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Research Paper

A Review of Methodologies to Approach Fraud in the Remanufacturing Industry

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ABSTRACT: *Fraud in the remanufacturing warranty service industry is an infrequently discussed topic which stems from a lack of observable volume. However, this issue will acerbate over time due to the rising demand for remanufactured products. Prior literature research has targeted related topics that include warranty policies, pricing and maintenance strategies. With the emergence of big data and recent advances in technologies, the identification of fraud is now possible. This paper reviews the prevalent theories and methodologies employed in handling fraud, underlining their effectiveness and limitations. This is an endeavor to lay out how these methodologies could be altered to deal with remanufacturing warranty fraud.*
KEYWORDS: *End-of-life, Reverse supply chain, Fraud, Remanufacturing, Warranty*

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I. INTRODUCTION

Progress in technology and innovation has sparked the rise in consumer electronics and has flooded the marketplace with low cost, high-quality consumer goods. The ample variety of inexpensive products has consequently also produced a change in the behavior of the consumers. The most notable change is that now products, especially small-scale electronics, are most often disposed of before they reach their product end of life (EOL). This has led to a trend where products becoming obsolete in a much shorter time span even though they may have remaining life. An unintended consequence of this is to forcefully shorten the product life cycle for a variety of goods, which over the long term would lead to the steady erosion of natural resources, to compensate for the ever-increasing demands of customers and consequently generate even more waste into the environment.

Over the last 50 years, there has been a steady rise in interest towards environmentally friendly practices both from the public as well as the government. This has resulted in a slew of new environmental legislation that has nudged even the largest corporations into moving away from age-old practices such as disposal and more toward EOL strategies. Environmentally conscious manufacturing [1] can be implemented at any point of the product's life, right from its initial design phase and all the way to its EOL. This flexibility in application is vital in getting a product to meet environmental standards. By keeping waste to a minimum, the firm can reduce disposal costs and permit requirements, avoid environmental fines, boost profits, discover new business opportunities, rejuvenate employee morale, and protect and improve the state of the environment [2].

One of the less obvious sources of waste comes from the presence of fraudulent activities in the reverse supply chain, which is responsible not only for revenue loss but also requires time, resources, and additional costs to rectify. Fraud may be defined as "the wrongful or criminal deception intended to result in financial or personal gain. There may or may not be an actual physical loss or damage for one to say that fraud has been committed for e.g. It may cause no loss of money, property, or legal right but still be an element of another civil or criminal wrong. From the legal perspective, wrongful deception cases refer to where a fraud victim may sue the fraud perpetrator to avoid the fraud or recover monetary compensation. Whereas a criminal deception case is when a fraud perpetrator may be prosecuted and imprisoned by governmental authorities.

There have been strides in researching Frauds for traditionally manufactured products (new products) [3-4] however issues of fraud in the remanufacturing industry have yet to be explored to the same extent. Fraud can be committed at any stage of the product's life cycle such as during the manufacturing stage (e.g. the use of substandard components in product assembly) and even after the product's EOL (e.g. Improper/ illegal

disposal). This paper has a number of objectives, the first is to briefly review the extant literature that studies the issue of fraud in different industries, next is to briefly highlight the more prevalent methodologies that are more frequently employed in dealing with fraud, and lastly, the paper discusses how that knowledge maybe be utilized in curtailing fraud in the remanufacturing sector (specifically with regard to product warranties).

II. LITERATURE REVIEW

Any sector where a there is a financial transaction, is susceptible to fraud and is not limited to any particular medium, such as through mail, wire phone, and more recently the internet. Fraud can also be carried out by almost any of the parties involved. There have also been cases where more than one party was involved in committing the fraud. When it comes to combatting fraud, the broadest way is through government legislation. For instance, In the United States organizations such as the Securities and Exchange Commission and Federal Trade Commission are responsible for monitoring and punishing fraud. Fraud is also monitored and investigated at the much more local level. Practices such as internal audits and random inspections help in routing out any discrepancies, as it is of personal interest to companies as it affects both their image as well as their profit.

