Seeing Customer Satisfaction without Asking

Applying Customer Health Metrics to monitor Retention in Non-Digital Services, A Case Study of Facilities Management Service TDGI

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Dissertation written under the supervision of Rute Xavier

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Abstract

Seeing Customer Satisfaction without Asking: Applying Customer Health Metrics to monitor Retention in Non-Digital Services, a Case Study of Facilities Management Service TDGI.

by Dang Huy Bui

The study aims to explore how TDGI can effectively monitor client retention based on CRM and corporate data through qualitative analyses by interviewing some clients and two distinct quantitative analyses – a customer relationship analysis and a retention analysis.

The research framework is adopted from customer health metrics currently used among IT companies, such as SaaS and PaaS. This framework seeks to understand the relationship dynamics, usage patterns, and value realization to analyze the health of the relationship between companies and customers.

The research found that operational metrics can partially explain and predict both customer satisfaction and the risk of churn. The customer relationship analysis reveals that factors like urgent service requests, labor hours, corrective working orders, and plan completion rates are significant in proactively inferring client sentiment and retention from internal system data. Compared to previous research, we found that within the service domain, especially facility management, interaction factors also account for the relationship health, which is expressed within labor hours and from interviews with customers.

Based on the findings, the company should optimize urgent request handling, allocate adequate and sufficient labor, monitor corrective works, and ensure a high completion rate of planned activities as key initiatives to maintain strong client relationships.

Key words: Customer health, Customer retention, CRM data, Operational metrics, Customer satisfaction, Churn prediction, Customer relationship management, Facility management

Resumo

Ver a satisfação do cliente sem perguntar: aplicando métricas de saúde do cliente para monitorar a retenção em serviços não digitais, um estudo de caso do serviço de gestão de instalações TDGI.

por Dang Huy Bui

O estudo tem como objetivo explorar como a TDGI pode monitorar eficazmente a retenção de clientes com base em dados de CRM e corporativos por meio de análises qualitativas, entrevistando alguns clientes, e duas análises quantitativas distintas: uma análise do relacionamento com o cliente e uma análise de retenção.

A estrutura da pesquisa é adotada a partir de métricas de saúde do cliente atualmente utilizadas entre empresas de TI, como SaaS e PaaS. Essa estrutura busca compreender a dinâmica do relacionamento, os padrões de uso e a realização de valor para analisar a saúde do relacionamento entre empresas e clientes.

A pesquisa descobriu que as métricas operacionais podem explicar e prever parcialmente tanto a satisfação do cliente quanto o risco de rotatividade. A análise do relacionamento com o cliente revela que fatores como solicitações de serviço urgentes, horas de trabalho, ordens de serviço corretivas e taxas de conclusão do plano são significativos para inferir proativamente o sentimento e a retenção do cliente a partir dos dados do sistema interno. Em comparação com pesquisas anteriores, descobrimos que, dentro do domínio de serviços, especialmente gestão de instalações, os fatores de interação também são responsáveis pela saúde do relacionamento, que é expressa em horas de trabalho e em entrevistas com clientes.

Com base nas conclusões, a empresa deve otimizar o tratamento de solicitações urgentes, alocar mão de obra adequada e suficiente, monitorar trabalhos corretivos e garantir uma alta taxa de conclusão das atividades planeadas como iniciativas-chave para manter relacionamentos sólidos com os clientes.

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1 Introduction

This paper aims to explore the key determinants behind customer retention at TDGI, with the goal of helping the company better understand their competitive advantages and leverage those to ensure long-term business sustainability.

TDGI is a leading facilities management services provider in Portugal. They offer a wide range of building management services, including energy and technical management, soft services, car parks and condominiums, special technical installations, and information technology supporting facilities management (TDGI, 2025).

Offering diverse services for various types of buildings, TDGI has a diverse client base spanning around 8 countries. Their clients can be divided into four main categories: commercial buildings, industrial complexes, healthcare facilities, and retail chains. This diverse client base necessitates a thorough monitoring system to manage customer relationships (TDGI, 2025).

While the company sees that they are doing well with low churn rates and improving financial revenue, they are still dedicated to improving their measurement system, as it exposes several potential drawbacks that need to be addressed.

The current practices on customer retention management rely mainly on qualitative observations from sales teams and satisfaction surveys, of which there are some inherent risks, such as missing data and subjectivity due to bias towards extreme observations, as only a few skewed customers typically take the time to complete the survey. This results in a lack of objective insight into how the company is performing in managing its customers.

These issues have prompted the company to seek more objective indicators to better understand and track customer satisfaction and loyalty. They recognize the need for a more comprehensive and data-driven approach to customer relationship management, going beyond just qualitative assessments.

This leads to the main research question of this study: "How can client retention be monitored based on CRM and corporate data?"

To answer the main question, we aim to address the following sub-questions:

- What are the key factors driving customer loyalty?
- What is the methodology to measure client relationship health on these key factors?

- How is TDGI performing in these key factors?

The project takes a top-down approach to identify potential and relevant metrics documented in academic papers and industry case studies. It will then assess the applicability and measurability of these metrics within the context of TDGI's operations and finally validate these key factors and metrics within TDGI's business environment to gain actionable insights that can inform and strengthen their customer relationship management practices. By adopting a more comprehensive and adaptable framework, the project aims to provide TDGI with a robust framework and set of indicators to better monitor and optimize their customer relationships for long-term business sustainability.

Recently, there have been new approaches to diagnose customers to better execute customer relationship implementations. Especially, with the advancements in technology, organizations now have access to a wider range of customer data points to consider. Rather than focusing heavily on just customer satisfaction like in the past, they are leveraging continuous data points and looking for early indicators of overall customer relationship health. However, these expansive data-driven practices are more visible in service-as-a-platform or software industries where data is typically more abundant and readily available (Hochstein et al, 2023).

Hence, this thesis aims to contribute a new perspective when applying this approach in a more traditional industry - facilities management services - provided by TDGI. The approach will not only maintain a holistic view of the customer relationship management trend but also be adaptable to the nature of the industry. Building upon traditional relationship marketing metrics, the thesis will seek to provide more comprehensive dashboards by including leading and objective indicators that can help TDGI better monitor and understand the key factors driving customer loyalty.

2 Literature review

2.1 Outsourcing industry and Facilities management services

The motivation behind outsourcing decisions varies, but most of the time can be categorized into three main drivers: cost saving; leveraging supplier competitive advantages - to avoid heavy investments and still achieve the same results; and satisfying the quality gap to meet the desired outcome (Rhodes et al., 2016).

With these multiple drivers, the relationship dynamics of outsourcing are also varied. Companies can have:

1. Tactical arm's length relationships, which are short-term and cost-driven;
2. Strategic partnerships to leverage vendor expertise and gain new competitive advantages; or
3. Transformational relationships where risks are shared instead of transferred to the vendor, aiming to co-create and transform the business together.

The dynamic of these relationships is based on the nature of customer demand and the value creation of suppliers (Rhodes et al., 2016).

Facilities management is often considered a non-core activity for building owners, so they frequently outsource it to other parties. However, due to its non-core nature, the expectations and management philosophy differ from those applied to core business suppliers.

To decide on contractors, firms often assess the risk-sharing capabilities of the services compared to self-management, and whether outsourcing can reduce costs and time consumption while improving quality. These are the main factors driving the decision to outsource. Furthermore, if the non-core activity requires high technology and skills, or is overly complex with extensive equipment, companies are more inclined to outsource (Assaf et al., 2011).

If an activity is considered non-core, the interaction depth is often limited to transactional, as companies want to transfer that risk and then not be as concerned. In such cases, the main drivers to continue the outsourcing relationship revolve around only cost reduction and efficiency (Rhodes et al., 2016).

However, in later interviews with TDGI clients, discussed further in this thesis, they commonly view TDGI as offering an expert service that is unparalleled in the market. The value TDGI provides can now be more expansive than the typical definition of facilities management, which warrants deeper consideration to understand customer loyalty.

2.2 Customer health

Customer health is a novel concept recently introduced in the customer success management literature and widely used in practice(Hochstein et al., 2023; Sanchez Ramirez et al., 2024a; Terpoorten et al., 2024; Tjaden et al., 2023), but not yet extensively studied in academic fields

such as marketing research, which often discusses related concepts like customer satisfaction, churn, and net promoter score.

The indicators of customer health are often viewed as extension of current customer relationship quality measure, which is based heavily on survey to measure customer satisfaction, trust and commitment. Customer health also investigates product usage data and customer relationship management information. A key progress is the integration of real-time data and predictive power, going beyond traditional methods (Hochstein et al., 2020).

Hence, customer health is expected to offer a more holistic view of customer relationships, mitigating the high dependence on surveys, which are sometimes biased and suffer from missing data – a pain point within the current process, as discussed previously. Furthermore, customer health also aim to have better predictive power by including more leading indicators. Survey-based data is often a lagging indicator when repurchasing decisions are often made before the survey (Hochstein et al., 2023).

In addition, some features of customer health are also incorporated in churn prediction models. However, the latter often focus primarily on forecasting churn rather than providing a comprehensive view of the customer's overall relationship. Churn models may also consider a wide range of factors, including competitive and external elements such as competitor actions and market trends, which are typically outside the scope of customer health analysis. These models tend to concentrate more on machine learning modeling practices, which are often black box models, rather than the explanatory power of different factors, which is the main purpose of this study (Lemmens & Croux, 2006; Mena et al., 2024).

Therefore, customer health can be seen as an intermediary between customer relationship analysis and churn prediction, offering a broader perspective on the customer relationship while still maintaining a focused approach on the relationship itself and its economic implications.

Despite the current lack of extensive research in this field, most of the factors considered within customer health are well-researched. However, defining customer health consistently remains challenging, as it varies across firms, raising questions about construct validity and whether it is a formative or reflective measure. For instance, Tjaden et al. (2023) included factors like machine age and degree of automation, which are specific to the metal processing

industry and may not be discussed in the general context of customer health.

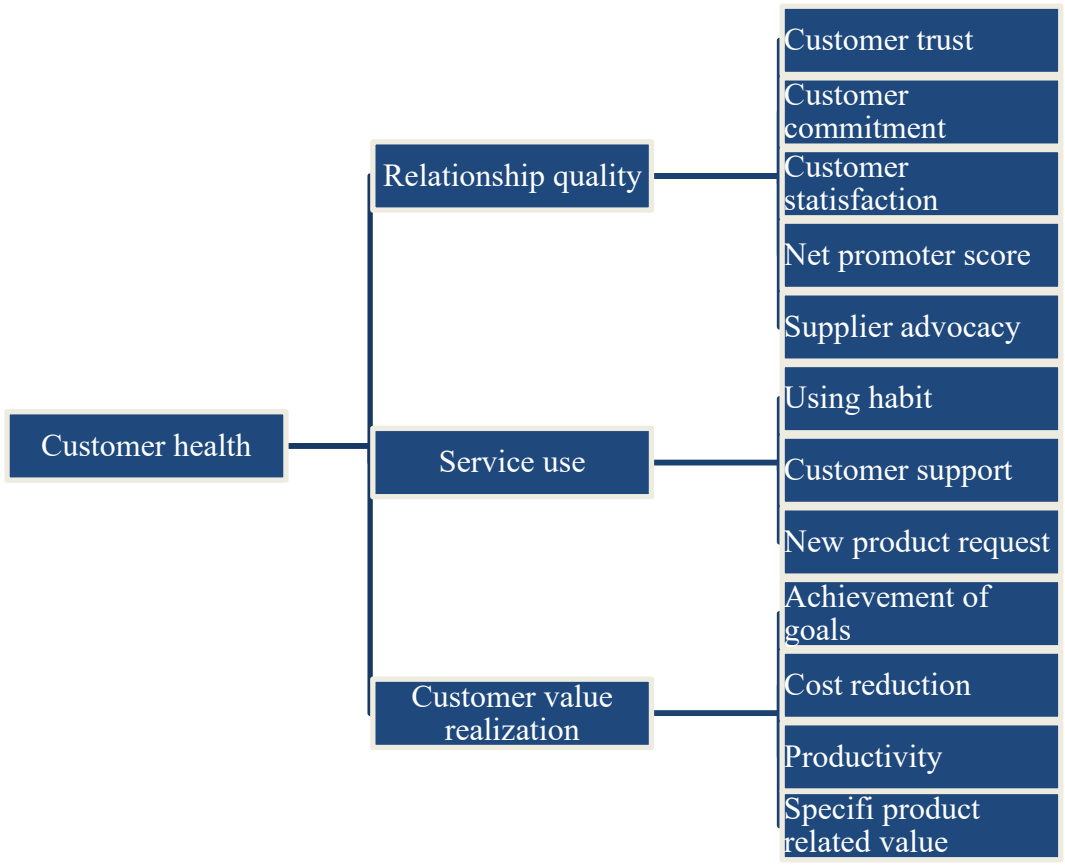

Figure 1. Customer health's dimensions (Hochstein et al, 2023)

2.3 Relationship quality

Relationship quality is a traditional and common approach in customer management to assess the strength of the relationship between the buyer and seller. It examines distinct yet interrelated dimensions, which vary across research (Dorsch et al., 1998). Although there are still debates about the exact composition that can convey relationship quality, there are three main pillars that are often used: satisfaction, trust, and commitment. These pillars are frequently highlighted across foundational studies (De Wulf et al., 2001).

