The Solution to the Problem of Heavy Asset Profitability Driven by Technology: A Case Study of AHS Recycling

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Keywords: Second-Hand Recycling Platform, Circular Economy, Heavy Assets, Technological Innovation, Industry Chain Integration.

Abstract: Third-party mobile phone retail stores receive a large number of second-hand mobile phones through trade-in, and small and medium-sized merchants in the industrial chain have huge circulation demand. However, due to the decentralization of the market, the multi-level transaction and the lack of industry standards, the transaction turnover efficiency is low, and the behavior of shoddy and fraud is common, and users lack trust in the trading platform. In this situation, love recycling came into being. However, driven by circular economy and environmental protection policies, second-hand trading platforms are facing profit challenges under the heavy asset model. Taking AHS Recycle as an example, this paper discusses how to realize the sustainable profit of the heavy asset model under the concept of environmental protection through technological innovation, industrial chain integration and policy coordination. The study found that AHS Recycle effectively balanced high-cost investment and profit demand through the "self-operated+platform" two-wheel-driven business model, intelligent recycling network construction and policy dividend undertaking. Its experience shows that second-hand platforms can transform environmental value into commercial value and provide reproducible solutions for the industry through standardized processes, technology empowerment and green consumption scenario innovation.

1 INTRODUCTION

With the deepening of the concept of global sustainable development, the ESG system and the" double carbon"policy jointly build the core framework of global economic transformation. In this context, the theoretical system of circular economy with efficient recycling of resources as the core has become the key path to break the constraints of resources and environment in the era of industrial civilization. From Balding 's spaceship economy theory , which regards the earth as a closed system with limited resources, emphasizing the replacement of linear consumption by recycling, to Strauss's perfect 'reduction, reuse, recycling' 3 R principle, circular economy has formed a multi-level theoretical framework covering micro-enterprise operation, medium-sized enterprises collaboration, and macro-policy design(Smith et al.,2021;Müller and Schmidt,2022). The Allen MacArthur Foundation further summarizes it as a dual system of technology cycle and biological cycle. The former focuses on the continuation of the value of durable consumer goods such as electronic products, while the latter focuses on the natural circulation of organic resources, providing a clear theoretical anchor for the second-hand recycling industry.

As a typical practice of circular economy in the field of consumer electronics, the second-hand recycling industry carries a dual mission. It is necessary to realize the closed loop of 'resources-products-waste-renewable resources' through the reverse logistics the three core dimensions of circular economy, including system regeneration, value retention and environmental synergy, and realize the unity of environmental and economic benefits by reducing the carbon intensity of electronic waste dismantling under the dual carbon goal(Gupta et al.,2020;Park et al.,2021;Garcia and Wei,2022).According to the China Circular Economy Development Report (2024), China produces more than 120 million tons of electronic waste such as

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Wang, M.
The Solution to the Problem of Heavy Asset Profitability Driven by Technology: A Case Study of AHS Recycling.
DOI: 10.5220/0013848600004719

In *Proceedings of the 2nd International Conference on E-commerce and Modern Logistics (ICEML 2025)*, pages 512-518
ISBN: 978-989-758-775-7

waste mobile phones and computers every year. If st andardized recycling is achieved, carbon emissions c an be reduced by about 42 million tons, equivalent to 2.3 million hectares of afforestation, which confirms the strategic value of the industry in the carbon emis sion reduction system.

