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Research on Legal Issues of Product Liability in Internet of Things Smart Home Products

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ABSTRACT

With the rapid advancement of Internet of Things technology, the smart home industry has achieved explosive growth. Nevertheless, prominent challenges including product defects, data security threats, algorithmic risks and ambiguous liabilities of multiple parties have emerged, posing severe challenges to the traditional legal system of product liability. Based as the Civil Code, Product Quality Law and Personal Information Protection Law of the People's Republic of China, this paper combines the technical characteristics of the Internet of Things and typical judicial cases. It systematically sorts out core difficulties concerning identification criteria, liability allocation, evidence rules and damage compensation of smart home product liability. The study explores liability identification standards and sharing mechanisms adaptable to Internet of Things scenarios, and puts forward compliance suggestions for enterprises, rights protection guidelines for consumers and regulatory references for the industry. It provides theoretical support and practical reference for judicial practice, industrial standardization and sound industrial development.

KEYWORDS: *Internet of Things; Smart Home; Product Liability; Data Security; Algorithmic Risk.*

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1. INTRODUCTION

Against the backdrop of interconnected everything, the smart home industry has developed rapidly and become a vital component of China's digital economy. By 2025, the domestic smart home market scale has exceeded 600 billion yuan, with the penetration rate of smart home appliances and household intelligent devices steadily rising and the industry maintaining robust growth momentum.

Rapid industrial expansion is accompanied by frequent safety incidents and legal disputes, such as fires caused by spontaneous combustion of products, property losses from hacked devices, privacy data leakage and personal injuries resulting from erroneous algorithm judgment. These incidents expose multiple hidden risks in hardware protection, data security and algorithm ethics, and bring unprecedented challenges to the application and improvement of the traditional product liability legal system.

The traditional product liability regime centers on tangible physical goods and adopts a dual-liability model covering producers and sellers, which fails to adapt to composite smart home products integrating hardware, software, data and services. Controversial issues remain unsettled under current laws: whether algorithmic defects qualify as product defects, how to compensate mental damages arising from data leakage, and whether platform operators and data service providers shall bear product liability. Unclear legal provisions lead to difficulties in liability confirmation in judicial practice, high costs for consumers safeguarding legitimate rights and vague compliance boundaries for enterprises. Targeting the aforesaid problems, this paper analyzes product liability of IoT smart home products from theoretical and practical perspectives and proposes improvement approaches.

2. Basic Theories and Legal Definition of Smart Home Product Liability

2.1. Legal Attributes of Smart Home Products

Different from conventional single physical industrial products, smart home products are highly integrated combinations of hardware equipment, embedded software, cloud algorithms, data services and network

transmission, featuring networking, intelligence and continuous updating. Traditional products only carry static defects formed during manufacturing, while potential risks of smart home products run through the whole life cycle including production, sales, daily use, OTA upgrades and background algorithm iteration, with defects characterized by dynamism, concealment and technical complexity.

Legally defined, smart home products are neither pure tangible goods nor simple network services, but integrated hardware-software intelligent products. Hardware parts are governed by traditional product liability rules, yet no specific legal provisions regulate damages triggered by software loopholes, algorithm deviations and data leakage, which constitutes the fundamental cause of frequent liability disputes.

2.2. Imputation Principles of Smart Home Product Liability

In accordance with the Civil Code and Product Quality Law, traditional product tort liability applies a dual imputation system: strict liability for producers and fault liability for sellers. This principle prioritizes consumer interests and lowers the burden of proof for ordinary users, while showing poor adaptability in smart home scenarios. On one hand, covert technical defects such as algorithm flaws and software vulnerabilities may cause damages despite producers' absence of subjective fault, justifying the continued application of strict liability. On the other hand, platform and data operators do not fall into the legal category of traditional producers or sellers. Indiscriminate strict liability will result in excessive liability expansion, while exclusive fault liability will deprive consumers of effective remedies, leading to inconsistent judicial adjudication criteria.

2.3. Scope of Product Liability Subjects

Traditional product liability is only applicable to producers and sellers. The industrial chain of smart home products involves multiple participants, including hardware manufacturers, software developers, algorithm service providers, cloud platform operators, network service suppliers and after-sales upgrade service providers. Diversified liable parties often pass the buck once accidents occur. For instance, accidents caused by faulty background algorithm updates may lead to disputes between hardware manufacturers and software service providers over defect attribution, leaving victims facing obstacles in claiming compensation due to blurred liability boundaries.

3. Judicial Dilemmas and Practical Problems of Smart Home Product Liability

3.1. Ambiguous Identification Criteria for Product Defects

Chinese laws take unreasonable danger as the core standard and classify product defects into manufacturing defects, design defects and warning defects. The criteria applicable to traditional tangible products cannot fit the intelligent attributes of smart home products.