In addition to the traditional pillars, many companies nowadays adopt the net promoter score as an efficient tool to benchmark loyalty compared to other competitors (Kato et al., 2022). This research will also discuss two other factors that can be tracked by company records without a survey: reference ability and other vendor supports.

2.3.1 Customer trust

Customer trust refers to the belief that a vendor will deliver positive outcomes, highlighting their credibility and reducing the need for constant monitoring, as customers feel secure in the service provided (Arthur et al., 2024).

In a B2B context, trust also encompasses honesty and benevolence, which facilitate fair interactions and prevent conflicts, thereby decreasing the transaction costs associated with the risk of exploitation. By reducing these transaction costs or the risk of emotional instability, customer trust enhances satisfaction (Voss et al., 2019).

Measuring customer trust can be challenging, as it is a multidimensional construct that combines both cognitive and affective components. It remains unclear which type of trust contributes more or is more decisive in influencing customer behavior or retention.

2.3.2 Customer commitment

Customer commitment refers to the desire to maintain a stable relationship and even a willingness to make small dedication. When there is a high level of commitment, it means that partners work with efforts towards shared objectives and maintain consistency. The strong emotional bonds during the tight commitment are often correlated with high satisfaction (Arthur et al., 2024).

However, while most research has found a correlation between customer commitment and satisfaction, it's debatable to see which is a causal relationship. Some studies suggest that satisfaction from positive exchanges is the foundation for long-term commitment (Chang et al., 2021; Keiningham et al., 2017). That is why most customer relationship quality models view the pillars as interactive factors and consider all of them together as a virtuous cycle in B2B partnerships (Keiningham et al., 2017).

2.3.3 Customer satisfaction

Customer satisfaction has been measured for a long time, often reflecting positive perceptions and feelings about the brand that lead customers to be glad they chose the firm. High satisfaction helps customers assign higher status to the vendors (Dick & Basu, 1994), prioritizing them for business and prospects of further retention in the future (Kingshott et al., 2020).

Despite being a traditional method, customer satisfaction warrants some consideration. Research has shown that satisfaction is often based on short-term emotional responses and may serve better as a moderator in predicting long-term loyalty or retention, rather than as a direct influence, especially in a B2B context . This has led companies to seek more leading and profound indicators to better manage customer relationships.

2.3.4 Net promoter score (NPS)

Net promoter score is adopted concept due to its simple mechanism and robust measurement (Reichheld, 2003). NPS measures the likelihood of customers to recommend the product or service, serving as a proxy for potential word-of-mouth impact.

While net promoter score is related to customer loyalty, research has found it challenging to prove that it directly predicts customer loyalty or sales growth, which are more complex and multidimensional, especially in sectors with long purchase cycles or high switching costs (Baehre et al., 2022). However, as an index of customer relationship quality in this thesis, the net promoter score can still serve as a powerful tool to gauge whether customers view their relationship with the seller in a negative or positive light.

2.3.5 Supplier advocacy: Referenceability and other vendor supports

Referenceability and other vendor supports represent supplier advocacy, which encompasses activities that buyers undertake to support the seller's business. This includes word-of-mouth, as well as more in-depth collaborations between the two parties, such as providing testimonials, serving as references, or participating in marketing campaigns or trade shows. The underlying theory is that when people feel connected to a brand, they are inclined to promote it (Leach et al., 2021).

In the B2B context, where there is often a buying center rather than a single sales representative, advocacy can also involve promoting a supplier within the customer's organization. This can be beneficial when done in moderation, but excessive promotion may backfire due to concerns about objectivity (Lawrence et al., 2019). Hence, in this thesis, the focus is on investigating the advocacy as support of the entire firm, rather than looking at individual support, which can have nonlinear results.

2.4 Service use

Service usage, even when proved to significantly impact customer retention, is rarely studied in marketing research on customer satisfaction and loyalty. However, recently companies with IT capabilities have been able to track customers' service usage and include it as an extension to the traditional customer relationship quality index in their customer health assessments (Hochstein et al., 2023).

The relationship between customer usage and satisfaction is interdependent, forming a feedback loop where prior usage influences satisfaction, which in turn impacts future usage. Embedded within this loop is the concept of payment equity, where customers assess the price fairness by comparing their actual usage and service performance against their initial normative expectations (Bolton & Lemon, 1999).

However, most B2B retention or churn studies have historically excluded usage data, as it was challenging to track the usage of B2B clients until the recent integration of software as a service and CRM tools. Yet, another challenge arises with the high dimensionality of data, as there is a wealth of information available from the history of transactions and support records (Sanchez Ramirez et al., 2024b).

2.4.1 Product usage

Product usage has been previously studied in highly specific settings where usage levels are decisive to service options and price equity, such as in the case of gyms or entertainment rentals, as the usage level more clearly impacts these contexts.
Not until recently, with the help of improvement in information systems, research on product usage steer focus to software or platform-as-a-service offerings, where firms can track customer activities within the software and analyze their usage behavior and engagement. The aim is to understand if customers use the product frequently and have a high level of engagement with it.
For physical services, however, tracking is often more limited compared to software, though a similar approach can be applied: defining the layers of actions or interactions that clients may have with the service offering or changes in usage, such as site visits or case studies. (Sanchez Ramirez et al., 2024).

2.4.2 Product support

Customer support services can start at any stage of the purchase process, but in this thesis, we focus on the post-purchase and repurchase phases:

1. During the post-purchase phase, the main goal of customer support is to build deeper relationships with clients by being there when they need assistance, or even proactively supporting and improving the process with clients.
2. During the repurchase phase or even before, companies can provide more personalized and tailored recommendations using usage data (Sheth et al., 2023).

Product support can come in various forms, such as training sessions, customer service ticketing, and hotline support (Sanchez Ramirez et al., 2024b). However, in the context of outsourcing, where customers may not want to engage extensively with the service or require training, the measurement and significance of product support to customer relations may be limited.

2.4.3 New product request

After-sales engagement is often not static. The usage habit can change through either expanding or contracting a customer's engagement with the service. These adjustments may involve changes in the frequency or breadth of services adopted (Hochstein et al., 2023).

This creates an essential feedback loop for both companies to maximize the value of the relationship and strengthen it in the long term. Hence, those adjustments, which are often expressed through product requests, indicate that customers are actively engaging with firms' offerings.

Moreover, new product requests are vital to measure the change in value realization in the next phase, as they also serve as a signal for evolving customer expectations about the product(Lemon & Verhoef, 2016).

2.5 Customer value realization

Customer value realization aims to understand the value that a service brings to customers by examining how the product helps firms achieve their goals. From the customer's perspective, the value proposition is often transactional, reflecting a balance between benefits and costs. This balance, which includes intangible social elements, can vary over time relative to other alternatives and customer needs, requiring companies to monitor it continuously.

The realization of value can be multidimensional, but can be broadly divided into push and pull factors: cost and benefit. Benefits can include quality, performance, time-to-market, etc., depending on the goal of the outsourcing strategy as discussed in the outsourcing relationship dynamics. Cost factors can include purchasing price, processing cost, effort, downtime, and coordination (Rhodes et al., 2016).

For managing purposes, companies often focus on high-level information to assess whether their value offers extend beyond the transactional. There are typically three key metrics:

1. Whether customer expectations are met (which can be served as a perceived balance between cost and benefit),
2. Transactional value: the amount of cost savings,
3. Special value: any unique value that the service provides (Hochstein et al., 2023).

3 Methodology

3.1 Research design

The concept of customer health provides insights into the factors to consider when investigating customer satisfaction. However, the effects and metrics are not consistent across studies that examine different sectors.

To adapt the customer health concept to the facility management domain, a qualitative analysis was conducted to explore specific factors in facility management that most closely align with the criteria proposed for customer health, and to formulate an initial hypothesis.

This qualitative analysis aims to answer two planned sub-questions:

- What are the key factors that may drive customer loyalty?
- What is the methodology to measure client relationship health on these key factors?

Based on the insights from the qualitative research, we conducted two main quantitative studies. The first examines the relationships between different factors, and the second identifies the best model to optimize at TDGI, both of which help to answer the last sub-question:

- How is TDGI performing in these key factors?

The first model – Satisfaction analysis - aims to test whether health metrics can predict client satisfaction. Statistically, this will help evaluate the role of customer satisfaction in the customer health model, which monitors customer retention. If customer satisfaction can be explained by other health metric factors, we can exclude it from the retention model to improve robustness and avoid multicollinearity.

Operationally, the model will determine if customer health metrics using internally available data can address the issue of lack of response from customer surveys, or if internal data can replace customer satisfaction surveys to monitor satisfaction and retention rates.

The second model – Retention analysis - is to test whether the customer health metrics that are available internally can predict retention rates, one step further than satisfaction assessment. The aim of this test is to identify the drivers of retention and determine if companies can monitor these metrics during the contract term to better ensure customer retention.

The insights from the first and second models can also examine whether customer relationships are mediators in the model. This would mean the customer survey is hard to replace by analyzing internal data. If customer relationships can be explained using internal data, it is a positive sign that the customer survey can be addressed using internal data about usage patterns and value creation.

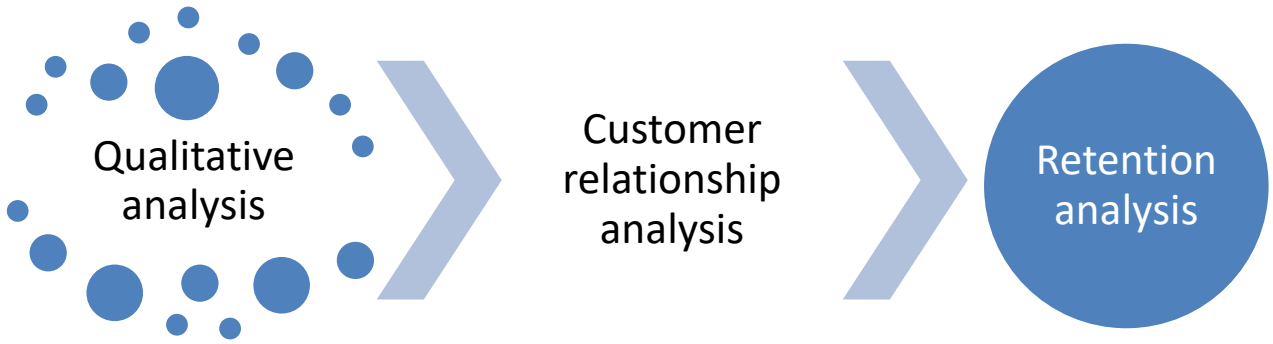

Figure 2. Research design

3.1.1 Qualitative analysis

The main purpose of the qualitative analysis was to explore the specific drivers and underlying mechanisms behind customer satisfaction in the facilities management service, in order to propose hypotheses for the subsequent quantitative analysis.

