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*Article*

# Social Innovation Pathways of 3D Printing for Disabled Pet Welfare: A Social Enterprise Model Based on Low Cost Custom Prosthetic Paw Pads

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**Abstract:** Disabled pets often face many obstacles when they want to get proper musculoskeletal aids; the main reason for this is the high price of available devices, and also that average pet owners have a hard time getting these without problems. This study mainly looks at how 3D printing technology, combined with the business model of social enterprises, can produce low-cost custom prosthesis paw pads for disabled companion animals, and at the same time shows the social innovation paths that come from this model. The research uses case analysis as its basic method, and all analysis materials were collected from publicly accessible industry reports, published company data, and existing scientific literature sources. This paper compares the full cost structure of existing veterinary orthopedic aids, and examines the production cost reduction potential of 3D printing technology. From the research data it can be seen that the cost of a fully manufactured custom prosthetic foot pad for pets using the traditional method lies between 1265 and 2125 US dollars; through digital manufacturing processes, optimized material use, and demand-oriented production, 3D printing technology can shorten the manufacturing time of the devices to a few hours or a few days. Social enterprises such as Bionic Pets and WIMBA, which are dedicated to the welfare of pets, have integrated parts of device production into their own manufacturing processes and at the same time use remote scanning technology in production, thereby fundamentally changing the traditional supply model for mobility aids for disabled pets. This paper creates a framework for social innovation with three levels: technical empowerment, business model, and social impact; this framework can provide social enterprises in the field of animal welfare with basic theoretical reference points for their practical work.

**Keywords:** 3D printing; welfare of disabled pets; veterinary prosthetics; social enterprises; assistive technology

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## 1. Introduction

Dog musculoskeletal diseases, like limb amputations and congenital limb development disorders, directly make the movement ability of pets worse, and greatly lower their general quality of life. Traditional veterinary orthopedic care has long been limited by high production costs, limited customization possibilities, and not enough scientific evidence about how effective the devices are; because of this, there is always a big gap between the actual clinical need and the available practical solutions [1]. In recent years, additive manufacturing, that is, the commonly known 3D printing technology, has gradually entered veterinary care; this technology offers new approaches for manufacturing orthopedic aids that are tailored to the individual anatomical conditions

of each pet, and enables the practical use of many aids that were previously too expensive or difficult to implement [2].

The use of 3D printing technology in veterinary orthopedics can partially solve the widespread problem that companion animals do not receive inexpensive, individually adjustable mobility aids. The research results of Mendaza-DeCal and his team show that Fused Deposition Modeling is a low-cost variant of additive manufacturing; with 3D scanning and 3D printing, professionals can design and manufacture orthoses and prosthetic sockets for dogs, thereby removing the cost barriers that previously prevented the spread of such devices. The manufacturing process summarized in this research can indeed reduce the manufacturing time and costs of veterinary orthopedic devices.

Nowadays, more and more case reports and case series studies are collecting a large amount of clinical data on the practical effectiveness of external 3D-printed prostheses. The research team around De Souza developed and mounted a socket-bound external prosthesis for a dog with amputation of the pelvic limb; immediately after mounting, the weight distribution and the load-bearing capacity of the dog's limb improved, and the animal's movement function continued to recover over a four-week observation period [3]. Later, the same research team expanded the sample size and conducted trials with custom external orthopedic 3D prostheses on six dogs with partial limb amputations or congenital limb malformations; the results showed that the test animals accepted the devices well and their gait stability as well as their everyday mobility were significantly improved [4]. A systematic review by Souza et al. (2025) further consolidated evidence on the impacts of exoprosthesis use in dogs with partial amputation and limb malformations [5].

Although existing clinical research results are steadily increasing, there is still a lack of sufficient investigation into how 3D printing technology can transition from individual clinical application cases in veterinary medicine to a long-term stably operated social enterprise model that serves the welfare of disabled pets. This paper takes up this research gap, focuses on analyzing how 3D printing technology can produce low-cost custom prosthetic foot pads for pets with the help of a social enterprise model, and presents the social innovation paths between technical application and the improvement of animal welfare. Specifically, the paper compares the cost reduction potential of 3D printing technology with the traditional manufacturing of veterinary orthopedic devices, analyzes the characteristics of the business models of newly emerging social enterprises in this field, and finally creates a comprehensive analysis framework for understanding technology-supported social innovation in the field of welfare for disabled pets.