Depending on whom the guilty party is the process for routing fraud differs. When the guilty party is the consumer, frauds are usually routed out through investigations carried out by the other party. Traditionally companies use a predetermined set of business rules to evaluate claims that are sent to them. But smart fraudsters can work around any publicly known set of rules to their own advantage. Approaches using business rules, anomaly detection, advanced analytics, and social network analysis into hybrid fraud algorithms to score each claim can free up auditors to look at claims that are 100% fraudulent and not some random selection of claims [5].

The traditional assumption is that fraud occurs between two players, namely the seller and the buyer; however, it is more complex when it relates to transactions, and sales in the large scale. Often product manufacturers are required to outsource services to outside companies or service providers. In such cases, the level of trust the seller places is of importance [6]. The most prominent types of fraud are insurance frauds, financial frauds, and business frauds and the type of frauds that they deal with are distinct and may offer clues as to how to solve remanufactured related frauds.

III. FRAUD IN HEALTHCARE INDUSRTY

Fraud is very prevalent in the insurance sector, but most notably in healthcare. The study of fraud in this area has been of interest to scholars from very early on [7]. Fraud in health insurance is the intentional deception or misrepresentation for gaining some shabby benefit in the form of health expenditures. Frauds that exist in the health care insurance sector are estimated to cost between 2 to 10 % of total value [8]. Insurers make use of flagging systems [8] as well as random checks to evaluate claims sent to them. Fraud in health care is generally considered to be committed on an individual basis between an insurance holder and provider, however, there have been reports of large criminal conglomerates exploiting the relatively transparent claim review process and racking up millions of dollars in fraud claims before being caught [9].

To assist in combating fraud and abuse on a large scale, the U.S federal government's False Claims Act was instituted [10] and since the late 80's the law has helped the government recover more than $30 billion [11]. Once someone is caught committing health insurance fraud it is most often up to the legal system and not the insurer to decide a suitable punishment. A study by [12] describes many scenarios of persons convicted of fraud and how the cases were settled. Another paper by [13] details the various parties involved in the health insurance system and their exchanges and relative responsibilities and provide details to guide an auditor to deal with all manner of health care frauds.

Detecting fraud in large sets of insurance claim data is most often done using data mining tools and techniques. Based on a few cases that are known or suspected to be fraudulent, the anomaly detection technique calculates the likelihood or probability of each record to be fraudulent by analyzing the past insurance claims. In one example [14], data mining was used to tackle the health insurance market in Turkey. Several studies made use of real-world data sets and data mining techniques [15-16]. The main objective of these analyses was to narrow the target for detecting fraud and establishing fraud patterns.

Typically, fraud detection looks at the data at just the transaction-level, which sometimes isn't enough to detect frauds effectively. Multidimensional data models and analysis techniques have shown to help predict the likelihood of fraud in this area [17], [9]. There have been many new methodologies (such as biometrics) that have been developed or are being developed to counteract healthcare fraud.

IV. FRAUD IN THE FINANCE INDUSTRY

The broad definition of financial fraud can be described as "an intentional act of deception involving financial transactions for purpose of personal gain". Financial fraud is a crime and is also a civil law violation.

While all frauds do have a financial component, financial fraud in the context of this paper refers to crimes such as money laundering, credit card fraud, stock market fraud, and other frauds of that nature. One paper [18] enumerated the challenges and presented a comprehensive review of the common techniques in detecting credit card frauds. They further showed the superiority of one particularly innovative fraud detection technique called the bagging ensemble classifier by comparing its results with more standard techniques.