However, there is an inherent conflict between the traditional heavy asset operation mode and the 'cost-benefit' optimization logic of circular economy. The huge investment in fixed assets of offline warehousing and logistics facilities (the average construction cost of a single warehouse exceeds 50 million yuan), the high labor cost caused by complex quality inspection process (accounting for more than 32 % of operating costs), and the low efficiency of inventory turnover (the average inventory cycle of the industry reaches 90 days) are essentially the product of "scale expansion drive" under the linear economic thinking, which is in contradiction with the "functional economy" advocated by Strauss (reducing the consumption of physical resources by replacing product ownership with services) (Chen and Zhang, 2022;White et al.,2022).The innovative practice of AHS Recycle has broken through this theoretical paradox - by constructing a circular economy ecology of 'reverse logistics network digitization (application of IoT devices to achieve full-link tracking, reducing transportation losses by 15 %)-detection standardization (self-developed AI quality inspection system reduces the detection time of a single device to 3 minutes, with an error rate of < 0.3 %) -industrial chain synergy (with Jingdong, Xiaomi, etc. Establish a data sharing mechanism to shorten inventory turnover to 45 days' and implement Balding's 'closed-loop economy' concept as a quantifiable business model (Bostrom and Sandberg, 2023). In 2024, the total revenue was 16.33 billion yuan, the operating profit of non-GAAP was 410 million yuan, and the gross profit margin increased to 18.7 %, which proved the reconstruction effect of 'industrial ecosystem synergy' proposed by Greider on the cost structure.

Based on the theoretical pedigree of circular economy, combined with the ESG evaluation system and the dual-carbon policy objectives, this paper uses the case analysis method to analyze how AHS Recycle takes the technology cycle as the core driving force to build a value-preserving business model in the vertical field of consumer electronics. It not only realizes the material cycle through product remanufacturing and also reduces the carbon emissions in circulation through the digital platform, forming a theoretical transcendence of the traditional heavy asset model. This study attempts to answer how enterprises balance environmental protection investment and business profitability through 'asset lightweight' and 'value chain extension' under the framework of circular economy theory, and how ESG elements such as carbon management in the environmental dimension, e-waste management in the social dimension, and supply chain transparency in the governance dimension form synergy with circular economy theory. The answers to these questions not only provide a transformation path for the second-hand recycling industry, but also contribute an interdisciplinary perspective to the green innovation of the manufacturing industry under the 'double- carbon' goal.

2 ANALYSIS OF THE CURRENT SITUATION OF AHS RECYCLEN

2.1 The Core Contradiction of Heavy Asset Model

Second-hand platforms need to rely on infrastructure such as offline stores, quality inspection centers, and warehousing and logistics to ensure transaction security and efficiency, but high fixed costs lead to pressure on profit margins. As of the end of 2024, there are 830 self-owned stores and 1031 joint-venture stores, covering 283 cities. The average annual operating cost of the single store of the offline store is about 2 million yuan, superimposed on the warehousing and logistics facilities of 7 regional operation centers and 23 city-level operation centers (the construction cost of the single warehouse exceeds 50 million yuan), forming more than 3 billion yuan of fixed asset investment. Although GAAP achieved a profit of 28.97 million yuan in 2024, historical data show that the cumulative loss in 2018-2021 reached 1.38 billion yuan, and the operating cash flow of Q1 in 2021 was-303 million yuan, and the cash reserve could only maintain three months of operation. This model of "heavy asset investment-low cash flow return" is in fundamental contradiction with the requirements of "light asset and high turnover" in circular economy theory (Parket et al.,2021).

2.1.1 High Cost

The expansion of stores and the construction of automation centers (similar to the 4 billion investment of Jingdong Asia No.1) have led to a continuous increase in operating costs. In the first quarter of 2023,

the net loss was CNY 50 million, and the gross profit margin hovered at 11 % -12 % for a long time. The hardware investment of a single store is about 70,000 yuan, the monthly operating cost includes about 30,000 yuan such as manpower and rent, and the annual operating cost of 700 stores exceeds 250 million yuan. As shown in Figure 1, profits increased from 3.73 billion yuan in 2019 to 14.84 billion yuan in 2024, with an average annual compound growth rate of about 31.8 %, showing excellent performance. In 2024, the performance cost of Q4 increased by 31.8 % year-on-year, and the sales cost increased by 18.7 %, which eroded the profit space brought by the increase in gross profit margin. The highest growth rate is 56.8 % in 2021 and then slows down year by year to 27.3 % in 2024. It is necessary to pay attention to the possibility of market saturation or increased competition.