## 2. Literature Review

The application of 3D printing technology in veterinary orthopedics is developing quickly overall. The team around Marouf summarized the various possible uses of this technology in veterinary medicine, including surgical planning, the production of anatomical animal models, the manufacturing of orthopedic implants, and the production of prostheses; the study states that additive manufacturing can produce individually adapted special devices according to the anatomical differences of each animal [6].

Besides the common applications in dogs, Carvalho also manufactured custom prostheses for three birds with amputation of the hind limbs; the test results show that these custom devices can effectively optimize the weight distribution of the birds and improve their everyday mobility; for small birds with a body weight under 50 grams, the suitable prosthesis weighs only about one gram and does not burden their daily activities [7].

From the point of view of sustainable production, Hafiz, Al Rashid, and Koç investigated the use of recycled polymers in 3D printing; their research confirms that recycled polymer materials can reduce the raw material costs of device manufacturing and enable a more environmentally friendly, more sustainable production model, yet there are still certain uncertainties and practical challenges regarding the economic feasibility and the long-term durability of these materials [8].

A detailed understanding of the practical effectiveness of mobility aids helps researchers to recognize the practical benefit of these devices more clearly. The survey data of Narum, Miscioscia, and Repac show that after pet owners purchased mobility carts, the quality of life of 62% of the dogs and 57% of the cats was significantly improved; at the same time, various complications occurred in 64% of the animals during device use, of which 53% of the complications were related to skin wounds [9].

The corresponding industry surveys clarify both the opportunities and the practical obstacles in the use of 3D printing technology. Sakib-Uz-Zaman and Khondoker conducted interviews with 22 professionals for orthotics and prosthetics in Canada; the results prove that additive manufacturing can reduce manufacturing costs and increase the efficiency of device development, yet the material properties and uniform certification standards of the industry remain central topics that the professionals pay special attention to [10].

Findings from materials science are constantly optimizing the usage properties of 3D-printed devices. Khan, Chen, and Sun summarized research on 3D printing of polymer nanocomposites and found that the addition of nanofillers effectively improves the mechanical and functional properties of the printed devices [11]. The team around Kondratenko collected global application cases of 3D-printed titanium implants and confirmed that such implants can be successfully used in veterinary care for the reconstruction of bone defects and the replacement of bone structures [12].

The far-reaching social effects of 3D printing technology are also noticed in cultural studies. Ibach investigated the inner connection between the maker movement and 3D printing technology and found that 3D printing can serve as a basis for communal discussions and the shaping of future developments and fits well with a new production model based on shared resources [13]. Emidi created a design analysis framework for integration into the circular economy and pointed out that the layer-by-layer deposition process of 3D printing enables demand-oriented production and efficient resource use and greatly reduces material waste during production [14].

The team around Singh also recorded various applications of 3D printing technology in corrective orthopedic surgery, including preoperative surgical planning, the production of custom implants, and the manufacturing of surgical templates; this study assumes that 3D printing technology is gradually building a bridge between modern manufacturing technology and the practical requirements of the veterinary clinic [15].

In summary, it can be seen from the existing scientific literature that 3D printing technology has been clinically tested in many veterinary application fields and has stable cost advantages compared with traditional manufacturing processes. Nevertheless, science still lacks in-depth, systematic investigation into how this technology can be used to build a long-term operated social enterprise model for the welfare of disabled pets; existing studies mostly concentrate on the clinical effectiveness of the devices, while investigations into the economic effects and business models of 3D-printed pet prostheses are rare. This is the central point that this paper examines.

## 3. Theoretical Framework and Research Methodology

This chapter presents the theoretical framework and the concrete research methodology of this study and clarifies the research foundations and implementation steps for investigating the social innovation paths of 3D printing-supported welfare for disabled pets. The study follows an overall qualitative analysis approach; all research data come from publicly accessible sources, including peer-reviewed specialist articles, published case reports, industry reports, and published company data. The study includes no surveys of human subjects and no animal experiments; all research data are publicly verifiable and traceable.

