Research on the formation logic and basic model of standards

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Abstract. The out-of-date and cross repetition of standards is one of the key issues in the current standardization work. Before the comprehensive application of modern technology to solve such issue, it is necessary to study the mechanism and logical relationship of standards in theory, so as to provide theoretical support for the research of modern technology. From the perspective of natural evolution and human social development, this paper studies and proposes the classification of standards and the mechanism of standards generation. Besides, from the perspective of system theory, the basic model of standards is also proposed and studied. Finally, from the perspective of development and implementation, current issues are summarized, which provides support for the future study to propose a systematic scheme of standards out-of-date and cross repetition.

1. Introduction

After years of development, the standard has become a "universal language" due to its regularity, wide recognition and self-consciousness of compliance. It plays an important role in solving the contradictions and inconsistencies among the world, countries, regions, social groups and groups, and in helping human beings cope with the challenges of the environment, resources, and development\textsuperscript{[1]}. However, out-of-date and overlapping standards have become a critical problem that we have to face. In addition to the traditional method of reviewing standards, how to use technical methods to solve this problem is particularly important. This paper studies the origin of standards, systematically explains the basic concept, formation logic and basic model of standards, and provides the most basic support for using modern advanced technology and methods to study standards.

2. The concept and classification of standards

According to the definition of the standard given by the international organization for Standardization (ISO): the standard is a document that is used and reused by consensus and approved by a recognized institution in order to obtain the best order within a certain range\textsuperscript{[2]}. This concept can cover common document standards and a small number of physical standards in daily life, such as delivery acceptance test specifications for launch vehicles, zero requirements for project product quality management. These standards generally have specific objects, so we are accustomed to thinking that the standards are tangible. However, there is also an invisible standard, widely existing in daily life, such as practice is the only standard to test the truth, a person's success standard, which is an invisible standard, but this is everyone's consensus or common view.

The core of the standard is unification, which is not only the objective existence but also the subjective establishment. Therefore, according to the objective existence and subjective establishment, the
standards are divided into the following three categories\cite{3}:

2.1. **Objective standards established by nature**
In the long-term evolution of nature, the standards of matter, energy, and law have been gradually formed. After the emergence of animals and plants, according to the unconscious instinctive behavior standards determined by the structure, gene, and shape of animals and plants, such standards will not change with the change of time, or change very little and very slowly. For example, water (H2O) is composed of hydrogen and oxygen.

2.2. **Subjective standard**
After the emergence of human beings, the standards of behavior, knowledge, material, energy, law and other aspects have been constructed through the conscious transformation of nature. Such standards change rapidly and are the standards of nature from scratch.

2.3. **Objective standard of subjective cognition**
In the process of remoulding nature, with the continuous development of science and technology and the gradual deepening of human understanding of nature, the objective existence of natural phenomena are found and expressed in knowledge, gradually forming a standard, which will change with the change of human understanding, and its change is long and intense.

Within the scope of ISO definition, the commonly referred standard is class B standard, which has formed a wide consensus and is widely used, such as ISO, IEC, GB, industry standards. The class A standard described in this paper is mainly about the expansion of human knowledge and the exploration of natural phenomena, including new phenomena, new matter, new energy and so on. It is usually called the results of natural science exploration, such as the structure of matter, dark matter in space, dark energy, black hole, and other natural phenomena. The class C standard is mainly based on the long-term observation and study of natural phenomena and its unified description, which is usually called scientific research results, such as Newtonian mechanics, Einstein's relativity.

3. **Time and logic of standard formation**
To sum up, from the perspective of the objective laws of human understanding and transformation of the world, the logical order of the origin of standards should be Class A standards, class B standards, and class C standards. Class A standard is the basis of class B standard, and class B standard is the basis of the class C standard. The process of establishing the standard includes not only the principle of the process from quantitative change to qualitative change and then to new quantitative change, but also the principle of contradictory movement between positive and negative.

This paper focuses on the logical process of establishing class B standards. In the process of establishing class B standard, the first is to understand the world and solve the problem of survival, which is mainly manifested in the animal's instinct standard, such as eating, self-protection. The second is to transform the world and solve the problems of the development and progress of human society, which are mainly manifested in the standards of labor behavior, language and characters, tool measurement and document standards\cite{4}.