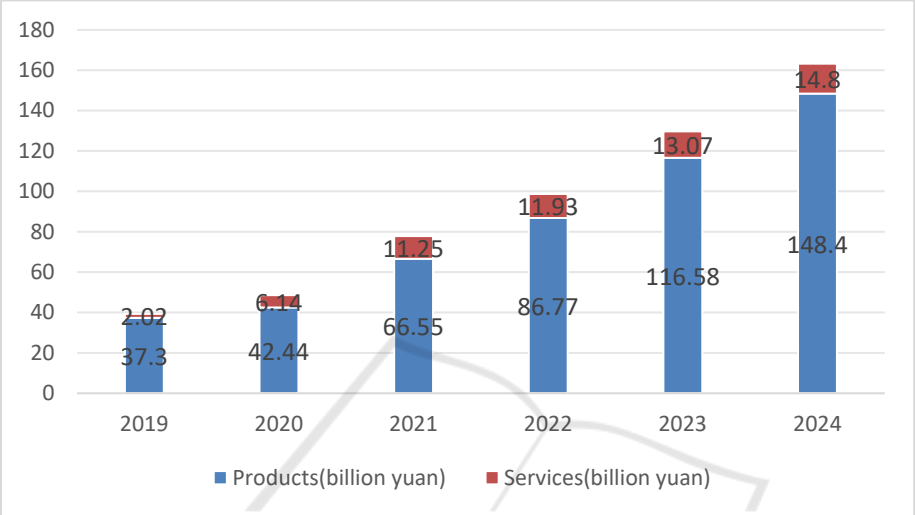


Figure 1: The revenue and proportion of each business of ATRENEW from 2019 to 2024.

As shown in Figure 2, the company has experienced a transition from loss to profit. After 2021, profits and profit margins have improved, and profits have improved significantly in 2023, reflecting the effectiveness of strategic adjustments. Profits of 410 million yuan and profit margin of 2.50 % are the best in history, benefiting from scale effect or high gross profit business.