### *3.1. Theoretical Framework*

The theoretical basis of this paper relies mainly on the theory of social innovation and existing investigations into technology-supported social enterprises. Social innovation

refers to solution approaches that satisfy social needs and at the same time build new social relationships or forms of cooperation. In the research field of welfare for disabled pets, a new form of social innovation arises when advanced technical capabilities are combined with a business model that increases the accessibility of services and puts the maximization of profit in the background.

The paper mainly draws on three theoretical perspectives: First, the perspective of technical empowerment, according to which additive manufacturing lowers the technical and economic hurdles in the manufacturing of custom aids and enables small-scale, distributed individual manufacturing. Second, the perspective of the social enterprise, with which it is analyzed how organizations maintain the balance between their social mission and financial sustainability. Third, the perspective of animal welfare, which serves to evaluate the practical effectiveness of the devices; here, above all, the restoration of the mobility of disabled animals, the alleviation of pain, and the improvement of the general quality of life are examined.

The combination of these three theoretical perspectives enables a comprehensive analysis of how the integration of 3D printing technology into the business model of social enterprises creates positive benefit for disabled pets and their caregivers, and presents the complete social innovation path.

### *3.2. Research Methodology*

This paper uses literature analysis as the central research method. Through the preparation and merging of various public research data, an analysis framework for the social innovation paths is created. The entire research process is divided into four consecutive steps.

Step 1: Data collection. All analysis data of the study come from publicly accessible sources, including specialist articles listed in scientific databases, public case reports from veterinary medicine, officially published industry reports, and published data from social enterprises in the field of pet prosthetics. Within the framework of the study, no primary data are collected, no human surveys and no animal experiments are conducted.

Step 2: Thematic analysis. The paper uses thematic analysis for the preparation and classification of the collected literature data in order to work out central research themes in connection with the cost structure of the devices, the manufacturing processes, the business models of the companies, and the social effects. All analysis themes are oriented toward the three-level framework of technical empowerment, business model, and social impact that was created in this paper.

Step 3: Comparative analysis. The paper comprehensively compares the traditional manufacturing process of veterinary orthopedic devices with the 3D printing approach. Above all, the differences and existing problems in four areas are examined: manufacturing costs, production time, customization possibilities, and accessibility of services.

Step 4: Framework construction. On the basis of the thematic analysis and comparative analysis, the paper creates a comprehensive analysis framework. With this framework it is explained how 3D printing technology advances social innovation in the field of welfare for disabled pets, and the inner connection between technical capabilities, business models of the companies, and the improvement of animal welfare is clarified.

### *3.3. Process Diagram of the Methodology*

Figure 1 shows the complete research process from data collection through data evaluation to the final framework construction.

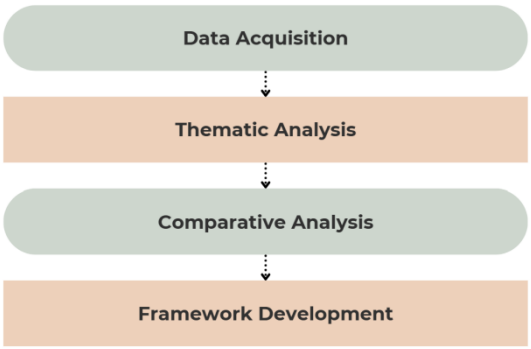



**Figure 1.** Methodology for Learning Path Mining from VR/AR Interaction Logs in Virtual Exhibitions

## 4. Research Results and Discussion

All results of this chapter come from publicly accessible literature sources, company publications, and industry reports. No primary investigations such as human experiments or questionnaires were conducted. The research results are structured according to the three-level framework of social innovation (technical empowerment, business model, social impact); four tables each summarize the cost comparison data, parameters of the manufacturing processes, business characteristics of social enterprises, and the practical results in connection with animal welfare.

