

Exploring the Pathways for Industrial Upgrading of China's Smart Home Appliances in the Age of Artificial Intelligence

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ABSTRACT

With the explosive development of artificial intelligence technology, the global home appliance industry is undergoing a transition from automation to cognitive intelligence. As the world's largest manufacturer and consumer of home appliances, China's industrial upgrading of smart home appliances is not only key to breaking free from the price war in the low-end market but also a core strategy for securing dominance in the future smart home ecosystem. However, the domestic market remains mired in practical challenges such as pseudo-intelligent interaction, ecosystem silos and disjointed manufacturing chains. Consequently, this paper conducts an in-depth study of the industrial upgrading pathways for China's smart home appliances in the AI era, seeking to break through the conversion barriers between underlying hardware and core algorithms, and to provide a scientific theoretical framework and practical reference for reconstructing a modern commercial closed-loop system—from flexible manufacturing to the delivery of whole-home smart scenarios.

KEYWORDS

Artificial intelligence; Smart home appliances; Industrial upgrading; Whole-home intelligence; Edge computing

1 Introduction

The Fourth Industrial Revolution is reshaping the landscape of manufacturing, whilst the convergence of artificial intelligence and the Internet of Things has fundamentally transformed traditional end-user interaction methods. Although China has established a leading position in global home appliance manufacturing, with the disappearance of the demographic dividend and adjustments in the property cycle, the extensive growth model reliant on hardware accumulation has nearly reached its ceiling. At the same time, the demands of the new generation of consumers regarding home living have shifted comprehensively towards emotional interaction and immersive spatial experiences. Due to these massive changes in both supply and demand, the industry must transition towards smart terminals with autonomous sensing capabilities ^[1]. However, during this transition to smart technology, the proliferation of pseudo-intelligent products, fragmented ecosystems, and constraints on underlying computing power have severely hindered commercial implementation. Consequently, this paper conducts an in-depth study of the industrial upgrading pathways for China's smart home appliances in the AI era, with the aim of overcoming current ecosystem barriers and technical pain points, and providing scientific theoretical guidance and practical references to propel China's home appliance industry towards the high end of the value chain.

2 Analysis of Pain Points in the Implementation of Smart Home Appliances in China

2.1 The Issue of 'Pseudo-Intelligence' Experiences and Device Ecosystem Silos

The current Chinese smart home appliance market presents a contradictory situation where superficial prosperity coexists with underlying fragmentation. The most prominent pain point is that a large number of products remain at the rudimentary 'pseudo-intelligence' stage of interaction. Many manufacturers have merely replaced traditional physical buttons with mobile apps or simple voice command modules, without endowing the devices with the ability for autonomous learning and logical reasoning. This mechanical command-response model increases the operational burden on users, contradicting the original intent of seamless, unobtrusive smart home integration. More seriously, leading home appliance giants and internet technology firms, in their quest to secure data dominance and control over access points, have each established closed communication protocols and IoT cloud platforms. This strategy of self-imposed isolation has created substantial digital barriers between cross-brand devices, making it fundamentally impossible to achieve underlying data interoperability and scenario-based coordination. When consumers attempt to build a whole-home smart system, they often find themselves switching back and forth between different control terminals. This phenomenon of 'ecosystem silos' severely disrupts the continuity of home life, significantly reducing the public's willingness to pay for premium-priced products, and has become a stumbling block to the industry's transition towards a fully integrated,

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all-scenario experience ^[2].

2.2 Constraints of Underlying Hardware and Insufficient Core Algorithm Implementation

The in-depth development of smart home appliances relies heavily on the seamless integration of underlying computing hardware and advanced algorithms; however, China still faces significant technical obstacles in this regard. At the hardware level, although China's home appliance assembly and manufacturing capabilities rank first in the world, there remains a high degree of reliance on overseas supply chains for core components such as high-end microcontrollers, digital signal processors and high-precision environmental sensing sensors, which underpin intelligent decision-making ^[3]. The low computational power of underlying chips directly limits the ability of end devices to process complex visual and auditory signals locally. Regarding algorithm adaptation, whilst China has achieved numerous breakthroughs in cutting-edge fields such as natural language processing and multimodal large models, the application of these.