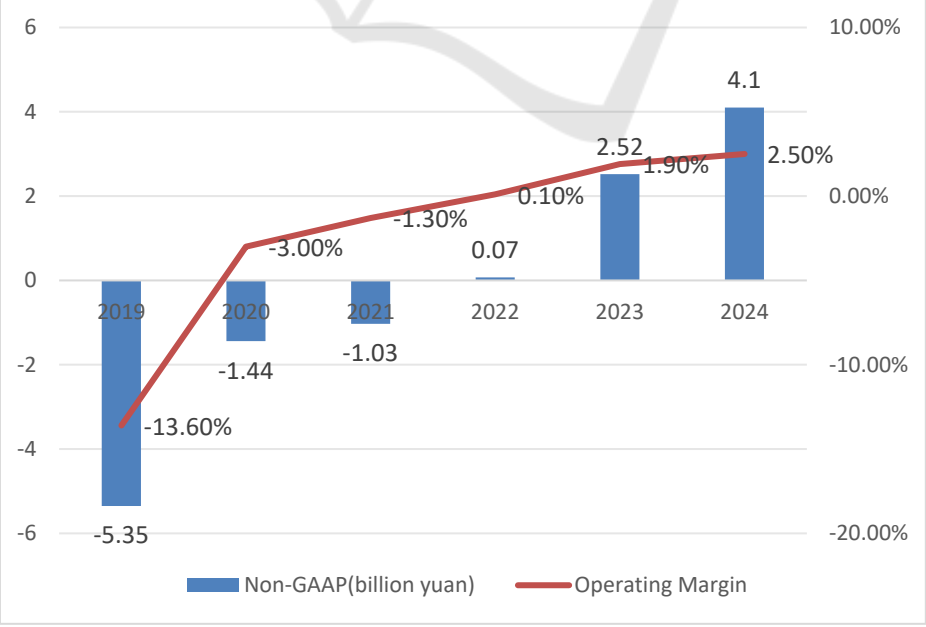
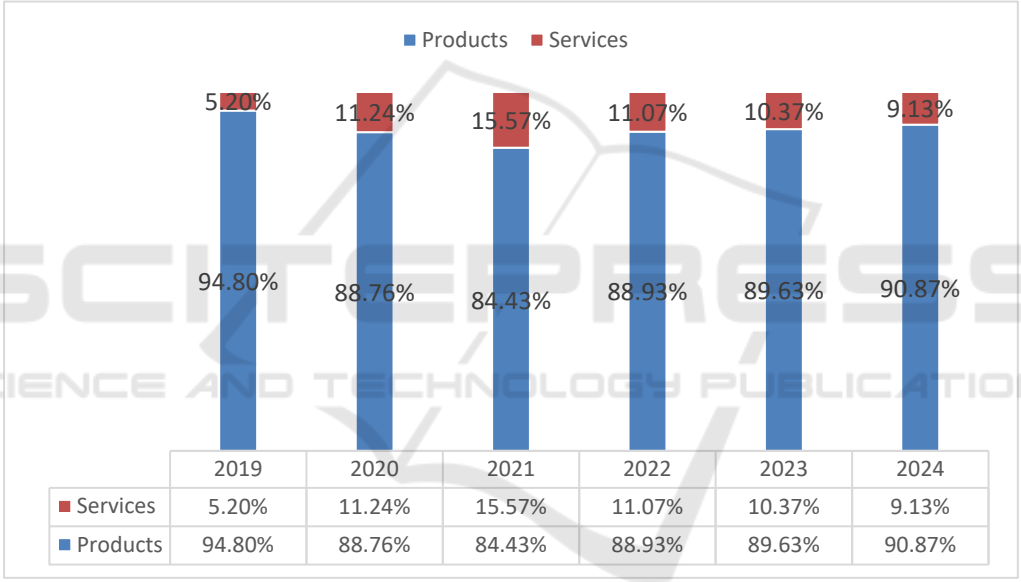


Figure 2: The operating profit and profit rate of ATRENEW from 2019 to 2024

2.1.2 Single Profit Model

Although the platform claims to build a 'C2B + B2B + B2C' closed-loop, the actual business is still dominated by to B, and the C-side growth is slow. In 2020, the to B business will contribute 83 % of revenue, the B2B platform will distribute more than 80 % of the recycling equipment, and the C-terminal GMV will account for less than 20 %. Compared with idle fish and transfer, love recycling has obvious shortcomings in user services (such as credit system and after-sales security), which makes it difficult to attract C-terminal users, resulting in C-terminal gene deletion. Over-reliance on self-marketing revenue (accounting for 90 % of total revenue), the proportion of platform service revenue is less than 10 %, and the income structure needs to be further optimized.

As shown in Figure 3, product income has always been dominant, but the proportion has shown a fluctuating downward trend. From 94.80% in 2019 to 90.87 % in 2024, it decreased by 3.93 percentage points. The lowest point was 84.43 % in 2021 and then rebounded due to business adjustments or changes in market demand. The proportion of service income is generally low, but it shows a trend of rising first and then falling. It rose from 5.20 % in 2019 to a peak of 15.57 % in 2021 and fell back to 9.13 % in 2024. The business dependence is high, the company's income is still heavily dependent on products, and the service business has not become a stable growth point. In 2021, the proportion of core products rebounded rapidly after the decline, showing that the core products are still competitive, which confirms that the product business has strong resilience.



	2019	2020	2021	2022	2023	2024
Services	5.20%	11.24%	15.57%	11.07%	10.37%	9.13%
Products	94.80%	88.76%	84.43%	88.93%	89.63%	90.87%

Figure 3: The sales of self-operated products and the income of third-party services of ATRENEW from 2019 to 2024.