3.1. **Standard of animal instinctive behavior**
In the process of animal evolution, due to different forms and different genes, the same kind of animals have gradually formed a unified standard, such as the way of eating and the content of eating, the way of excretion, the way of movement, the behavior of self-protection, the behavior of self-reproduction and so on. In the process of evolution, the animal's instinct behavior is constantly unified and changed, and finally, a relatively constant standard is formed to exist for a long time. The reason why this standard is relatively unchanged is that human instinct behavior is different from other animals. Human's instinct behavior constantly adapts to the changes in the environment and makes minor adjustments in the process of evolution, which is also one of the most basic states of a modern standard.
3.2. Standard of labor behavior
The standard of labor behavior is the standard formed in constant competition for the survival of animals on the basis of the standard of instinctive behavior.

1) Language Standard: Most animals have the ability to voice. Voice is used to express the demand for instinct behavior or labor behavior. Compared with human language behavior, this kind of language can become a low-level language. In order to obtain a better survival ability and living environment, human beings need to teach them good behaviors that have been found and proved, which requires the language that can express the basic information concepts and can describe, and form a unified standard, so that this skill can be taught and spread continuously. Language behavior standards solve the problem of communication and teaching, but these language behaviors cannot be recorded and preserved for a long time. It is necessary to find a method as a long-term way to record events, and this method should have a unified attribute. It can be said that words are the supplement of language behavior, which solves the limitation that language communication cannot cross time and space, and enables the standards formed in the process of human evolution to be preserved and inherited.

2) Tool Metrics Standard: Human beings constantly meet and improve their instinctive needs through labor. At the same time, after the emergence of language and character standards, a large number of effective exchanges have begun, which makes the results of labor more abundant and the utilization rate of results further improved. This has given birth to a large number of standard tools to further expand the ability to obtain results. The emergence and development of standard tool products have further widened the differences between human beings and other animals. After the development of human society to a certain extent, the social division of labor appears, and rich products begin to exchange in a certain way, which gives birth to a new standard, that is, to meet the measurement standard of fair trade of products. Measurement standard is not only a legal standard but also a physical standard. The emergence of measurement standards makes human society develop from qualitative to quantitative. With the gradual enhancement of human's ability to understand and transform the world, human society ushered in industrialization.

3) Document Standard: With the continuous improvement of industrialization, advanced experience and technology produced in the process of industrialization are expressed in words and managed by a unified organization. The establishment of document standards usually has strict procedures. Through a complete set of procedures, the objects with unified requirements and reusable methods and technologies are expressed in words or in kind, which is reviewed and approved by experts and issued by special agencies. The establishment of document standards also needs rigorous scientific research and necessary practical verification. Document standard is also the standard in the modern sense.

3.3. Establishment path and future development trend
From the perspective of the established path and future development trend of class B standards, the formation of standards generally includes three paths: first, experience summary standard; second, fact standard; third, the next-generation standard.

1) Experience Summary Standard: The standard of experience summary comes from human instinct, which solidifies and inherits good experience, technology, knowledge, and achievements, and implements ambiguous experience and technology by consensus. Such as the long-term exploration of self-protection skills and other instinctive behaviors.

2) Fact Standard: Due to the complex reasons, some advanced management concepts, technologies, and services have not formed standards according to the fixed procedures, but some organizations or enterprises still rely on their own advantages to form the actual standards in the form of standards and social soft links.

3) Next-Generation Standard: The next generation of standards is the creation of the unknown world and the unknown knowledge system. Generally, it is led by the standard making body with superior technical ability to gather the industry and social advantageous resources, which will help the advanced technology and products of the standard making body form a new generation of standards, push them to the market, and promote the progress of science and technology of the whole society.
4. Basic model of standards

Take Technical Standards (TS) as an example to study the basic model of standards, and other types of standards are similar to it. The path of establishing standards tells us that standards and technology are dialectical unity and mutual promotion. The existence of standards builds the foundation of technology, the progress of technology promotes the emergence of new standards, and the emergence of new standards leads to the development of technology. Therefore, the research on the relationship model between standards and technology can be carried out from two aspects:

Research Technology Formation Standard (RTFS) and Research Standard Creation Technology (RSCT).

4.1. Technical standard generation model (TSGM)

Definition 1: TS function $S_1$:

$$S_1(u, m, t) = \sum_0^t (u_i + m_j)$$

(1)

It represents the sum of general technology (GT) and mature technology (MT) that certain technology can be refined and solidified as a standard at time $t$. Where $u$ represents GT and $m$ represents MT. Obviously, $S_1(0, 0, t) \equiv 0$, $S_1$ is an increasing function of $t$.