To this end, semi-structured interviews were conducted with four client representatives and the technical manager, who oversaw the service performance during the contract. The outcome of the qualitative analysis was a set of hypotheses regarding customer satisfaction.

3.1.2 Customer relationship analysis

The purpose of this analysis is to examine whether internal data can predict customer satisfaction. The OLS regression analysis is a viable model for this purpose:

- The dependent variable would be the satisfaction factor, which represents monthly transactional satisfaction score conducted through TDGI's system after every customer request. The variable was recorded on a 5-point Likert scale.
- The independent variables are gathered from internal systems, covering three main areas: customer relationship, usage and value realization (details in 3.2.2).

3.1.3 Retention analysis

The purpose of the analysis is to determine if customer health metrics can predict customer churn. The logistic regression model is a viable approach to achieve this objective:

- The dependent variable would be a binary indicator of customer retention, which would be retrieved from internal data sources.
- The independent variables are gathered from internal systems, covering three main areas: customer relationship, usage and value realization (details in 3.2.2).

3.2 Data

3.2.1 Qualitative analysis

Four random in-depth interviews were conducted with TDGI client representatives: Facilities Manager in the Buildings segment, Workplace Solutions Project Specialist in both the Buildings and Industry segments, Maintenance Coordinator in the Retail segment and Property Manager in the Buildings segment.

The interviews explored the clients' perspectives on factors influencing customer health (Customer relationship, Service usage, Value creation), the underlying reasons for their views, and additional factors that contributed to their decision to continue their relationship with TDGI.

Furthermore, interviews with technical managers provided insight into whether the viewpoints expressed were coherent with internal strategy and the types of internal metrics that could expose these viewpoints.

3.2.2 Customer relationship analysis

The rating represents the monthly average customer satisfaction score collected after service requests. This data includes responses from 40 customers, resulting in 283 monthly observations. Their satisfaction levels will be analyzed using a regression model that incorporates multiple internal data points from these clients, including usage metrics and realized value.

- Customer relationship
    - Rating_Response Rate (% of clients providing ratings)
    - Rating_Responses (Raw count of rating responses)
- Usage
    - Usage in Plan
        - Prevention Plan (Existence/volume of prevention plans)
        - Inspection Plan (Existence/volume of inspection plans)
        - Total Plan (Overall scope of combined plans)
    - Usage in Requests (Client Interactions/Demand)
        - Service Requests (Overall number of client requests)
        - Service Requests_Pending (Client requests awaiting action)
        - Service Requests_On Going (Client requests in progress)
        - Service Requests_Urgent Rate (Proportion of urgent requests)
        - Service Requests_Urgent Requests (Raw count of urgent requests)
    - Usage in Hours (TDGI Effort/Labor Allocation)
        - Labor Hours (Total man-hours spent)
        - Labor Hours_Preventive Hours (Hours dedicated to scheduled preventive tasks)
        - Labor Hours_Corrective Hours (Hours spent on corrective work)
        - Labor Hours_Preventive Rate (Proportion of labor hours on preventive tasks)
        - Labor Hours_Corrective Rate (Proportion of labor hours on corrective tasks)

        - Labor Hours_Others Rate (Proportion of labor hours on other tasks)
        - Labor Hours_Others Hours (Count of hours on other tasks)
        - Labor Hours_Extra Hour Rate (Proportion of extra hours worked)
    - Usage in Working Orders (TDGI Work Execution)
        - Working Orders (Overall number of work orders initiated by TDGI)
        - Working Orders_Pending (Work orders awaiting action)
        - Working Orders_On Going (Work orders in progress)
        - Working Orders_Corrective (Work orders specifically for reactive fixes/issues from investigations)
- Value Realization
    - Plan Completion & Execution Effectiveness
        - Prevention Plan_Completed Rate (% of scheduled preventive tasks completed on time)
        - Inspection Plan_Completed Rate (% of scheduled inspection tasks completed on time)
        - Total Plan_Completed Rate (% of all scheduled plans completed on time)
        - Working Orders_Execution Rate (% of all work orders resolved efficiently)
        - Service Requests_Completed Rate (% of client service requests resolved efficiently)
    - Cost Efficiency & Resource Optimization (for client)
        - Cost_Material (Material costs incurred)
        - Cost_Labor (Labor costs incurred)
        - Cost_Service (Service-specific costs incurred)
        - Cost_Total (Total costs incurred for the client)

The sample will include the data of all customers that participated in the survey. The internal data cover the record of two years, from 04/2023 to 04/2025.

3.2.3 Retention analysis

The analyses consider 14 customers having churned, having 163 usage records in the systems and balanced with 163 usage records from other having made a retention decision. The churned and retained customers were randomly selected from a 2-year window, and efforts

were made to maintain a balanced number between churn and retention to avoid skewing the logistic regression analysis.

Monthly data leading up to clients' retention or churn decisions would be considered, using the same data available in the customer relationship analysis.

4 Qualitative analysis

4.1 Interview insights

Interview coding tree

Interviewee said	Encoding	Observations
If they continue to be here, it's because they really have merit and our trust...And if I don't have confidence in their work…[we would] terminate the contract because we work very hard on the basis of trust.	Reliance on built trust	**Customer trust** toward TDGI is strong, built on consistent performance over the years.
I think it's important that TDGI has been here since the beginning, since 2008. And therefore, I think we are talking about 2008 to 2025. I think that demonstrates the work that has been done and the trust we maintain in them	Trust over time	
There is a reason why we continue to have TDGI as a provider since 2014...Our company actually has a set of indicators, but we've determined they are not worth it. Perhaps they make sense applied to larger contracts, where there's more discussion, less visibility..	Reliance on built trust	
I think we don't have to go and accompany the technician to verify if the service is well done.	Reliance on technician team	
In the area of hardware maintenance, I think TDGI is, without a doubt, a market leader; they have very, very strong technical teams, with great commitment... I can speak of the teams we have had here since 2019, and they are excellent.	Reliance on technician team	
The bottom line in general is positive, and therefore there isn't much need to consider alternatives. The alternatives to consider would be for price and not for service.	Committed over price	**Customers** demonstrate **commitment** when they choose the service over price, reflecting their high trust.
If we had to find another player in the market today, it would be for price reasons, not for service reasons. Because the service level is really very good. The final result has always been very positive. We	Committed over price	

have a very good relationship with the account management and with the teams on the ground.		
We have been lucky since the beginning when we established the contractual relationship... to have a very stable team... And this is reflected in the results.	Committed because of the technician team	
Overall, the performance is positive. But much of it also has to do with the resident technician, who is excellent... Fortunately, we have a fabulous resident technician there.	Satisfied with technical competence	**Customer satisfaction** is driven by the high quality and expertise of the technical staff
Very, very satisfactory, I wouldn't say excellent because excellence in our area is a very difficult thing to achieve. But despite being difficult, TDGI comes very close to excellence.	Satisfied with technical competence	
In the area of hardware maintenance, I think TDGI is, without a doubt, a market leader; they have very, very strong technical teams, with great commitment... I can speak of the teams we have had here since 2019, and they are excellent.	Satisfied with technical competence	
I think I am satisfied with the performance. In terms of technical expertise, they are very good	Satisfied with technical competence	
TDGI is one of the important teams here that feels an undertaking as if it were the company's own. Therefore, there is a behavior, a very high commitment on the part of TDGI.	Satisfied with technical competence	

I would say it's a company that shows a genuine willingness to serve, value continuity, and values its customers…By comparison with other companies I've also known that I don't have exactly the same attitude, I would say that for a colleague, I could give a word of recommendation.	Advocacy and Recommendation Driven by Attitude	**Client advocacy** is often demonstrated by recommending the services to others, driven by the company's willingness to go above and beyond in serving the client.
TDGI fulfills the contractual requirements and in many cases exceeds compliance... striving to meet customer needs, even if sometimes it goes beyond what is contractually established.	Advocacy and Recommendation Driven by Attitude	
I think TDGI fulfills the contractual requirements, even in many cases exceeding the requirements... striving to meet the client's needs, even if sometimes beyond what is contractually established	Advocacy and Recommendation Driven by Attitude	
Every time someone comes here to visit the development, they praise how the equipment is maintained, how the rooms are always clean, and therefore, I think it is also important to convey this sentiment	Advocacy and Recommendation Driven by Quality	
We use Glose, yes and no…It's not a very practical application. It's not very user-friendly, but yes, we use it to register requests and to monitor the execution of requests.	Mixed feelings of Glose	**The usage** of the facility management services is on a daily basis, encompassing both planned maintenance activities and compliance tasks. However, customer feedback on the facility management platform itself appears to be mixed.
The tool has already been transformed, and TDGI has already adapted it so much to daily routines and our needs that it is currently very difficult to guarantee that another maintenance management platform can respond to what we have implemented currently	Postive feelings of Glose	
I think the platform responds to what we need.	Positive feelings of Glose	
I didn't interact directly with Glose, so I don't have a strong opinion about it. It seemed okay to me; that is, at least the resident technician masters Glose and everything he needed to do, he did it naturally. So	Mixed feelings of Glose	

it seems positive to me...Now with the (new) maintenance management program, we hope it will be different. We could do our own evaluation.		
In the area of hardware maintenance, I think TDGI is, without a doubt, a market leader; Then there's the soft services area, which is very complicated and generally we rely a lot on subcontracting... And then those more differentiated areas... for [Client], it's a bit different from other areas, because besides hard and soft, we also had other services like the sales shop, staff, and general services.	Wide range of services	
There, I can also say that the level of satisfaction has been high, because it is challenging for TDGI to find solutions for these areas, because it is not their core business. They always found a way to satisfy [Client]'s needs, sometimes with a bit of improvisation here and there, but the final result has always been very positive.	Flexible scope of service	Customers highly regard TDGI's **customer support**, which provides quick responses and a willingness to go beyond the current scope of services.
There is no attitude of 'Well, it's not in the contract, I won't do it'...There's a willingness to respond, possibly beyond the contract if possible.	Flexible scope of service	
TDGI responds quickly and generally effectively when there are complaints... it responds to complaints and anticipates complaints and prevents them from being made, and in most cases, I would say that is happening	Efficient service request handling	
TDGI manages to respond within normality	Efficient service request handling	
And this assessment is based on the fact that what is expected from the service provision is also very clear. Therefore, our contract is based on a series of criteria and documents that are highly valued, such as all the legal compliance part, everything related to the facility inspection programs... Because it is a very strong company, which has a great capacity for execution in this area. And that is very important for us	Legal compliance	TDGI is expected to address a variety of **business goals**, ranging from legal compliance and facility efficiency to ESG objectives.

We have a set of activities that are mandatory. Which is basically compliance with the law, legislation, what we cannot escape.	Legal compliance	
It's part of the expectations. We state from the beginning what our targets are? What is the efficiency we expect from the steam plant, from the cooling plant?... It's green or it's red, right? For all these items, we have that clear, what the expectation is? And these KPIs. And every day we have KPIs that we follow.	Facility efficiency expectation	
We have a path that we've been following. We will continue to do optimization at the level of environmental indicators, therefore, energy consumption, water consumption, We count on TDGI to help us on that path	Environmental goal	
...a partner who, being a specialist in our field... they bring us more of these novelties, and we bring this to the table so we can have productivity.	Reallocation of Resources	**Cost reduction and efficiency** are often achieved through time savings and the reallocation of resources.
We made the first facilities contract, we used to manage directly, therefore all activities... One of the drivers for contracting with TDGI was precisely to hand over that coordination professionally to a single entity, and thereby have synergies that otherwise wouldn't have.	Reallocation of Resources	
It's almost more time because then we are on many fronts. And that analysis should exist, basically we use the KPIs produced in TDGI's reports.	Increased Time Efficiency	

Figure 3 Qualitative Analysis - Interview Coding Tree

4.1.1 Customer trust

The interview reveals that the clients significantly value their ability to rely on TDGI's services and commitments. This trust has been built through TDGI's consistent performance over time.