Table 1 compares the total production costs of traditional custom prosthetic foot pads for pets with those of 3D-printed prosthetic foot pads. All cost data come from publicly accessible product price information of companies and published industry studies. The total costs include measurement and impression taking, manufacturing, material expenses, and all adjustment work before delivery.

**Table 1.** Full-cycle Cost Comparison for Custom Pet Prosthetic Paw Pads (USD)

| Device manufacturing route | Minimum full-cycle cost | Maximum full-cycle cost |
|---|---|---|
| Conventional cast-based custom prosthetic paw pad | 1265 | 2125 |
| 3D-printed custom prosthetic paw pad | 410 | 830 |

Table 2 summarizes central manufacturing parameters from the published technical documents of the companies Bionic Pets and WIMBA. The calculation of the production time begins as soon as the company receives the complete anatomical data of the pet. The customization capability refers to the possibility of adapting the device shape to the physical differences of various animals in order to fulfill individual requirements.

**Table 2.** Production Workflow Parameters of Two Manufacturing Routes

| Parameter | Conventional cast-based route | 3D-printing digital route |
|---|---|---|
| Typical production turnaround | 14-21 working days | 3-8 working days |
| Core data input method | Physical plaster cast | 3D scan or standardised photographic measurement |
| On-demand batch capability | Low | High |
| Iterative design modification cost | High marginal cost | Low marginal cost |

Table 3 summarizes central business characteristics of some social enterprises in the field of pet mobility aids. The corresponding information comes from official company

publications and public industry information. The degree of manufacturing control indicates whether central manufacturing steps are carried out in the company itself or by external service providers. The priority of the social mission is assessed on the basis of the publicly presented animal welfare goals and business goals of the companies.

**Table 3.** Operational Attributes of Selected Veterinary Prosthetic Social Enterprises

| Enterprise name | In-house manufacturing control | Remote patient data acceptance | Social mission priority stated in public materials |
|---|---|---|---|
| Bionic Pets | Partial internal processing | Limited remote measurement support | Yes |
| WIMBA | Full in-house additive manufacturing | Full remote scan and photo-based submission | Yes |

Table 4 collects the practical application results of pets with 3D-printed prosthetic foot pads from public case reports. The contents include the behavior of the animals during use as well as practical problems of the devices and directly show the advantages and existing weaknesses of this class of devices.

**Table 4.** Documented Practical Outcomes for Animals Fitted with 3D-printed Prosthetic Paw Pads

| Outcome category | Observed practical description |
|---|---|
| Locomotion improvement | Gait stability gains and partial restoration of weight-bearing function |
| Device acceptance | Majority of companion animals show voluntary use of fitted devices |
| Common practical challenge | Pressure related skin irritation and fixation stability failures |
| Material related strength risk | Wear and abrasion under high-activity animal usage conditions |

From the perspective of technical empowerment, the data from Table 1 and Table 2 clearly show that additive manufacturing can reduce both the manufacturing costs and the production time of pet prostheses. The digital process of data collection and manufacturing removes geographical restrictions in care; pet owners do not have to send a physical plaster model in order to order a custom-made product. Modular digital design files enable professionals to make multiple adjustments to the device parameters without causing large material waste. In addition, the use of recycled polymers expands the scope for cost reduction at the technical level.

From the point of view of the business model, the data from Table 3 prove that such social enterprises fundamentally change the traditional supply model for pet mobility aids. By controlling the central manufacturing steps themselves, the companies avoid additional price markups of external workshops. The model of remote data collection enables pet caregivers in other places to obtain custom assistive devices in a simple way. The companies finance their ongoing operation through the sale of the devices and lower the access hurdles for normal households through flexible pricing. The primary business goal of these companies is not profit maximization, but the ensuring of an accessible animal welfare service.

From the perspective of social impact, the application data from Table 4 show that 3D-printed prosthetic foot pads can improve the mobility state of disabled pets and increase their quality of life, yet the devices show many weaknesses in practical use. With permanent wear, skin irritation from pressure and a slipping of the device can occur; with very active animals, the device material wears out faster. Such problems cannot be completely eliminated by 3D printing technology alone. There is a need for constant

optimization of the device design as well as an adapted adjustment by qualified veterinarians in order to reduce the usage risks.