Definition 2: TS function $S_2$:

$$S_2(n, o, t) = \sum_0^t (n_k + o_l)$$

(2)

Where $S_2$ represents the sum of newly created technology and inherited technology in the process of producing a TS at time $t$. Where $n$ represents the new technology (NT) and $o$ represents the inheritable technology (IT). Obviously, $S_2(0, 0, t) \equiv 0$, $S_2$ is an increasing function of $t$.

The model is shown in Eq. 1 is called the RTFS model, and the model is shown in Eq. 2 is called the RSCT model.

Eq. 1 is essentially a process of technology changing from private to public. In order to form a TS, the technology owner needs to contribute its technology and form a recognized technology for everyone to reuse. Once the standard is formed, the technology owner may also face the possibility of self-adjustment to adapt to the relevant technical indicators. In addition, the standards shown in this model are inherently lack of foresight and guidance, which is also the source of standard aging lag. Eq. 2 is the process of technology changing from public to private. This kind of standard is not completed by a certain enterprise or research institution in the process of formulation, but by gathering the wisdom of all walks of life, discussing and forming a standard together, and then the enterprise decomposes and occupies the technology in this field according to its own advantages. The obvious advantages of this kind of standard are technological leapfrogging and huge economic benefits, e.g. communication technology, intelligent manufacturing technology.

Rewrite the TS model shown in Eq. 1 and Eq. 2:

$$S_1(u, m, t) = \frac{\sum_0^t u_i}{\sum_0^t m_j}$$

$$S_2(n, o, t) = \frac{\sum_0^t n_k}{\sum_0^t (n_k + o_l)}$$

(3)

(4)

As can be seen from Eq. 3, there are three sources of TS in RTFS model:

Firstly, the GT or products bearing the GT are directly solidified into TS, such as raw materials and components standards. Secondly, the MT verified by the product or market is refined and solidified to form TS, such as a single machine or parts standards. Thirdly, integrating two standard formation methods to form TS, e.g., the development standards of basic projects.

As can be seen from Eq. 4, in order to achieve the overall optimization of the project, it is necessary to study the specific indicators in the project in the RSCT model.
First, we need to study the standards, such as the design and manufacturing standards of components and raw materials, the standards of components or stand-alone products, and the overall standards of the system. We need to study the standards to determine those that need new research technologies and those that need to inherit the existing technologies. After that, we can study the standards based on the standards obtained by the research technology, and create new technologies to meet the needs.

To ensure the reliability of products and technologies, GT and MT can be recognized as IT, combining Eq. 3 and Eq. 4:

\[ S(u, m, n, t) = \sum_{i,j,k}^{} (u_i + m_j + n_k) \]  \hspace{1cm} (5)

When \( k = 0 \), Eq. 5 forms the RTFS model. When \( i, j = 0 \), Eq. 5 forms RSCT model, which updates almost all of the existing technologies and completely adopts the standards of new technologies. Generally, the generation cycle of such standards is quite long. For this reason, Eq. 5 can be called Technical Standard Generation Model(TSGM).

4.2 Standard change model

In order to further study the development of TS, it is assumed that some of the new TS become Mature Technical Standard(MTS) or General Technical Standard(GTS) with the passage of time, and some are replaced by the latest TS.

Definition 3: function:

\[ p(n, t) = \frac{\partial S(n, t)}{\partial n} \]  \hspace{1cm} (6)

It represents the distribution density of new TS in all TS of an enterprise at time t. Therefore:

\[ S(n, t) = \int_{0}^{n} p(\rho, t) d\rho \]  \hspace{1cm} (7)

Note that \( Q(n, t)\Delta n\Delta t \) is the total number of New Technical Standard(NTS) generated in the standard age range \((n, n + \Delta n)\) and time interval \((t, t + \Delta t)\).

Definition 4: function:

\[ \mu(n, t) = \frac{Q(n, t)\Delta n}{p(n, t)\Delta n} = \frac{Q(n, t)}{p(n, t)} \]  \hspace{1cm} (8)

It represents the obsolescence rate of enterprise TS. That is the proportion of the standards formed by the eliminated technology in the total TS.