Workplace Solutions Project Specialist in both the Buildings and Industry segments emphasized the importance of trust in their business relationships:

> *If they continue to be here, it's because they really have merit and our trust. And if I don't have confidence in their work…[we would] terminate the contract because we work very hard on the basis of trust.*

Facilities Manager in the Buildings segment also remarked that any consideration of alternatives would be driven more by price than service quality, indicating their strong trust in TDGI's service delivery relative to other competitors.

4.1.2 Customer commitment

The commitment was not discussed extensively in the interviews. Rather than seeing it as a willingness to go the extra mile, it was more a matter of the clients still being there even when the price is higher than some competitors, staying due to the trust and quality of TDGI's services.

> *The bottom line in general is positive, and therefore there isn't much need to consider alternatives. The alternatives to consider would be for price and not for service*

Commitment is often closely tied to trust, and can take precedence over pure performance metrics at times.

> *There is a reason why we continue to have TDGI as a provider since 2014...Our company actually has a set of indicators, but we've determined they are not worth it. Perhaps they make sense applied to larger contracts, where there's more discussion, less visibility...*

4.1.3 Customer satisfaction

Overall satisfaction levels are generally high, closely linked to the competence of the technical staff and the stability of the service offerings.

Paulo emphasized the stability of the service:

> *We have been lucky since the beginning when we established the contractual relationship to have a very stable team…And this is reflected the results.*

and quality of the team:

> *I would underline the issue of teams, the teams that provide services are precisely critical. If the team is not good or has elements that are not good, let's say, the result is compromised.*

Maintenance Coordinator in the Retail segment had the same view:

Overall satisfaction is positive – your technicians make all the difference.

4.1.4 Supplier advocacy and promotion

In most of the interviews, the main advocacy from clients was their willingness to recommend TDGI's services. For them, the main drivers for recommending TDGI were the trust and commitment they have towards the company.

When asked how he would describe TDGI to a colleague with the same facility management needs, Facilities Manager in the Buildings segment responded:

> *I would say it's a company that shows a genuine willingness to serve, value continuity, and values its customers…By comparison with other companies I've also known that I don't have exactly the same attitude, I would say that for a colleague, I could give a word of recommendation.*

TDGI's commitment was often highlighted by its willingness to go beyond the contractual coverage. As Facilities Manager in the Buildings segment noted:

> *TDGI fulfills the contractual requirements and in many cases exceeds compliance...striving to meet customer needs, even if sometimes it goes beyond what is contractually established.*

In current practices, the statement seems coherent. TDGI have their own standard and internal SLAs and KPIs to commit to, which makes them often exceed expectations when the contract lacks any defined metric figures.

4.1.5 Using habit

The usage of the service, recorded with Glose, a platform used by TDGI to receive service requests and manage overall services, has received mixed feelings from clients.

> *We use Glose, yes and no…It's not a very practical application. It's not very user-friendly, but yes, we use it to register requests and to monitor the execution of requests.*

Moreover, even with the positive intent of professional facilities management, Paulo explained that the motivation behind the contract was to allow them to focus on their core activities, which reduced their direct involvement in facilities management tasks:

> *We made the first facilities contract, we used to manage directly, therefore all activities…One of the drivers for contracting with TDGI was precisely to hand over that coordination professionally to a single entity, and thereby have synergies that otherwise wouldn't have.*

The observation suggests a new hypothesis - the relationship between usage and customer perceptions may not be linear. On one hand, using Glose helps clients manage and monitor their facilities inspection plan and other tasks. On the other hand, clients also express a desire to minimize their own management effort in this area.

The technical manager suggests that usage habit can be calculated using the baseline from contract expectations, including the number of planned preventive tasks and legislative compliance schedule. This portrays the customers' demand for the service. Furthermore, the customers' tendency to evaluate request completion can also indicate their effort in managing the services.

4.1.6 Customer support and service requests

For TDGI's outsourcing services, customer support primarily focuses on handling service requests. As discussed earlier, customers find it challenging to register service requests within Glose, which may contribute to lower motivation to use the platform.

However, TDGI is flexible in accommodating new service requests that might fall outside contractual boundaries. These are also the opportunities that are acknowledged by the clients:

> *There is no attitude of 'Well, it's not in the contract, I won't do it'…There's a willingness to respond, possibly beyond the contract if possible.*

It is also common that the scope of the services evolve overtime:

> *We've already had security integrated into the facility management contract; there was a time when, by indication from [Client] at an international level, it was separated…And on contrary, we've already added other things that were note previously done by TDGI. They started to be.*

The observation also suggests a non-linear relationship between service requests and customer perceptions about the service. And Glose also provides metrics to track these service requests, this data can serve as an index to measure the usage patterns.

4.1.7 Achievement of business goals

Regulatory compliance is a baseline strategic objective for them most of the time.

> *With TDGI, our legal compliance safeguards became more robust; they brought full coverage we lacked.*

Property Manager in the Buildings segment noted that there are other objectives beyond those explicitly stated or in central roles.

> *We have achieved our objectives, so these are things that we could potentially use in the future, right?*

Or

> *We have a path that we've been following. We will continue to do optimization at the level of environmental indicators, therefore, energy consumption, water consumption,…We count on TDGI to help us on that path.*

Then to effectively measure business goals, it is most relevant to start with the baseline of plan compliance, and then further investigate other metrics.

According to the technical manager, there are three key metrics that can convey the achievement of goals: completion of the preventive maintenance plan, and other service requests. The completion of the legislative requirement plan serves as the baseline and can be measured using binary variables, while the other metrics can be recorded as percentages.

4.1.8 Cost reduction and efficiency

Centralization of facilities management under TDGI often enables clients to reallocate their internal resources toward more strategic activities, as agreed by most interviewees. This synergy between cost savings and increased efficiency is a key advantage of the outsourcing arrangement, as noted in almost all interviews.

The concept of productivity influences how people view the potential for cost savings. Hence, the number of working hours can be a measure of efficiency from the client's perspective - the more hours TDGI spends managing the site, the more time the client can devote to their core activities.

4.2 Hypotheses

Based on the observed viewpoints on relationship (trust, commitment, satisfaction, and advocacy), which were mainly reflective of TDGI's performance over time, it is reasonable to propose the following hypotheses:

H1: Operational metrics can predict relationship metrics

We then investigate whether operational metrics have the power to predict retention patterns without relying on survey metrics:

H2: Operational metrics can predict risk of churn, without the need for survey metrics

The results from testing H2 can also help explain a third hypothesis:

H3: Relationship metrics can be omitted if there are available operational metrics

If operational metrics alone cannot sufficiently explain the risk of churn, the company should make efforts to conduct satisfaction surveys frequently and retest the model in order to achieve a more comprehensive explanation.

5 Customer Relationship Analysis

5.1 Overview

The rating is recorded monthly after the customer raises service requests and provides feedback. Customers may or may not respond to the rating survey. Out of 180 potential contact points, 40 stakeholders provided ratings, resulting in 283 observations out of 4,041 monthly records over a 2-year period.

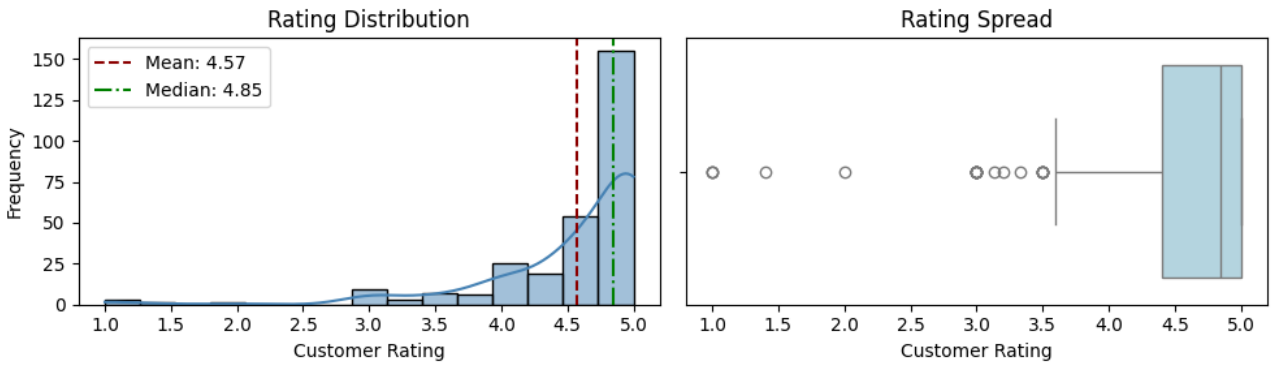

Figure 4 Rating distribution and spread

Overall, customers are highly satisfied with the services, with only a few outliers below a rating of 3.5. More than half of the ratings are 4.85 or higher, which is nearly a perfect 5.

However, the meaning behind the rating appears to vary across different clusters. For example, the 283 monthly rating observations were distinct when examining the range of service requests, revealing two main clusters:

- For service requests below 500, the rating is more diverse and shows a pattern along the range of service requests.
- For service requests above 750, the rating come solely from a single major client, and their rating remains consistently above 4.5 throughout the month. However, there is no month where the rating reaches a full score of 5, suggesting that there is still room for improvement in satisfying this client.

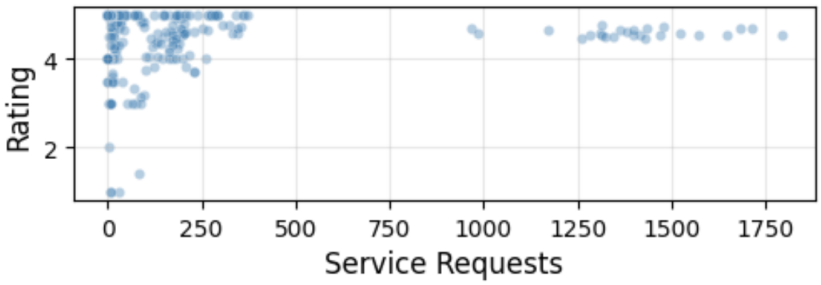

Figure 5 Rating by service requests

The analysis centered primarily on the service request range below 500 per month, as the cluster of requests above 750 was already consistent. In the lower range, there were some monthly ratings of 1, but these were one-time ratings, indicating that customers provided specific negative feedback on those occasions and did not commit to feedback if it was higher. In this analysis of finding usage patterns, the focus would be on the usage pattern rather than one-time dissatisfaction, so monthly ratings are examined when there is more than one rating response for that month.

Out of these observations, only one case received a rating less than 2, while the others scored 3 or above. This particular case involved 83 service requests, with 5 urgent requests, and received an average rating of 1.4 across 5 responses. It appears that the urgent requests were critical and heightened the customer's sensitivity to disappointment. However, this is an outlier case and will be removed from the analysis to avoid skewing the model.

When considering the remaining observations, we observed that the rating of 5 appeared to have no clear patterns across various dimensions. suggesting that these high ratings are independent from usage and other matrixes discussed here. With the consistence 5 in up to 25 responses, it might show now a level of trust also within the rating or auto feedback, which needs further investigation. However the observations will not included in here when we examine the usage of CRM data in explaining the rating.