The four tables clarify the inner interactions between the three research levels. The advanced development of 3D scanning and 3D printing provides the technical basis for innovative business models of the social enterprises. New company business forms enable the implementation of the social benefit of an improved animal welfare supply. At the same time, inherent limits of the technology directly influence the production and operation of the companies and ultimately restrict the unfolding of the social innovation effect. This mutual relationship of dependence and restriction confirms that the three-level framework of this paper can well explain the regularities of social innovation in the field of welfare for disabled pets.

Even though 3D printing technology has clear advantages in cost control and production efficiency, its practical application is subject to numerous limitations. The material durability of the devices under high mechanical load requires further technical optimization studies. So far there are no uniform certification standards and application rules worldwide in veterinary medicine for 3D printing materials. Social enterprises must find a balance between customer-friendly prices, material costs, and costs for rework in order to ensure the stability of their operation.

In summary, it can be derived from the public research data that 3D printing technology offers a feasible social innovation path for the improvement of the welfare of disabled pets. Positive social effects in animal welfare cannot, however, be achieved by technical improvements alone. A suitable social enterprise model is the central link that converts technical advantages into an actual improvement of animal welfare, and possesses an irreplaceable function.

## 5. Conclusion

This study analyzes the social innovation paths of 3D printing technology in the field of welfare for disabled pets and focuses on the social enterprise model for low-cost custom prosthetic foot pads. The study relies entirely on public literature and published data, creates a three-level analysis framework of technical empowerment, business model, and social impact, compares the differences between traditional manufacturing processes and additive 3D manufacturing, and presents the central business characteristics of existing social enterprises in this field.

The central results of the paper are: 3D printing technology has clear advantages over traditional manufacturing processes in the cost control, production efficiency, and customization of pet prostheses. The digital, demand-oriented manufacturing model solves the old industry problem that expensive devices can only be spread with difficulty. Nevertheless, purely technical improvements cannot fully bring about the optimization of animal welfare. The innovative business model of social enterprises is the central interface between technical advantages and practical application. With their own manufacturing and remote data collection, the companies remove geographical supply hurdles, make pet mobility aids affordable for more normal households, and keep the area-wide animal welfare supply in view as the central business goal.

The three-level research framework created in this paper confirms the close connection between technical prerequisites, business models of the companies, and the results of animal welfare. Technical advantages form the basis of new business models; the design of the business model directly determines the scope and quality of the social benefits in animal welfare. At the same time, the limits of the technology transfer via the company operation to the practical application and lead to problems such as device wear, insufficient fixation, and skin irritation. These existing problems show that the improvement of animal welfare must be further advanced. A permanently safe use of the devices requires constant design optimization and an adapted adjustment by veterinarians.

This study possesses a certain theoretical and practical benefit. On the theoretical level, the paper extends the research field of technology-driven social innovation to the

area of companion animal welfare and provides a structured analysis framework for future investigations at the interface of additive manufacturing, social enterprises, and animal care. On the practical level, the results of the study can serve relevant social enterprises and industry professionals as orientation. In the development of inexpensive veterinary aids, practitioners can consider both technical further developments and the optimization of company mechanisms. Decision-makers in the industry can also pay attention to the positive effect of a digital distributed manufacturing model on the expansion of the supply offering in animal welfare.

This study also has some limits. All conclusions are based on existing public literature and case records; no original experimental observations and device tests were conducted. The publicly available industry data are currently limited; there is a lack of uniform evaluation standards for veterinary-suitable 3D printing materials and long-term data on device performance, so that no in-depth quantitative comparative analysis of the durability of devices from different materials is possible. Future research can collect further public operating data of social enterprises in order to investigate their model of financial sustainability more deeply. In addition, circular production models such as the use of recycled polymers in the manufacturing of pet prostheses can be further explored.