Several research studies have focused on data mining approaches to evaluate credit card fraud. Studies such as [19], [20], and others have shown relative effectiveness of certain data mining techniques over other more conventional approaches. Corporate financial fraud has a severe negative impact on investors and the capital market in general. The current resources committed to financial fraud detection (FFD), however, are insufficient to identify all occurrences in a timely fashion. Methods for automating FFD have mainly relied on financial statistics, although some recent research has suggested that linguistic or vocal cues may also be useful indicators of deception. Tools based on financial numbers, linguistic behavior, and non-verbal vocal cues have each demonstrated the potential for detecting financial fraud. However, the performance of these tools continues to be poorer than desired, limiting their use on a stand-alone basis to help identify companies for further investigation. A review paper [21] pointed out that many fraud studies neglected to address the association among fraud types. A literature review by [22] presented an analysis of existing fraud detection literature based on key aspects such as detection algorithm used, fraud type investigated, and performance of the detection methods for specific financial fraud types. Another review [22] investigated several important fraud detection experimental issues including problem representation, detection algorithms, feature selection, and performance metrics. They noted that the techniques were not all equally sensitive to all performance areas.

V. FRAUD IN THE AUTOMOTIVE AND OTHER INDUSTRIES

Fraud in the automotive industry comes in many forms. It is estimated that actual criminal automotive fraud amounts to less than 1 percent, but the gray area known widely as “soft fraud” may be upward of 30-40 percent in some areas [23] of Massachusetts. To address automotive fraud, insurers typically use four approaches [23]. An early study [24] indicated that investigation of suspected fraudulent claims reduced claim payments by about 18 percent. Insurers in the automotive industry often outsource their claims to third-party service providers and as such this creates another avenue for potential fraud. [25] studied strategies of how to select claims that need auditing, with an aim at detecting frauds in third party claims, by using strategies like logistic models and neural networks to estimate the probability of fraud detection.

Methodologies such as Iterative Assessment Algorithm [26] and discrete choice models [27-28] were shown to be useful as an expert system for detection and subsequent investigation, of groups of collaborating automobile insurance fraudsters. A study [29] showed how fraud detection can be approached as an anomaly ranking problem. It is often assumed that when a claim is examined by an inspector and found to be true, that judgment is assumed to be accurate all the time. Another study [30] used a modified logit model that allows for the possibility that some claims classified as honest may be fraudulent. This model was applied to the auto industry in Spain, and the results showed its ability to identify misclassified claims.

VI. FRAUD IN THE REMANUFACTURING INDUSTY

Upon reviewing the extant literature on how fraud is dealt with in other industries, several conclusions and parallels may be drawn. The warranty service chain for remanufactured products bears a great resemblance to the service chains for the other industries examined in the review. This section also highlights some of the case scenarios that examine fraud in remanufacturing.