First, algorithmic black boxes, biased algorithms and misjudgment do not belong to traditional manufacturing or design defects, and are not incorporated into the legal defect system. Related tort cases can only be handled under general tort provisions with insufficient compensation.

Second, OTA remote upgrades may generate new vulnerabilities even if products are defect-free when leaving factories, and current laws lack basis to define such acquired dynamic defects.

Third, privacy data leakage from intelligent equipment is essentially a failure of product safety performance, but such cases are usually judged as personal information infringement rather than product liability cases in judicial practice.

3.2. Chaotic Liability Division among Multiple Parties

The long industrial chain and diversified participants expose loopholes in the traditional dual-liability framework. Firstly, cloud platforms serving core operational functions often claim exemption by merely providing technical services rather than manufacturing products. Secondly, outsourced software and algorithm developers who create core defects only bear contractual liability instead of product tort liability, failing to fully compensate victims for personal and property losses. Thirdly, producers and sellers bearing compensatory liability encounter difficulties in recovering losses from actual defect-causing parties, resulting in misplaced liability assumption.

3.3. Excessive Burden of Proof on Consumers

Consumers need to prove product defects, actual damages and causal relationship between defects and damages in liability disputes. Technical barriers break the original balance of proof burden. Hidden defects such as algorithm loopholes and background data anomalies are inaccessible to ordinary consumers, creating unequal proof capabilities. In addition, accidents are usually caused by multiple intertwined factors, making it hard for consumers to verify direct causal links between product defects and damages, and many claims are dismissed due to insufficient evidence.

3.4. Limited Scope of Damage Compensation

Traditional compensation rules focus on personal injury and tangible property loss, failing to cover

diversified damages of smart home products. Firstly, privacy and biometric information leakage may incur severe mental harm, but relevant compensation standards under product liability law are inadequate. Secondly, interconnected smart devices may suffer cascading property losses triggered by single equipment defects, beyond the coverage of conventional compensation rules. Thirdly, recurring potential risks can only be remedied by post-hoc compensation, with no preventive liability clauses to avoid prospective hazards.

4. Improvement Paths for Smart Home Product Liability Legal System

4.1. Restructure Identification Criteria for Product Defects

Revise defect judgment rules adapting to dynamic and intelligent product features. Include algorithmic flaws into the scope of product defects and adopt dual evaluation standards of technical rationality and ethical compliance. Clarify enterprises' full-life-cycle safety liabilities for defects arising from OTA upgrades and algorithm iteration, and establish systems for upgrade filing and log preservation. Incorporate data security flaws into defect assessment and align product liability with data safety obligations.

4.2. Establish Multi-party Liability Sharing Mechanism

Break the traditional dual-liability mode and build an industrial-wide liability system. Expand liable subjects to algorithm service providers, platform operators and software developers. Specify respective liabilities: hardware manufacturers bear strict liability for hardware defects, software and algorithm providers assume strict liability for intelligent functional defects, and platforms undertake presumed fault liability for data security and system stability. Impose joint and several liability for composite defects and improve internal recourse mechanisms among responsible parties.

4.3. Optimize Burden of Proof and Evidence Rules

Implement reversed burden of proof for technical defects, requiring enterprises to prove non-defective products and irrelevant causal relations, otherwise tort liability shall be presumed. Mandate enterprises to preserve operational, algorithm and upgrade logs for at least five years, and impose adverse legal consequences for refusal of evidence submission. Set up professional technical appraisal institutions to support judicial judgment and reduce consumers' proof costs.

4.4. Coordinate Enterprise Compliance and Industrial Supervision

Build a three-dimensional governance system combining corporate self-regulation, industrial autonomy and governmental supervision. Enterprises shall formulate comprehensive compliance systems, conduct regular risk inspections and fully disclose product functions, algorithm logic and data usage rules. Industry associations shall unify technical safety and ethical standards and establish credit evaluation and disciplinary mechanisms. Relevant government departments shall launch cross-department collaborative supervision, enforce market access certification and rapid complaint response mechanisms to standardize industrial development.

Sound legal guarantees underpin the healthy development of the IoT smart home industry. Continuous technological innovation and industrial upgrading will bring new challenges to product liability laws. Legal provisions shall be dynamically adjusted to keep pace with technological progress, facilitating positive interaction between legal systems and technological innovation. A inclusive, forward-looking and effective product liability legal framework will consolidate the legal foundation for high-quality development of the smart home industry and advance the rule of law construction in the digital economy era.

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