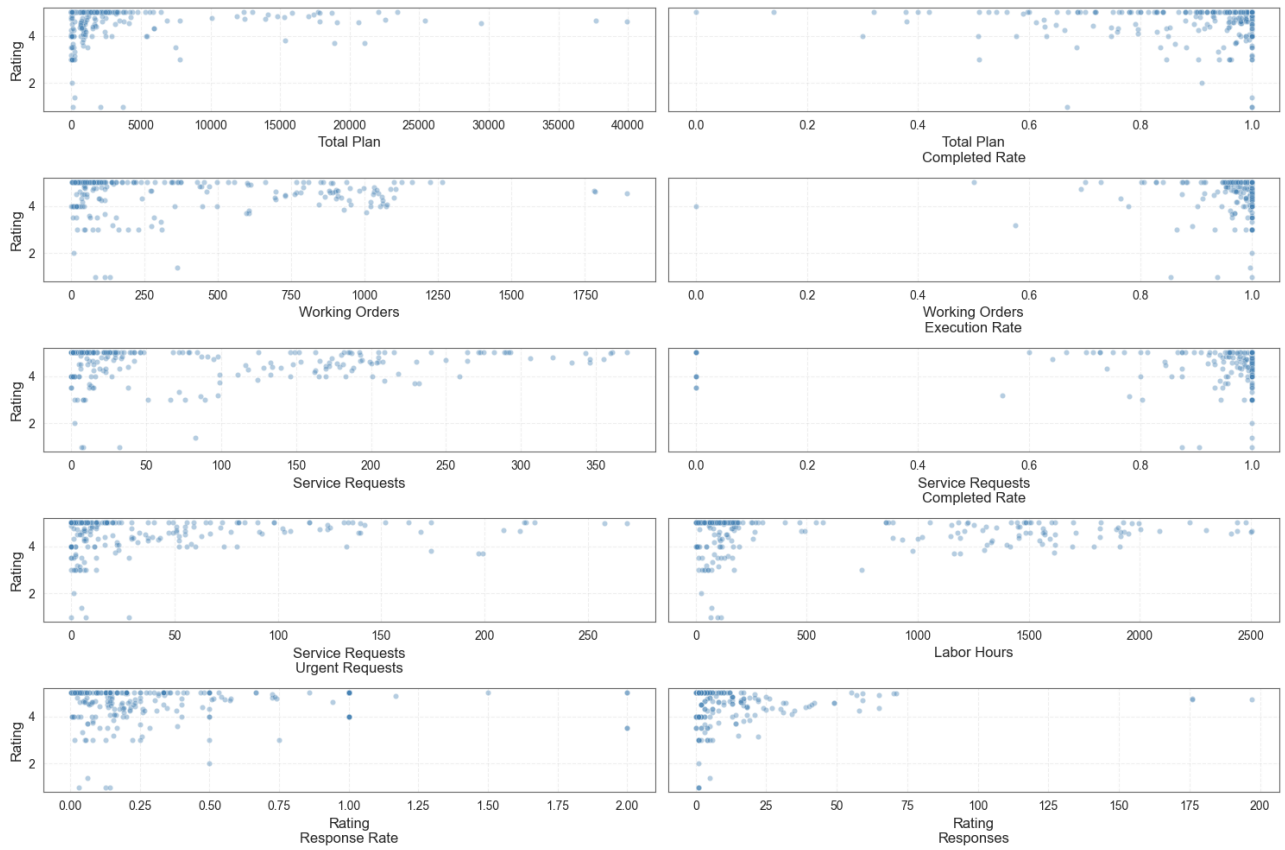

Figure 6 Rating by usage and value creation (request services < 500)

Upon closer examination of the range below 5, we observe patterns where the power of certain dimensions affects the overall monthly rating. However, some factors are not straightforward. The trend for urgent requests appears non-linear, with ratings increasing up to around 50% urgent requests, but then slightly decreasing thereafter. However, the high requests sides seems lack of observation to check if the trend can be generalized.

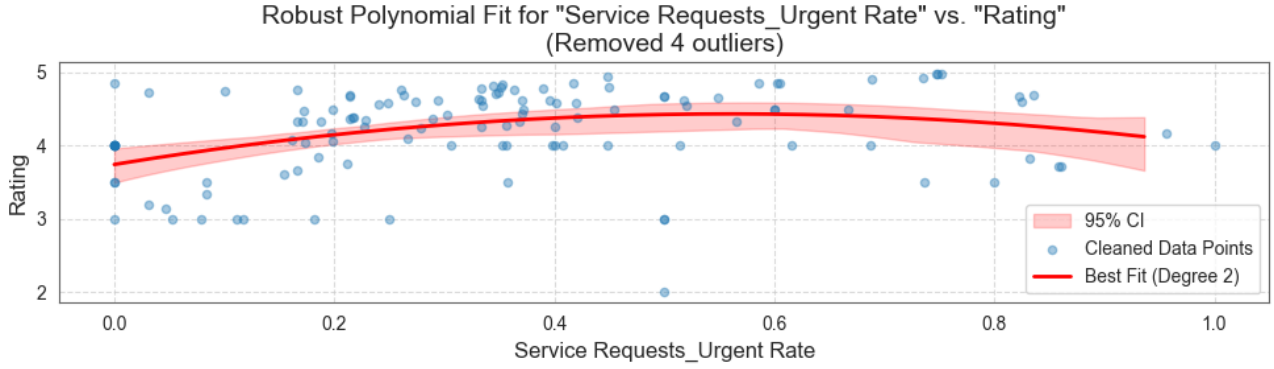

Figure 7 Polynomial Fit for Urgent Rate of Service Requests and Rating (Appendix 3)

It seems some variables may not have significant power in the model. For example, the completed rate of service requests is already high, over 75%, so the rating may not be strongly influenced by the completed rate. Furthermore, completing 100% of the requests does not necessarily guarantee high satisfaction.

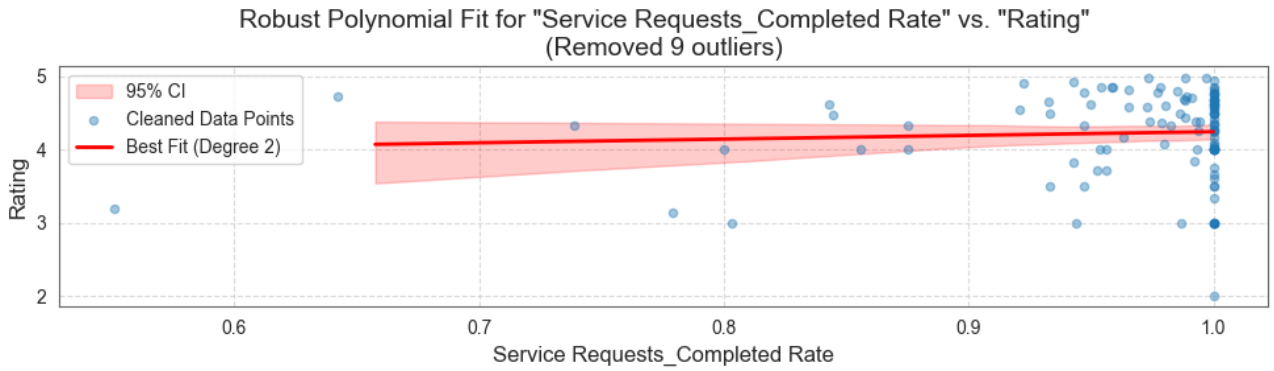

Figure 8 Polynomial Fit for Completed Rate of Services Requests and Rating (Appendix 3)

5.2 Customer relationship model

To develop the customer relationship model, various usage, value creation, and customer feedback metrics were explored. The final model incorporates Service Requests – Urgent Rate, Inspection Plan, Cost Material, Labor Hours, and Rating Response Rate as they significantly impact the model without being highly correlated with each other (Appendix 3 and 4). The model uses both linear and

polynomial relationships, with the coefficients representing the standardized change in the independent variables – per standard deviation unit.

Model Summary:

OLS Regression Results

Dep. Variable:	Rating	R-squared:	0.476
Model:	OLS	Adj. R-squared:	0.443
Method:	Least Squares	F-statistic:	12.32
Date:	Tue, 27 May 2025	Prob (F-statistic):	3.05e-10
Time:	13:47:59	Log-Likelihood:	-44.730
No. Observations:	103	AIC:	103.5
Df Residuals:	96	BIC:	121.9
Df Model:	6		
Covariance Type:	HC3		

	coef	std err	z	P>|z|	[0.025	0.975]
const	4.3171	0.040	108.973	0.000	4.239	4.395
Service Requests_Urgent Rate	0.6180	0.200	3.090	0.002	0.226	1.010
Service Requests_Urgent Rate_deg2	-0.5172	0.174	-2.979	0.003	-0.857	-0.177
Inspection Plan	-0.0390	0.057	-0.689	0.491	-0.150	0.072
Cost_Material	0.1192	0.068	1.748	0.080	-0.014	0.253
Labor Hours	0.1705	0.059	2.867	0.004	0.054	0.287
Rating_Response Rate_log	0.2423	0.053	4.551	0.000	0.138	0.347

Omnibus:	18.498	Durbin-Watson:	1.846
Prob(Omnibus):	0.000	Jarque-Bera (JB):	41.947
Skew:	-0.631	Prob(JB):	7.79e-10
Kurtosis:	5.860	Cond. No.	9.74

Notes:
[1] Standard Errors are heteroscedasticity robust (HC3)

Figure 9 Rating OLS Regression Results (Appendix 5)

The model accounted for 47.6% of the variance in Rating, with statistical significance supported by a high F-statistic of 12.32. This indicates that a portion of the variation in Rating can be explained by the included features.

5.2.1 Service use

The Rating appears to have a complex relationship with Urgent requests, which is not entirely linear (linear coefficient = 0.6180, quadratic coefficient = -0.5712, $p<0.005$). A slight increase in the Urgent request rate can lead to a positive change in the Rating. However, this trend reverses at an optimal point of 0.6 standard deviations above the mean rate. Beyond this point, further increases in the Urgent request rate result in a decrease in the Rating.

The Labor Hours exhibit a statistically significant positive linear relationship with Rating (coefficient = 0.1705, $p=0.04$). This suggests that overall labor dedication in service and

maintenance activities can contribute to customer satisfaction. This is also relevant to qualitative analysis about customer satisfaction, which indicates that technician staff with stable performance contribute mainly to their feedback. Labor Hours as a time commitment from TDGI can be a driver for this assessment.

5.2.2 Customer relation

The Rating Response Rate is one of the most significant predictors of the rating (coefficient = 0.2423, p = 0.000). A higher log-transformed rate is associated with a higher rating. This suggests that customers who are more engaged with TDGI and provide feedback tend to give higher ratings, or that customers who are satisfied with TDGI tend to provide feedback.

However, the pattern of skewing towards higher ratings appears to be magnified by this customers' satisfaction behavior, as nearly all observations have ratings higher than the SLA level of 4. This may reflect a tendency for a few customers who frequently provide positive feedback.

5.2.3 Value creation

Meanwhile, the value creation indicators do not appear to contribute as much to the customer Rating. This may be because the Rating is based on a monthly timeframe, when customers assess specific services, making overall performance indicators as a sense of value creation less compatible.

The OLS model provides strong statistical evidence to support the hypothesis H1 that operational metrics can predict customer relationship metrics. The model can explain a substantial portion of the variance in Rating through several key operational and statistically significant metrics: Service Requests – Urgent Rate, Labor Hours, and Rating Response Rate.

6 Retention Analysis

The number of churns at TDGI is rather small, with only 14 cases out of 180 clients recorded over a 2-year period. To be considered a churn, we define inactive duration as more than 2 months from the last activity to the current date (April 2025). Out of the database, 56 cases were identified by mapping CRM and Sales data to detect whether they had renewed or churned within the last 2 years, including 14 cases of churn and 42 cases of renewal.

For this analysis, we analysed the pattern of usage of churned customers monthly by comparing with the customers who made decisions to renew.

6.1 Overview

In general, the service usage of both renewed and churned customers is often limited in certain aspects. For example, they rarely have prevention plans or service requests. However, when considering the outliers or examining inspection plans, renewed customers tend to have higher service usage compared to churned customers.