In summary, 3D printing technology offers a new development direction for the improvement of the welfare of disabled pets. In order to fully exhaust the benefit of this technology, a coordinated optimization in technology, company operation, and practical application is needed. The innovative business model of social enterprises can effectively convert the technical advances of manufacturing into an actual increase in the quality of life of disabled companion animals and represents a practicable development path in this field.

## References


1. M. M. N. De Souza, M. da Cunha Antonioli, M. H. M. Dos Santos, B. M. dos Santos Véras, and L. R. R. A. Carvalho, "3D exoprosthesis in socket model for dog with amputed pelvic limb: case report," *BMC Veterinary Research*, vol. 21, no. 1, p. 113, 2025.
2. R. Mendaza-DeCal, S. Peso-Fernandez, and J. Rodriguez-Quiros, "Orthotics and prosthetics by 3D-printing: Accelerating its fabrication flow," *Research in Veterinary Science*, vol. 162, p. 104960, 2023.
3. M. M. N. De Souza, R. R. de Lima, D. V. de Araújo, A. F. M. Dantas, and L. R. R. A. Carvalho, "Customized 3D orthopedic exoprostheses for dogs with amputations and congenital malformations: a case series study," *Frontiers in Veterinary Science*, vol. 13, p. 1854874, 2026.
4. T. M. Wendland, B. Seguin, and F. M. Duerr, "Prospective evaluation of canine partial limb amputation with socket prostheses," *Veterinary Medicine and Science*, vol. 9, no. 4, pp. 1521–1533, 2023.
5. M. M. N. D. Souza, J. N. G. D. Lima, D. J. A. D. Menezes, and L. R. R. A. Carvalho, "Impacts of exoprosthesis use in dogs with partial amputation and limb malformations: a systematic review," *Frontiers in Veterinary Science*, vol. 12, p. 1699152, 2025.
6. N. O. Marouf, N. Mimoune, A. Benchabane, D. Khelef, and R. Kaidi, "3d printer uses in veterinary medicine: a review," *Veterinarska stanica*, vol. 54, no. 2, pp. 223–237, 2023.
7. L. R. R. Carvalho, "3D printed orthopedic prostheses for domestic and wild birds," *Scientific Reports*, vol. 14, no. 1, p. 7989, 2024.
8. H. M. Hafiz, A. Al Rashid, and M. Koç, "Recent advancements in sustainable production and consumption: Recycling processes and impacts for additive manufacturing," *Sustainable Chemistry and Pharmacy*, vol. 42, p. 101778, 2024.
9. M. Narum, E. Miscioscia, and J. Repac, "Caretaker-reported quality of life, functionality, and complications associated with assistive mobility cart use in companion animals," *Frontiers in Veterinary Science*, vol. 11, p. 1466405, 2024.
10. C. Sakib-Uz-Zaman and M. A. H. Khondoker, "Polymer-based additive manufacturing for orthotic and prosthetic devices: industry outlook in Canada," *Polymers*, vol. 15, no. 6, p. 1506, 2023.
11. S. B. Khan, S. Chen, and X. Sun, "Advancements in polymer nanocomposite manufacturing: revolutionizing medical breakthroughs via additive manufacturing," *Polymer Bulletin*, vol. 81, no. 11, pp. 9465–9517, 2024.
12. A. A. Kondratenko, S. A. Peleshok, V. S. Sheveleva, and A. A. Pavlov, "World experience in use of three-dimensional titanium implants in veterinary practice," 2022.
13. M. K. Ibach, "Printing utopia: the domain of the 3D printer in the making of commons-based futures," *Design and Culture*, vol. 15, no. 3, pp. 323–344, 2023.
14. N. Emidi, "Layered sustainability: Design inference for circular economy in additive manufacturing," in *P/References of Design*, Cumulus Conference Proceedings Series, vol. 2, Moholy-Nagy University of Art and Design Budapest, 2024, pp. 35–36.
15. G. Singh, R. Singh, M. Husain, A. Anand, A. P. Singh, and J. P. Davim, "3D printing assisted corrective orthopedic surgery of veterinary patients," in *Additive Manufacturing Solutions for Advanced Veterinary Practice*, Elsevier, 2025, pp. 133–149.

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