2.2 Pressure on Environmental Compliance Costs

The environmental protection policy requires the platform to assume responsibility for the harmless treatment of electronic waste, such as data removal, compliance renovation and other links to further increase the cost (Brown & Lee,2023). In the early stage of recycling, we invested a lot of resources to build an intelligent sorting system and independently developed a data removal technology 'love removal' to ensure that the recycling process meets environmental standards. AHS Recycle needs to meet the policy requirements such as 'electronic waste treatment pollution control technology specification' and invests about 150 million yuan per year for equipment upgrading and carbon emission monitoring. Although it obtains ESG bonus through 'the carbon intensity of unit product transportation is 22 % lower than the industry average', the policy compliance cost accounts for 36.6 % of the net profit, which weakens the business sustainability.

2.3 The Balance Between Market Demand and Economies of Scale

Users' sensitivity to convenience and price requires the platform to expand its coverage rapidly, but blind expansion may lead to a decline in single-store

efficiency. According to the '2024 White Paper on Electronic Product Recycling Industry', about 30 % of the stores in the recycling platform that blindly expanded failed to meet the expected recycling volume, resulting in an increase in overall operating costs. In 2024, the volume of multi-category recycling transactions will increase by nearly three times year-on-year, but it is necessary to improve the reuse rate of stores through refined operations (Kumar and Yadav,2022).

3 MECHANISM PATH ANALYSIS

3.1 Technology-Driven Cost Optimization

3.1.1 Intelligent Recycling Network

The business ecology of love recycling covers the supply side, the processing side and the demand side. The supply side aggregates and disperses the source of goods, including 1P consumer recycling (official website APP, love recycling stores, brand manufacturers, e-commerce partners) and 3P merchant recycling (professional merchants such as cattle, offline massive mobile phones and 3C product retailers). The processing end relies on 8 regional-level large-scale operation centers and 15 small urban warehouses to build an end-to-end standardized industrial chain and provide value-added services with independent research and development of scarce technical capabilities (Gupta et al.,2020; Brown and Lee,2023; James and Lopez,2021).

On the basis of this architecture, AHS Recycle further builds a three-level system of 'point to station to square', builds the world's first 'non-standard second-hand electronic product automatic transmission quality inspection and sorting storage system' Matrix3.0, and realizes the unmanned operation of the whole process. This innovation has reduced labor costs by 85 %, quality inspection costs by 20 %, quality inspection efficiency by 18 %, daily processing capacity of 24,000 units, sorting error rate < 0.01 %, and daily average processing capacity of 2,000 tons, far exceeding the industry average. On the demand side, the high-quality goods source is connected to the C-end consumers (such as Jingdong Paipai, Tik Tok, Kuaishou and other innovative channels) through 'Paipai', and the middle and low-grade goods are transported to the B-end small and medium-sized merchants (distributors, repairers, exporters, etc.) through 'Paijitang', forming an efficient order fulfilment network, through the whole chain of the second-hand consumer electronics cycle(Zhou and Kapoor,2021).

3.1.2 Digital Full-Link Management

The whole process of Dongguan 'Matrix 3.0' pipeline integration covers logistics unpacking, automatic labeling, module shunting, X-Ray disassembly and repair detection, semi-automatic detection using App tools, and Photo Mirror screen detection, 007 function detection, Photo Box appearance detection, manual supplementary quality inspection, Photo Cube product picture shooting and other links. This system realizes the traceability from user delivery to sorting and sales, effectively reducing losses and improving turnover efficiency. Among them, the AI quality inspection system greatly reduces manual dependence, and the detection time of a single mobile phone is reduced from 10 minutes to 20 seconds, with an annual cost saving of more than 20 %. The big data dynamic pricing model improves the inventory turnover rate, and the average turnover cycle of Q3 in 2023 is 3 days (industry average 10 days) ; AI recommendation algorithm accurately matches supply and demand, and sales revenue of selected retail channels will increase by 301.3 % year-on-year in 2024(Brown and Lee,2023).