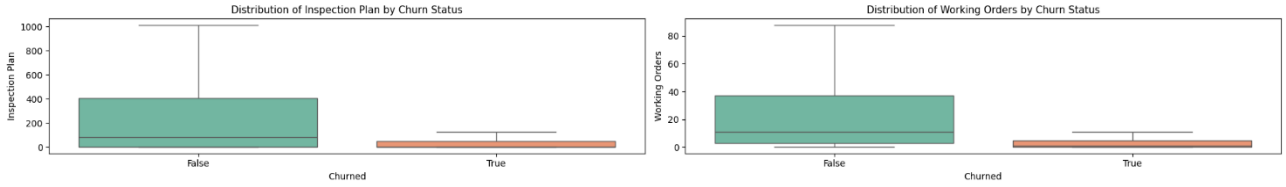

Figure 10 Distribution of Inspection Plan and Working Orders by Churn Status – without outliers (Appendix 6)

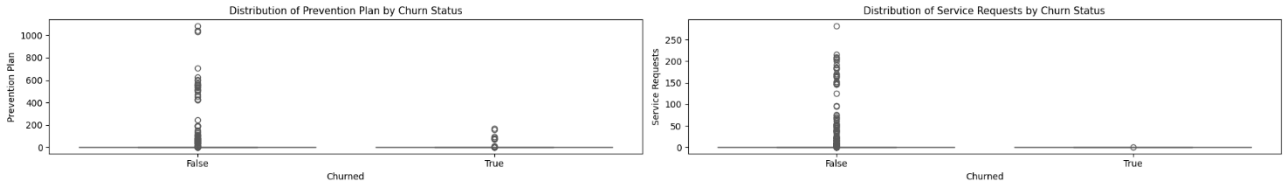

Figure 11 Distribution of Prevention Plan and Service Requests by Churn Status (Appendix 6)

For renewed customers, the labor hours and costs indicate a higher level of engagement from both sides when the service requires a greater investment of labor and cost. Meanwhile, for churned customers, this pattern is not observed.

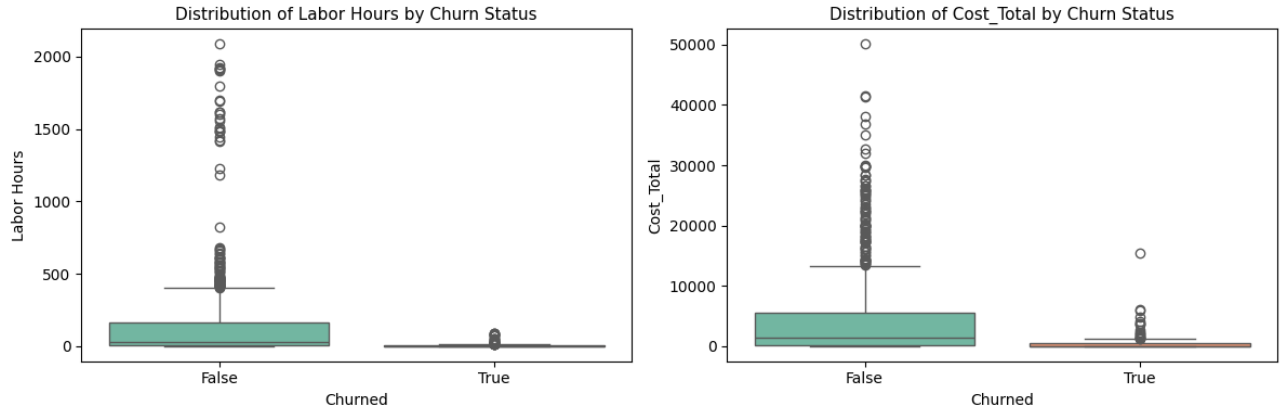

Figure 12 Distribution of Labor Hours and Total Cost by Churn Status (Appendix 6)

Within the value creation aspect, the performance to complete the contract plan is similar across both types of customers. However, for the working orders, the execution rate appears more random within churned customers compared to those who renewed their contracts. It's worth noting that the

amount of work within churned customers is relatively low, so even a single unit of work can significantly scale the completed rate.

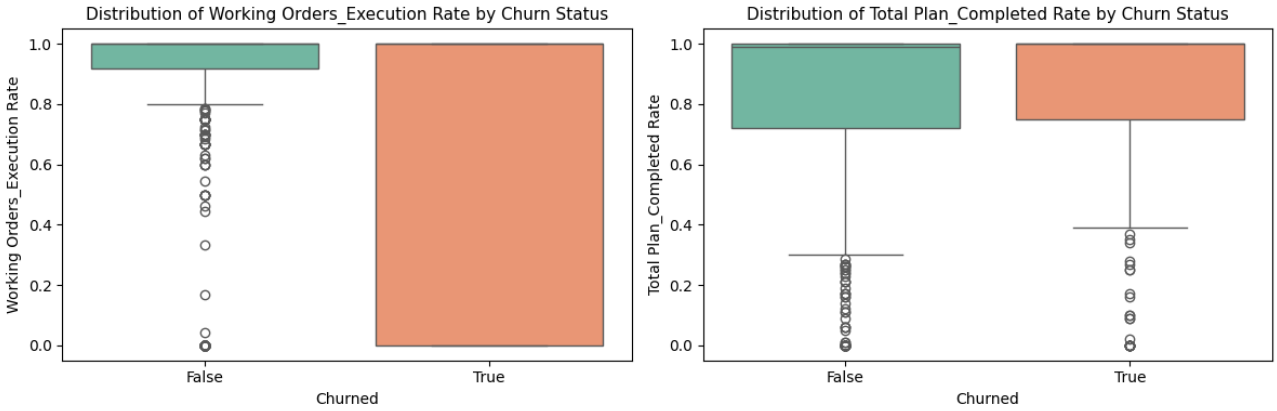

Figure 13 Distribution of Completed Rate of Total Plan and Execution Rate of Working Orders by Churn Status (Appendix 6)

Both types of customers, those who renewed and those who churned, exhibit a lack of engagement with feedback tools. Even when examining outliers, there is no discernible difference in this trend - churned customers do not provide feedback.

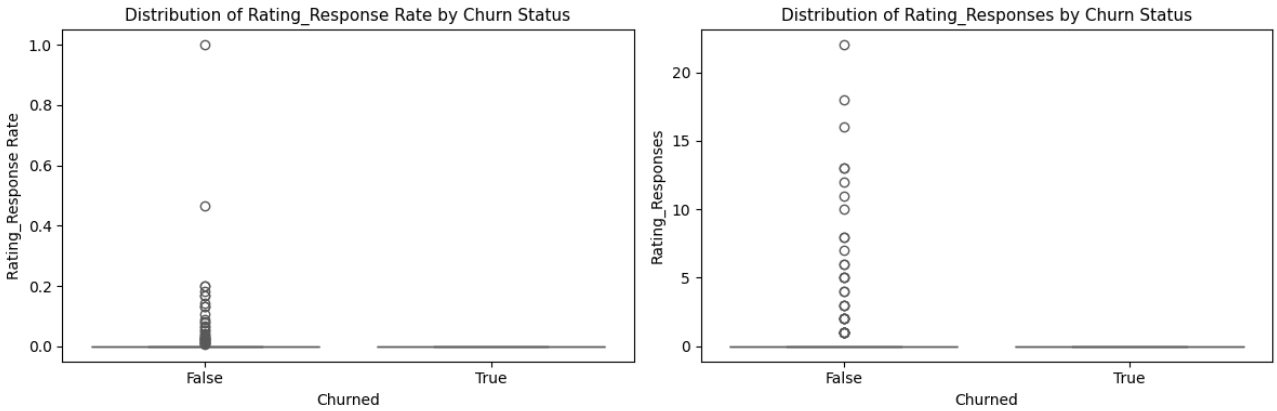

Figure 14 Distribution of Rating Response and Response Rate by Churn Rate (Appendix 6)

6.2 Retention model

To address the imbalance between churned and non-churned customers, the modelling will balance the monthly usage observations. Specifically, 162 monthly observations will be randomly selected from the 926 observations for non-churned customers, matching the number of observations for churned customers.

After extensive testing with multiple variables, a set of highly relevant yet non-multicollinear factors was selected to explain the customer churn habit. The model can significantly explain 30.15% of the variance in customer churn with a low p-value.

Logit Regression Results

Dep. Variable:	Churned	No. Observations:	324
Model:	Logit	Df Residuals:	316
Method:	MLE	Df Model:	7
Date:	Wed, 28 May 2025	Pseudo R-squ.:	0.3015
Time:	17:55:11	Log-Likelihood:	-156.86
converged:	True	LL-Null:	-224.58
Covariance Type:	nonrobust	LLR p-value:	4.583e-26

	coef	std err	z	P>|z|	[0.025	0.975]
const	-0.9967	0.347	-2.873	0.004	-1.677	-0.317
Working Orders_On Going	0.3605	0.193	1.869	0.062	-0.017	0.738
Working Orders_Corrective	-4.3298	1.174	-3.688	0.000	-6.631	-2.029
Labor Hours_Corrective Rate	-0.4811	0.190	-2.528	0.011	-0.854	-0.108
Total Plan	-0.7716	0.516	-1.496	0.135	-1.783	0.239
Labor Hours_Preventive Rate	-0.5415	0.175	-3.098	0.002	-0.884	-0.199
Working Orders_Execution Rate	0.3191	0.180	1.773	0.076	-0.034	0.672
Total Plan_Completed Rate	-0.4663	0.159	-2.927	0.003	-0.779	-0.154

--- Odds Ratios and their 95% Confidence Intervals ---

	Odds Ratio	Lower CI (95%)	Upper CI (95%)
Working Orders_On Going	1.433979	0.982697	2.092501
Working Orders_Corrective	0.013170	0.001319	0.131499
Labor Hours_Corrective Rate	0.618112	0.425689	0.897517
Total Plan	0.462284	0.168200	1.270549
Labor Hours_Preventive Rate	0.581864	0.413100	0.819573
Working Orders_Execution Rate	1.375847	0.966975	1.957604
Total Plan_Completed Rate	0.627297	0.459030	0.857246

Figure 15 Churn Logit Regression Results

In general, the churning decision appears to be highly sensitive to corrective work, as two key factors relate to this type of task: the number of Work Orders_Corrective and the proportion of Labor Hours_Corrective Rate devoted to corrective activities.

6.2.1 Service use

Labor Hours are an efficient indicator for retention. Both increases in the Rate of Corrective or Preventive Labor hours can help decrease the risk of churn. Specifically:

- Corrective Labor Hours: A one-standard-deviation increase in the proportion of corrective labor hours decreases the chance of churning by 38.2% (1 – Odds Ratio, p=0.011).
- Preventive Labor Hours: A one-standard-deviation increase in the proportion of preventive labor hours decreases the chance of churning by 41.8% (1 – Odds Ratio, p=0.002).

6.2.2 Value creation

Both renewed and churned customers rarely submit service requests. However, the process of TDGI investigation often leads to an increase in corrective working orders. This rise in Corrective

Working Orders seems to heighten the perceived value of TDGI services, making it the most powerful factor explaining customer retention. The model indicates that a one-standard-deviation increase in corrective working orders can dramatically decrease the odds of churn by up to 98.7% (1- Odds Ratio, p=0.000).

Additionally, a higher Total Plan Completion Rate is associated with a 37.3% (1- Odds Ratio, p = 0.03) decrease in the odds of churn, which suggests that a stronger sense of contract plan commitment can also improve the retention rate.

Although not statistically significant at $p<0.05$, two other factors also moderately impact churn at the $p<0.1$ level. Increases in Ongoing Working Orders and Working Order Execution Rate have an inverse effect on the risk of churn. While an increase in unresolved working orders per month can lead to a higher risk of churn, the execution rate of working orders can positively impact the churn habit. However, this effect may be diluted by the influence of the task type, as Corrective Work Orders can also be ongoing and executed.

The Log Regression model provides strong statistical evidence to support the hypothesis H2 that operational metrics can explain risk of churn. The model can explain a substantial portion of the variance in Churn through several key operational and statistically significant metrics: Working Orders_Corrective, Labor Hours_Corrective Rate, Labor Hours_Preventive Rate, Total Plan_Completed Rate.

7 Operational and Relationship metrics to explain Retention

The evidence from H1 and H2 suggests that operational metrics can partly explain both customer satisfaction and the risk of churn. This indicates that the missing of relationship metrics may be acceptable when assessing retention, provided that operational metrics are available.