2.3 Disconnects in the Manufacturing Chain and the Limitations of Traditional Sales Models

The business model of the traditional home appliance industry is based on a one-way, linear logic of mass production and inventory-heavy distribution; in the age of artificial intelligence, this model has clearly begun to lag behind. On the manufacturing side, many companies' digital transformation efforts remain superficial, and flexible supply chains and agile manufacturing systems have yet to be properly established. Due to the lack of real-time collection and feedback mechanisms for end-user usage data, R&D departments often operate in isolation, resulting in product definitions that are severely disconnected from genuine smart technology needs. This leads to prolonged development cycles and high trial-and-error costs. On the sales side, bloated multi-tiered distributor networks not only erode profits, but traditional shelf-based displays also struggle to convey the experiential premium associated with smart scenarios. As smart products rely heavily on network connectivity, scenario orchestration and continuous firmware updates, the traditional transactional relationship based on one-off sales is no longer sustainable. Unless distribution channels transition towards solution design, professional site surveys and long-term maintenance, smart devices purchased by consumers often become isolated, conventional appliances due to a lack of professional setup. This dual disconnect between the manufacturing and sales chains severely hinders industrial upgrading.

3 Pathways for AI-Empowered Home Appliance Experience Upgrades

3.1 Moving Beyond Passive Response to Proactive Perception and Interaction

The most fundamental leap in AI-empowered home appliances lies in completely overturning the traditional 'trigger-execute' passive service model, establishing a proactive perception and interaction model capable of self-sensing the environment and anticipating user intent. Through the integration of multimodal sensing technologies, smart home appliances will become the digital sensory tentacles of the domestic space. Air conditioning units, utilising millimetre-wave radar and infrared thermal imaging arrays, can accurately track human posture whilst analysing skin temperature and subtle changes in heart rate during sleep in real time. The system feeds this high-dimensional physiological data into a built-in deep reinforcement learning engine for analysis, enabling it to proactively and seamlessly adjust airflow direction, temperature and humidity without the need for user commands ^[4]. Kitchen appliances can utilise visual algorithms and large-scale models to automatically identify the condition of ingredients, generating personalised recipes and heat control programmes based on the user's health records. This leap from mechanical compliance to the realm of an invisible butler imbues appliances with a proactive, thinking 'soul', effectively reducing redundant user operations and elevating the comfort of human-machine interaction in smart homes to unprecedented heights.

3.2 Driving Software-Hardware Decoupling to Enable Continuous Device Iteration

To break free from the inevitable functional decline inherent in traditional home appliances—where features are fixed at the point of manufacture—it is essential to achieve a complete decoupling of software control from underlying physical hardware at the system architecture level. The core of this upgrade path lies in drawing inspiration from cutting-edge concepts in the automotive industry, introducing a highly modular microkernel operating system and standard hardware abstraction layers within home appliances. Under this architecture, core physical components such as motors and compressors are uniformly defined as standardised call interfaces. Appliance manufacturers can rely on cloud computing clusters to perform in-depth data mining and model training on scenario data, and use OTA technology to frequently push firmware update packages. Users can continuously unlock new washing programmes, more efficient

energy-saving algorithms or more human-like voice interactions through software updates, without needing to replace expensive physical units. The decoupling of software and hardware significantly extends the product lifecycle, enabling products to ‘grow’ alongside users’ habits. This allows manufacturers to transition their business models from infrequent, one-off hardware sales to continuous software value-added services and feature subscriptions, fundamentally altering the value distribution landscape.

3.3 Enhancing Edge Computing to Safeguard Privacy and Ensure Offline Operation

As home appliances become increasingly intelligent, vast amounts of highly privacy-sensitive image, audio and lifestyle data are generated within the home environment. An IoT architecture that relies entirely on centralised cloud processing carries significant risks of data leakage and high network latency, whilst its absolute dependence on public networks can easily compromise the user experience. Therefore, strengthening the computational capabilities of edge computing nodes is a crucial means of enhancing the reliability of smart home appliances and boosting user trust. By embedding lightweight neural processing units with powerful tensor computing capabilities into home gateways or the motherboards of high-end appliances, tasks such as facial feature matching, voiceprint recognition and basic logical reasoning can be performed directly within the local area network. Core biometric data is processed entirely within a local closed loop and is not uploaded to the public cloud, thereby physically severing the chain of potential privacy breaches. At the same time, ample edge computing capacity ensures that even in the event of a fibre broadband disconnection or cloud server outage, whole-home device coordination and local interaction commands can still be executed smoothly, forming a highly resilient and secure underlying defence barrier for smart homes.