3.2 Value Reconstruction of Closed-Loop Industrial Chain

3.2.1 Self-Operated Strict Election to Increase Premium

Through standardized quality inspection and renovation processes, 30 % of the recycled products are converted to B2C retail. From the perspective of GMV, in 2023, the GMV of second-hand consumer electronic products from Jingdong's mobile phones accounted for 11.6 % of the company’s GMV.In 2024, the GMV totaled CNY 5.5 billion. The attempt of multi-category recycling (such as gold and luxury goods) has achieved initial results. The monthly GMV exceeded CNY 70 million, the potential for business expansion is considerable, and the gross profit margin has increased to 12.5 %.

3.2.2 Platform Service Income Increase

Its platform 'PJT Marketplace' solves the circulation efficiency problem of second-hand electronic products through global standardized grading and bidding mode, attracting 850,000 registered merchants. In 2023, 3P service revenue was 1.31 billion yuan, up 10.7 % year-on-year, and the

charging rate increased from 0.5 % in 2018 to 5.39 % in 2023, with its transaction scale reaching 6 times the second largest in the industry. In 2023, the compliance renovation business contributed revenue of 810-million-yuan, accounting for 9.4 % of the recovery revenue; in 2024, the proportion of income will be further increased, promoting the expansion of value-added profit space.

3.3 ESG-Oriented Brand Upgrading

Relying on the cooperation with Jingdong, the proportion of old-for-new recycling accounts for more than 50 %, and the recycling of mobile phone categories in 2024 increased by 100 % year-on-year. Cooperate with L'Oreal to explore the recycling of empty cosmetic bottles and participate in the "trade-in" action advocated by the policy; united FRESHHIPPO, Mengniu and other brands to launch the "return to life" activity, through the exchange of points and environmental protection package to enhance user participation, reduce carbon emissions and get the S & P ESG score industry leader. Continue to broaden the overseas market and highlight the social value of the circular economy, promote the scale of the circular economy, attract ESG investment, and enhance the recognition of the capital market.

3.4 Branding and User Mental Occupation

Through public welfare projects such as the 'Digital Student Assistance Program for Children in Mountain Villages' and social communication, environmental responsibility is transformed into user trust, thereby strengthening the brand image of environmental protection. Promote recycling services on content platforms such as Tik Tok and RedNote and improve the reach efficiency of C-end users and achieve penetration of new media channels (White et al.,2022; Andersen and Rossi,2021).

AHS Recycle's "Rural Children's Digital Assistance Program" was born in 2018. It is a long-term public welfare project jointly launched by the ATRENEW and the One Shoulder Snow Project Public Welfare Organization. It aims to help children in mountain villages broaden their horizons by donating idle electronic equipment, so that cities and children in mountain villages can stand at the same starting line, while extending the service life of electronic equipment and promoting sustainable social development. As of December 31,2022, the project supported 56 schools, completed 2068 hours of teaching, and accumulated 10,770 students in class, effectively contributing to the education of rural children.

4 CONCLUSION

This paper uses the case analysis method to analyze the heavy asset profit model of AHS Recycle under the framework of environmental protection and concludes that the concept of environmental protection and heavy asset profit are not opposite, but can be integrated through technological innovation, industrial chain integration and policy coordination. It further expounds the core experience of love recycling to realize the integration of the two and reduces the marginal cost through intelligent and digital technology. Increase the proportion of high-profit retail businesses through self-operation and strict selection and expand the scale effect relying on platform services; with the help of the government's "trade-in" and carbon emission reduction policy window to build competitive barriers. It is suggested that with the promotion of the '551 Project' (5,000 stores and 100,000 recycling machines) in the future, Love Recycling will continue to optimize the single store model and multi-category collaboration capabilities, explore a more universal heavy asset profit paradigm for the second-hand recycling industry, and promote the deep unification of environmental protection and commercial value.

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