However, the lower R-squared for the Retention Analysis (30.15%) compared to the Customer Relationship Analysis (47.6%) suggests that the operational metrics' power to predict churn could be partially exerted, potentially through an indirect influence on customer satisfaction, which could then impact churn.

Examining the relationship between Relationship metrics and Churn could provide valuable insights into the mediating role of Relationship metrics. However, in this case, the survey results are unavailable for churned customers. Nevertheless, the drop in R-squared is expected if a mediator is present in the chain.

In summary, the results from H1 and H2 support H3, indicating that operational metrics can still predict churn, though not as powerfully as they explain customer satisfaction. Further research could explore including customer satisfaction in the model to potentially enhance the predictive power.

8 Recommendations

8.1 Monitoring satisfaction

Based on the Customer Relationship Analysis, there are two key metrics TDGI can actively manage and regulate: urgent service requests and labor hours, as these can potentially impact customer satisfaction.

8.1.1 Optimize level of urgent service requests

Regarding urgent service requests, there is an optimal level that maximizes customer satisfaction. Beyond this point, too many urgent requests can lead to dissatisfaction. Therefore, TDGI should focus on optimizing the handling process of urgent requests, mindful that there may be diminishing returns in customer satisfaction beyond a certain amount of urgency.

In the short term, TDGI can reactively allocate sufficient resources to handle urgent requests. This may involve having a dedicated responsive team, implementing a prioritization system to address urgent issues, and establishing protocols for managing similar urgent requests.

In the long term, TDGI can proactively adopt approaches to mitigate issues with high-volume urgent clients and effectively prevent urgent problems. As they approach the optimal threshold, TDGI can suggest more frequent preventive work, invest in early warning systems, and adopt machine learning to predict the possibility of urgent issues.

8.1.2 Allocate adequate and consistent labor

Regarding labor hours, as a sign of service dedication and engagement with stakeholders onsite, this dedication can contribute linearly to customer satisfaction. Therefore, TDGI should focus on allocating adequate and consistent labor to service and maintenance activities.

The analysis also discussed that some stakeholders highlighted the importance of technician availability and their preference to communicate directly with technicians about their issues, rather than raising requests through an app. This demand can compound the influence of labor hours in driving customer satisfaction.

If there is a plan to cut labor hours, TDGI should provide a transparent justification and implement a plan to compensate for the potential lack of communication. This could involve providing an easy-to-use portal for customers to communicate their needs or actively reaching out to quickly capture their requirements.

8.1.3 Improve rating responsiveness

While rating response rate is a useful tool for measuring customer engagement and understanding the current state of customer satisfaction, it can be challenging to act on this information to directly improve customer satisfaction. Additionally, the patterns observed in the response rate may skew the overall record.

Hence, improving the rating response rate would be beneficial not to directly improve customer satisfaction, but to gain a better understanding of customer satisfaction and quickly address any dissatisfaction. To better understand customer satisfaction, we can also adopt different rating approaches within different segments, considering the varying rating habits discussed in the analysis.

- For customers with service requests below 500, the priority should be to encourage them to provide ratings. Offering small, non-monetary incentives, such as entry into a monthly draw for a free investigation, can help drive participation. This should be coupled with linear and straightforward surveys to gather feedback.
- For the specific large customers that have service requests above 750, the priority should be to identify the gap between their current satisfaction level and a perfect 5 rating. The contract manager can conduct periodic and deeper conversations with these customers to better understand their specific needs and how TDGI can address them.
- For the straight 5 customers, the priority should be to understand why they are particularly satisfied, as the analysis has not yet revealed a clear pattern in their usage records. Following up with open-ended questions to welcome their suggestions for improvement would be beneficial, allowing us to better satisfy this segment.

8.1.4 Diversify rating and feedback loop

Transactional feedback provides insights into temporal sentiment, and the impact of relevant operational data is already evident. However, understanding holistic satisfaction could be more beneficial, as research suggests it has greater power in predicting customer retention. A survey on

holistic satisfaction could further investigate usage patterns and broader factors, such as performance, strategic prevention, and inspection plans.

8.2 Monitoring churn

Based on the Retention Analysis, there are three key areas to monitor retention actively: Corrective Working Orders, Labor Hours, and Completion Rate.

8.2.1 Monitor corrective work and labor hours

Within corrective tasks, both the number of corrective labor hours and the total corrective labor hours are highly relevant to retention risk. Since an increase in one of these factors will likely lead to a corresponding increase in the other, the compounding effects can significantly impact the risk of churn.

Conducting thorough inspections would help better identify the corrective demand. Highly skilled technicians can be leveraged in this process to more accurately predict potential problems. As one interviewee mentioned, technicians sometimes have the ability to predict facility malfunctions or issues, which can foster trust and satisfaction with the customer. In some cases, it may be beneficial to proactively predict malfunctions and deploy highly skilled technicians to quickly address the corrective work required.

8.2.2 Optimize corrective and preventive efforts

Labor hours are again an influencing factor, specifically the proportion of corrective and preventive effort. Increasing focus on these two tasks can decrease the risk of churn, with the goal now being to optimize the balance between them.

Similar to optimizing the level of urgent service requests, TDGI can proactively adopt approaches to effectively prevent unpredicted corrective problems. As they approach the optimal threshold, TDGI can suggest more frequent preventive work, invest in early warning systems, and leverage technology to predict the possibility of urgent issues.

More frequent inspections would also raise the possibility of detecting malfunctions, which could sustainably boost the corrective rate. Increasing efforts in both preventive planning and detailed corrective work, and communicating this dedication to clients, can help proportionally increase satisfaction as discussed previously. Initiatives focused on proactive preventive planning and comprehensive corrective efforts can allow clients to better perceive the service benefits and value creation, thereby helping to increase retention.

8.2.3 Monitor plan completion rate

It is clear that a higher plan completion rate corresponds to a lower risk of churn. This indicates that clients value TDGI's ability to deliver on the agreed preventive and inspection plan. Therefore, contract managers and technicians should consistently review the plan's completability each month and ensure an adequate workforce to meet the SLA completion rate.

8.2.4 Focus on case by case

Given the low churn rate of 14 customers out of 180 recorded over the past 2 years, it is challenging to develop a comprehensive model to explain and predict churn. This is because any anomaly from the churned customers could significantly impact the model.

Hence, the retention model can be useful as a tool to identify customers at risk of churning based on similar patterns. However, it should not be viewed as a strict instruction on how to prevent churn solely by improving those metrics. Instead, TDGI can take a more personalized approach, focusing on addressing the unique issues of each customer individually.

8.3 Customer health practices

The analyses shed light on the practicality of adopting customer health practices to understand satisfaction and retention. However, due to limitations in data availability, not all aspects of customer health can be investigated. To capitalize on the potential of these practices, TDGI can move forward by integrating more data related to the system to better understand the health of its customer relationships.

Particularly, adopting data on customer relationship measures, such as customer commitment and customer support, could help improve the models. For instance, TDGI could start collecting more holistic customer feedback, not just based on transactions, which would provide deeper insights into how customers perceive their relationship with TDGI.

Additionally, since the main measure of value realization is now to assess how well the plan is executed and the extent to which requirements are met, gathering more data on the aspect would be beneficial. This could include financial metrics on the proportion of service fees relative to the client's cost structure, or qualitative metrics that identify the unique value TDGI provides.

9 Conclusion

9.1 Answers to thesis question

The main research question this study aims to address is "How can client retention be monitored based on CRM and corporate data?" The findings from the study indicate that client retention can be effectively monitored by directly using operational metrics, which have been shown to partially explain and predict both customer satisfaction and the risk of churn.

This statement is supported by two main quantitative analyses. The customer relationship analysis shows that operational data can explain part of the variation in customer relationship metrics. This means that TDGI can infer some aspects of customer satisfaction by tracking operational data within its CRM and corporate systems.

The retention analysis also indicates that operational metrics can significantly explain the risk of churn. It suggests that by regularly monitoring these operational metrics, it is possible to identify clients who are at a higher or lower risk of churning, allowing for proactive measures to be taken.

9.2 Discussion

The study found it successful to adopt the new concept of customer health by embracing the main topics discussed in the framework, while adapting to the available data. It shows that the client can lower their dependence on surveys and instead observe operational metrics to monitor satisfaction and churn rate. Thus, the study justifies the adoptability of customer health into non-digital services, where customer usage data might not be as varied and granular.

The study also indicates that some adaptation is necessary when applying the framework to different service domains. As other previous studies have suggested, factors highly relevant to a particular industry should be considered when applying the framework in other service contexts. For instance, in Tjaden et al.'s adoption of the metrics in metal processing, factors such as machine age and autonomy were particularly relevant to that industry (Tjaden et al., 2023).

In the case of facility management, where interaction between people is involved, especially for TDGI, the engagement between customers and technician staff is a strong driver of satisfaction and retention. The physical interaction between staff and customers should be considered more in the metrics, and when a service company adopts the framework, they should have a good measure to assess this dynamic.

9.3 Limitations

The lack of data on customer relationship, such as signs of support and commitment, limits the adoption of customer health practices in this case. This, in turn, constrains the full understanding of customer health and its predictive power for retention. Additionally, the unavailability of holistic survey results from customers, as suggested by other adoptions of customer health practices, hinders further exploration of the impact of customer relationship on churning.

9.4 Suggestions for future studies

The study suggests that relationship metrics may serve as a mediator between Operational metrics and Retention, given the lower R-squared for the Retention Analysis compared to the Customer Relationship Analysis. Further research could explore integrating customer satisfaction into the churn prediction model, in order to justify the benefits and costs of incorporating customer relationship data into the retention model.

Furthermore, waiting for the Glose system to have a longer recording timeframe would allow for the adoption of additional relevant time-series or panel data. This could help identify usage patterns over time, which could provide further insights. Alternatively, investigating the size of specific customer segments and conducting segment-based analyses might yield higher R-squared values by addressing differences in satisfaction and churn behavior.

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11 Appendix

11.1 Appendix 1: Qualitative analysis – Interview Questions

Compliance

- Como avalia o nível de cumprimento dos requisitos contratuais por parte da TDGI? - How would you rate TDGI's level of compliance with contractual requirements?

- Como descreveria globalmente a sua satisfação com os serviços prestados pela TDGI? - How would you describe your overall satisfaction with the services provided by TDGI?

Communication

- Em que grau consegue a TDGI responder às "reclamações" informais ou oportunidades de melhoria? - How well does TDGI respond to informal “complaints” or opportunities for improvement?

- Usa o software Glose? Qual é o seu nível de satisfação em relação ao software Glose, e porquê? – Do you use the Glose software? How satisfied are you with the Glose software, and why?

- Como avalia as ferramentas e os canais de comunicação utilizados pela TDGI? -How would you assess the tools and communication channels used by TDGI? (email, glose, whatsapp, teams, etc)

- Como descreveria a sua relação com os pontos de contacto da TDGI? - How would you describe your relationship with TDGI's points of contact?

Relationship quality

- Com que frequência considera que a TDGI aborda proactivamente os desafios antes de estes terem impacto nas suas operações? -How often do you feel TDGI proactively addresses challenges before they impact your operations?

- Houve situações em que trabalhar com a TDGI exigiu mais envolvimento ou esforço do que você esperava inicialmente? Se sim, como você se sentiu em relação a esse esforço adicional — ele valeu a pena no final? -Have there been situations where working with TDGI required more involvement or effort than you initially expected (for example: plan or adopt new service)? If so, how did you feel about that extra effort—was it worthwhile?

- Como descreveria a TDGI a um colega que enfrentasse desafios semelhantes de gestão de instalações? -How would you describe TDGI to a peer facing similar facility management challenges?

- Já partilhou comentários sobre a TDGI com outras pessoas do seu sector? Em caso afirmativo, que aspectos destacou? -Have you shared feedback about TDGI with others in your industry? If so, what aspects did you highlight?