Then, at the time of t, the number of NTS in the standard age interval \((n, n + \Delta n)\) is \( p(n, t)\Delta n \). After a period of time \( \Delta t \), some TS survive to the time of \( t + \Delta t \), and become MTS and GTS. The other technologies will be obviously eliminated, and the relevant TS will be invalid. At the same time, NT that replace these technologies will gradually appear. Even NTS will appear ahead of time. Since the changes in \( \Delta n \) and \( \Delta t \) are the same, it can be proved that the following equation holds.

\[ p(n + \Delta n, t + \Delta t)\Delta n - p(n, t)\Delta n = -\mu(n, t)p(n, t)\Delta n\Delta t \]  \hspace{1cm} (9)

When \( \Delta t = \Delta n \rightarrow 0 \), a differential equation can be obtained:

\[ \frac{\partial p}{\partial t} + \frac{\partial p}{\partial n} = -\mu(n, t)p \]  \hspace{1cm} (10)

Note that \( f(n, t) \) is the conversion rate of the TS with the standard age of \( n \), that is, the TS formed by RSCT changes into a GTS or an MTS; \( \phi(t) \) is the generation rate of the NTS at the time of t, combining Eq. 10.

\[ \begin{align*}
\frac{\partial p}{\partial t} + \frac{\partial p}{\partial n} &= -\mu(n, t)p + f(n, t) \\
p(n, 0) &= p_0(n) \\
p(0, t) &= \phi(t)
\end{align*} \]  \hspace{1cm} (11)
Among them, the conversion rate of TS, the invalidation rate of TS and the production rate of NTS will have an impact on the Technical Standard System of enterprises, and then affect the product status of enterprises.

4.3. Technical standard structure

Based on the above model, the TS is structured according to the definition of the current standard, as shown in Figure 1.

![Figure 1. Technical standard structure](image)

The structure of technical standards can be roughly divided into format elements and technical elements. For format elements, it generally includes fixed format information, fixed element information, technical chapter information and technical inheritance information, which can be realized by machine learning; for technical elements, it is mainly new technical information, which needs to be realized manually. The common practice is that the engineer put forward the technical roadmap firstly, and then the experts come up with his judgment whether it is feasible or even give good suggestions. The information obtained by machine learning can be processed as structured data, the information obtained through manual sorting and judgment needs to form a mind map or technology roadmap. Finally, the technology roadmap and structured database are fused to form a standard graph, as shown in Figure 2.

![Figure 2. Technical standard graph](image)

5. Problems in the development and implementation of standards

In the process of development and implementation of TS, there is always some resistance.

5.1. Resistance of technicians

RTFS can not only obtain rapid benefits but also do not need to invest human and material resources to develop standards. These standards are produced synchronously with the production of products. Because of its low content of NT, low conversion rate, low void rate of standards and the production rate of NTS,
the TS are in a stable state for a long time, which is one of the root causes of the problems of standard aging and cross repetition.

In the process of RTFS, due to a large number of MT and GT, this standard plays a certain role in the production process of products, but it has little role and significance in the development of new markets for products, leading to the low enthusiasm of enterprises in developing standards[5].

5.2. Resistance of management decision makers
RSCT can occupy the future market and bring huge profits to the enterprise. It is the core weapon for the enterprise to obtain the "discourse right" and occupy the "commanding height"[6]. However, this situation also brings great risks.

Due to the lack of technical support, enterprises need to invest a lot of human, material, financial and energy to develop and gather advantageous resources in the process of RSCT. After the formation of standards, they need to further invest in R&D to create technologies matching with standards, which will result in the secondary investment and bear a huge burden of enterprises.

Due to the continuous development and improvement of technology, the conversion rate of TS, the invalidation rate of TS, the production rate of NTS and other relevant indicators will continue to improve, which may cause the standards developed with great efforts to be transformed into GTS and MTS in a short time, and even more likely to be eliminated, which brings great uncertainty to the development of enterprises.

5.3. Resistance of human behavior and habits
The resistance to the development and implementation of TS also comes from the contradiction between habit and change, restriction and freedom. The TS comes from the summary of habit and the solidification of restriction, which is naturally opposed to the characteristics of technology changing and free exploration. Therefore, in the development of TS, it is not only necessary to consider the summary and solidification of existing technologies, but also necessary to consider the change of technology itself, the ratio between efficiency and cost, and the operability of TS in the implementation process of these technologies, so as to minimize the implementation of pseudo technical standards with empty content, no substantive role, and management purpose.

6. Conclusions
Today, with the development of human society, globalization has become an irreversible development trend. As a universal language in the world, standards need coordinated development and promote world connectivity. Standardization plays an increasingly important role in facilitating economic and trade exchanges, supporting industrial development, promoting scientific and technological progress, and regulating social governance. From the perspective of natural evolution and human social development, this paper studies the concept, classification, formation mechanism, basic model and problems in the implementation of standards. Combined with the definition of standards by ISO, the scope of the standard is expanded from the theoretical level, which improves the universality of the standard and provides support for the study of standardization to a certain extent.

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