4 Pathways for Collaboration within the Smart Home Appliance Industry Chain and Business Restructuring

4.1 Transition of the Manufacturing Sector towards Digitalisation and Flexible Production

Faced with the fragmented and personalised demand for devices in the age of artificial intelligence, traditional rigid mass production lines are no longer sustainable; the manufacturing sector must accelerate its transition towards a digitalised, highly flexible Industrial Internet ecosystem. Home appliance manufacturers must first break down data silos and establish an end-to-end digital twin system encompassing R&D and design, component procurement, final assembly and testing, warehousing and logistics, and other stages. Machine vision quality inspection, intelligent material handling, and autonomous collaborative robots should be utilised to facilitate high-frequency data exchange between physical workshop equipment and cloud-based production execution systems ^[5]. More importantly, by relying on flexible manufacturing modules, production lines can achieve seamless mixed-line scheduling for products with different smart module configurations based on front-end sales data and direct custom orders from consumers, thereby completely eliminating the chronic problem of high inventory backlogs. Agile supply chain responsiveness enables enterprises to test cutting-edge smart hardware innovations at minimal changeover costs, significantly shortening the distance from concept to market for prototype products. This establishes a highly resilient, advanced manufacturing foundation for the smart home appliance industry’s rapid technological iteration and diversified delivery.

4.2 Transitioning from Retailers to Whole-Home Smart Scenario Solution Providers

The complex nature of smart home appliances dictates that sales strategies must shift from traditional single-product retail to the delivery of system-level scenario solutions. Consumers are no longer purchasing isolated products such as refrigerators or air conditioners, but rather comprehensive solutions for an entire smart kitchen or a deep-sleep bedroom. This necessitates a transformation in the roles of distributors and retail channels, evolving from mere traders and logistics providers into whole-home smart scenario solution service providers. Physical retail outlets must undergo radical refurbishment to create immersive showrooms, allowing consumers to experience the seamless coordination of lighting, temperature and appliances orchestrated by AI algorithms within a realistic setting. At the same time, the sales side must employ designers with expertise in electrical wiring and network topology planning. Pre-sales services should involve on-site surveys of customers’ homes and the drafting of proposals, whilst after-sales support should provide professional whole-home network configuration and debugging, scene programming, and long-term system maintenance guidance. By offering high-value-added, one-stop scene delivery services, companies can not only secure substantial upfront budgets but also build a robust service moat that competitors will find difficult to replicate.

4.3 Deepening Value in Home Wellness and Lifestyle Derived Services

Hardware delivery is merely the starting point of the smart home appliance business cycle. Leveraging the vast amounts of private household data accumulated from the operation of numerous devices, deepening post-market derived services is the core pathway for the industry to achieve a breakthrough in its second profit curve. A matrix of smart home appliances equipped with advanced sensors effectively constitutes a round-the-clock monitoring network for household behaviour and physiological indicators. Appliance manufacturers can capitalise on this momentum to expand into the broader health and home wellness sectors. By collaborating across sectors with specialist medical institutions and conducting anonymised analysis of sleep monitoring data, environmental indicators and dietary intake, they can provide remote health alerts and dietary intervention services for specific demographic groups. Furthermore, by leveraging smart refrigerators' monitoring of remaining food supplies, companies can seamlessly integrate with automated restocking channels for fresh food e-commerce; based on the operational characteristics of laundry and care appliances, they can precisely recommend specific high-end consumables. This data-driven expansion of the downstream ecosystem completely shatters the curse of low-frequency transactions in traditional manufacturing, transforming durable consumer goods into high-frequency interaction points for household services, and opening up boundless possibilities for building a sustainable subscription-based business model.

5 Conclusion

The industrial upgrading of China's smart home appliances in the age of artificial intelligence is not merely a superficial digital transformation of traditional, cold hardware, but a systematic campaign that touches upon underlying algorithms, system architecture, flexible manufacturing and all-scenario business models. Faced with the current growing pains of pseudo-intelligent interaction, fragmented ecosystems and insufficient conversion of underlying computing power, all stakeholders in the industry must fundamentally reshape the underlying logic of product experience by breaking through active sensing technologies, accelerating the decoupling of software and hardware, and deploying computing power at the edge. At the same time, only by taking digital flexible manufacturing as the foundation, using whole-home smart scenario delivery as the terminal touchpoint, and tapping into the value of data derived from home healthcare and lifestyle services, can the commercial closed loop of smart home appliances be realised. Looking ahead, as general-purpose large-scale model technology becomes further compressed and democratised, smart home appliances will inevitably evolve into 'digital silicon-based lifeforms' capable of fully autonomous decision-making. Only by continuing to deepen research and development in core technologies and fostering ecosystem synergy can China's home appliance industry maintain its global leadership in this sweeping transformation of smart living environments.

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