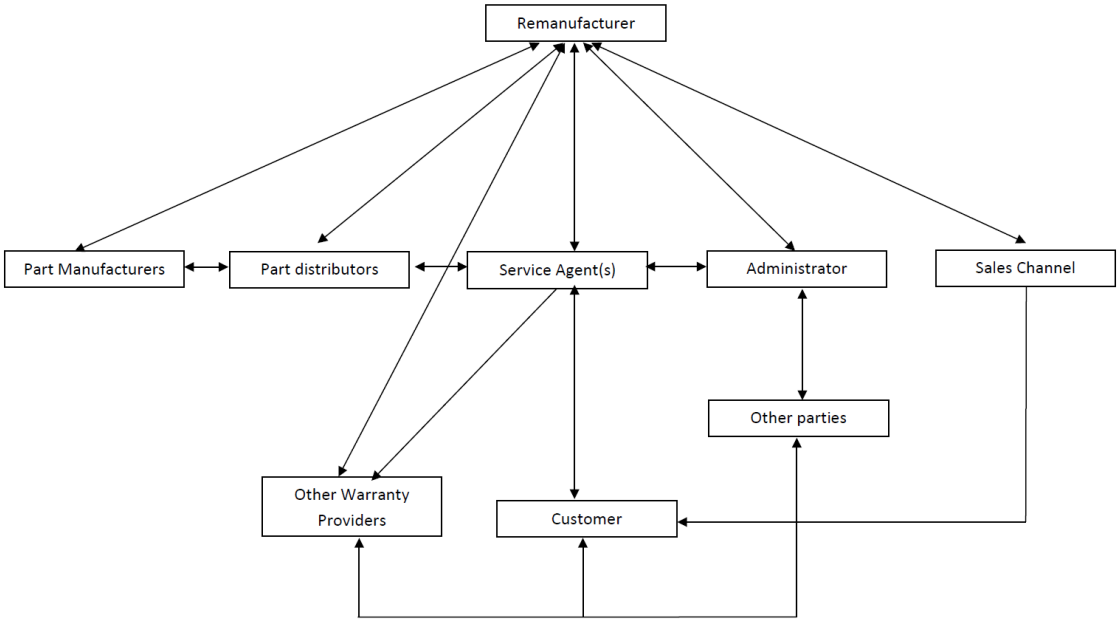

Diagram 1: Information flow between key parties involved in a warranty servicing chain

Diagram 1 describes the warranty supply chain for remanufactured products [31]. When a warranty provider offers a warranty on a remanufactured product to a customer, there are a host of other parties that are also involved in the service and thus may also be involved in any potential fraud. In most warranty service scenarios, when a product is rendered nonfunctional, it is inspected to determine the cause of failure. The information related to any such failure is transmitted to the service personnel (maybe a third party) who conducts the required service operations to rectify this issue; for example, replacing the failed component or components. After this process, failed products are transferred to the service facility. The service agent normally has a maintenance contract with the warranty provider, which requires the products to be brought back to working condition through whatever operations that are deemed necessary. Once the maintenance service operations are concluded, the products are returned to the customers.

Tackling frauds that affect one or more of the primary parties (Remanufacturer, service agent, and customer) presents varying challenges. If the source of the fraud is the service provider (in charge of conducting the maintenance service operation), the audit of claims mirrors the same steps as for the review of claims in the health care and automotive field, and as such data mining and neural network methods would present the best way of dealing with such frauds. In a similar vein, if a service agent overcharges a claim, methodologies (anomaly detection) that are employed in the financial sector would assist in monitoring such frauds. Finally, if the source of fraud is the customer, the process of assessing the validity of a customer's claims is comparable to that of the health care and automotive industry and it follows that similar techniques would be effective.

The review considered a variety of fraud scenarios and checked compatibility against various fraud modeling and detection techniques. It was summarized that there was no "one size fits all" methodology that would properly encapsulate the problem. The merits of certain techniques, some that were not covered in the review were also noted. Regarding fraud modeling, game theory was shown to be useful in determining a parties (players) optimum decision given the payoff (fraud amount) [32]. A study [33] used Nash equilibrium to contrast the optimum decision between the remanufacturer and the service agent for an overcharging warranty fraud scenario and examined the relationship between fraud amount, penalty value, inspection cost, and player risk. Discrete event simulation was also shown to achieve some measure of success in properly recreating the fraud scenarios and was also the most easily adaptable to fit new scenarios. This was shown to be the case when a fraud model developed in order to model service agent fraud [34], was able to be adapted to simulate customer- driven fraud as well [35]. As with many other industries, the Internet of things shows the greatest promise in both fraud detection and prevention. Past studies have shown the usefulness of sensor implementation [36] in dealing with disassembly line quality issues and this would also extend to fraud detection (location data, temperature data, etc., which would assist in determining if a product was actually serviced and or used within recommended guidelines). A theoretical model was proposed by [37], which considered the benefits of incorporating sensors into products would have with regards to reducing maintenance service times and inspection costs. A study by [38], which attempted to use a neural network model in a

remanufactured product warranty scenario, noted that the main hindrance to researching remanufactured product fraud is the lack of readily available data sets to conduct said research.

VII. CONCLUSION

This paper shone the spotlight on the issue of fraud and the forms it appears across many key industries. Concepts and trends in fraud research were reviewed, with a few cases being highlighted. This aided in outlining the available tools that could be employed in tackling fraud in the remanufacturing sector. Game theory, discrete event simulation and neural networks models are some of the more promising methodologies that were deemed to be of use in detecting and dealing with these frauds

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