raw material batch tracking
The batch information of raw materials, auxiliary materials and sugar materials is integrated with the section equipment, quality, personnel and other information of slicing, premixing and feeding in MES system to realize the construction of batch traceability information of raw materials.

2) Silk making batch tracking
Starting from the production task of MES system, according to the production process requirements, the raw materials that have been processed are put into the silk making section for cutting, drying, blending and entering the finished tobacco cabinet. Among them, batch scanning is carried out for the blending and flavoring section, and information such as equipment, quality and personnel of each section is recorded to form the information of silk making section. With the operation plan number as the tracking means, the tracking information of silk making batch is constructed. By associating with the tracking information of raw material batch, the tracking information from raw material batch to silk making batch can be constructed.

3) Strip tobacco batch tracking
Starting from the production task of MES system, scan the auxiliary materials according to the batch scanning rules of auxiliary materials, and associate and integrate with the process information of equipment, quality, personnel and other process information in the process of crimping and packaging to strip to form the tracking information of crimping batch. Through the association with the tracking information of silk making batch, the tracking information from raw material batch to strip tobacco batch can be constructed.

4) Piece tobacco batch tracking
Starting from the production task of MES system, scan the auxiliary materials according to the batch scanning rules of auxiliary materials, associate and integrate with the information of packaging box equipment, quality, personnel, etc., and integrate with the coding information of No.1 Project, so as to form the information of piece tobacco batch tracking. Through the association of Strip tobacco
batch tracking information, the construction from raw material batch information to piece tobacco batch tracking information is realized.

6. Conclusion
The demand for traceability of tobacco products has been deeply rooted in people's minds. Traceability has become an important feature of tobacco quality management, which can be used to identify the root of many quality problems. The Tobacco Quality Traceability Technology Based on information collaboration established in this paper can realize the tobacco quality traceability, realize the full information supervision from production, logistics to supply, and have good quality traceability positioning and identification ability in the quality problem event layer, quality event cause layer, business segment layer and business data layer.

7. References
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