- Quais são os fatores mais importantes na hora de decidir continuar um contrato com uma empresa de gestão de instalações? E, por outro lado, o que poderia levá-lo a reconsiderar ou encerrar esse contrato? -What factors are most important to you when deciding to continue a contract with a facilities management provider? And conversely, what would lead you to reconsider or conclude such a contract?

Usage

- Qual o nível de atendimento da TDGI a outras necessidades do cliente? - How well does it meet other customer needs?

- Sente que está aproveitando ao máximo os serviços prestados pela TDGI? (Sim, Parcialmente, Não) Porquê? Extra: Mede a eficiência dos mesmos? Se sim, como costuma medir ou avaliar a eficiência dos serviços que a TDGI oferece? - Do you feel you're making the most of TDGI's services? (yes, not totally, no) Why or why not? Extra: Do you measure their efficiency? How do you currently measure or evaluate the efficiency of the services provided by TDGI?

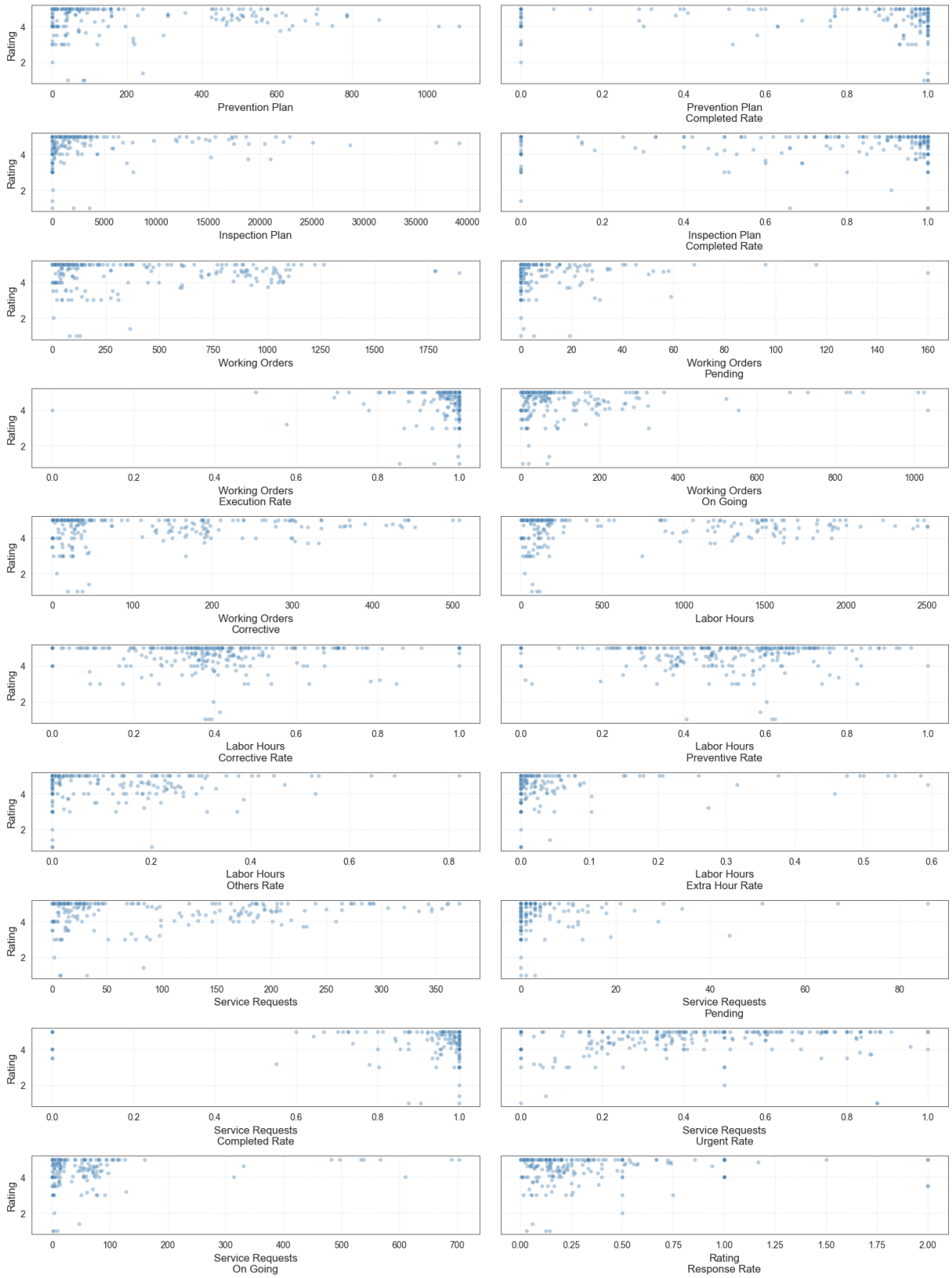
- Que desafios emergentes acredita que vai enfrentar num futuro próximo, na gestão das instalações? - What emerging challenges do you think you will face in the near future in facilities management?

Value creation

- Como é que a TDGI o ajudou a realocar recursos (tempo, orçamento, pessoal) a tarefas de maior prioridade? -How has TDGI helped you reallocate resources (time, budget, staff) to higher-priority tasks?

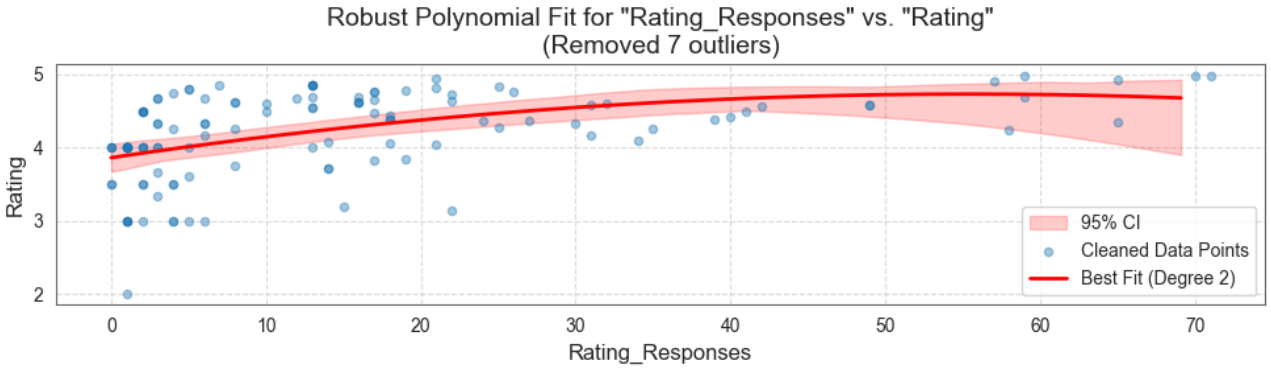
- Gostaria de analisar o impacto dos serviços prestados pela TDGI nos seus KPIs operacionais? -Would you like to analyse the impact of the services provided by TDGI on your operational KPIs? (Retail and Industrial clientes)

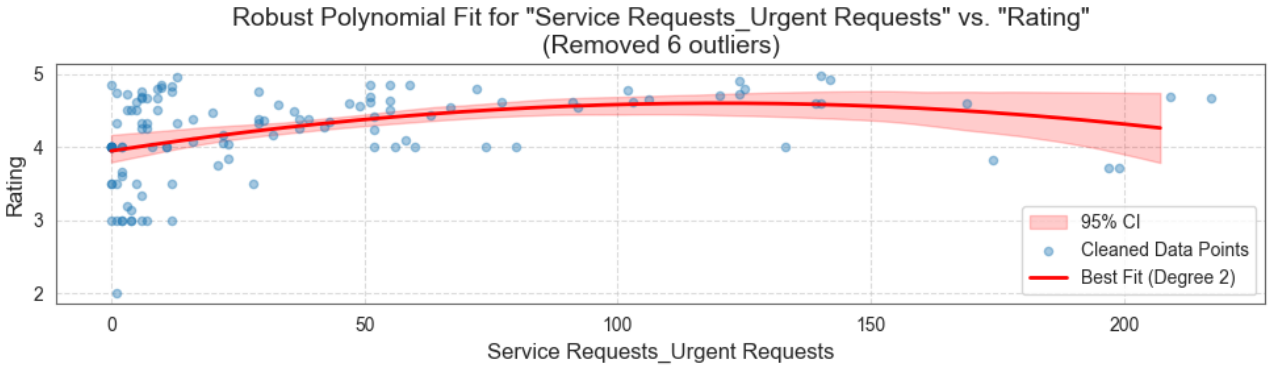
11.2 Appendix 2: Customer Relationship Analysis - Rating by all of the matrixes

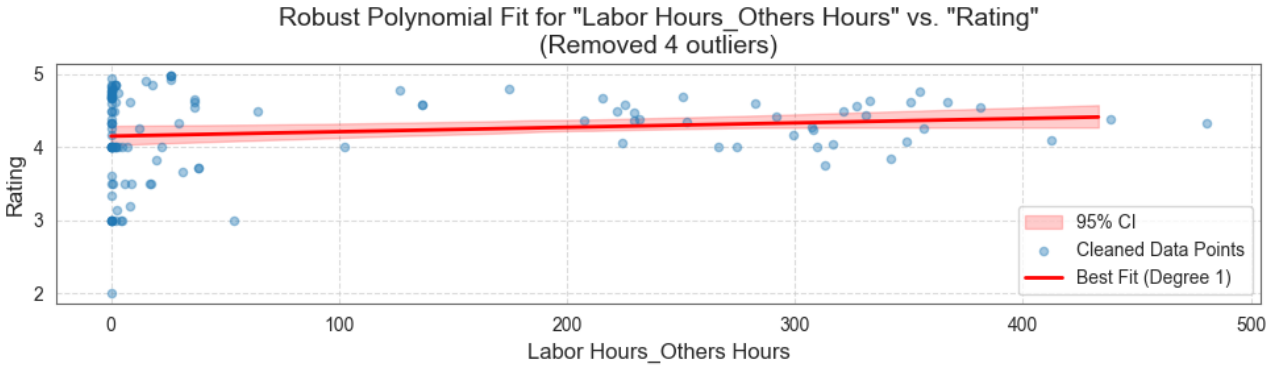


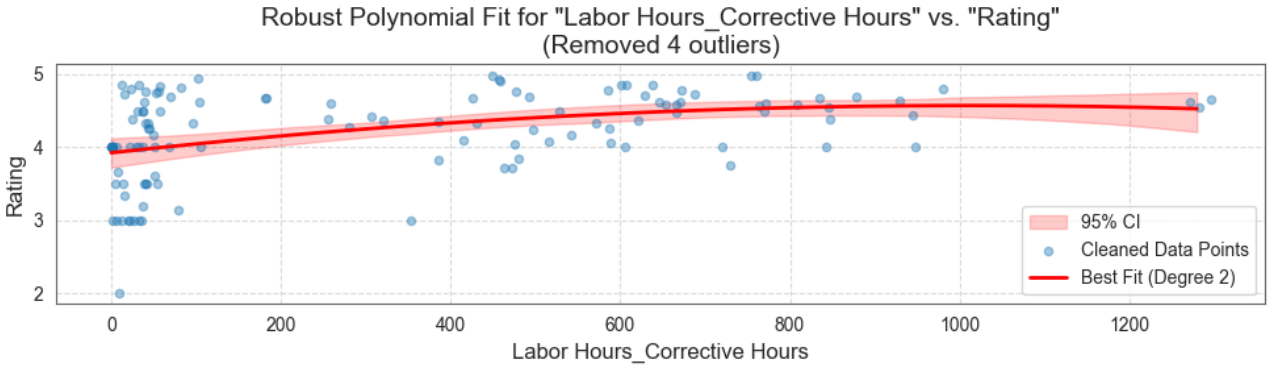

Rating
Rating
Cost Material
Cost Labor
Cost Service
Cost Total
Months since first activity
Total Plan
Total Plan Completed Rate
Labor Hours Preventive Hours
Labor Hours Corrective Hours
Labor Hours Others Hours
Service Requests Urgent Requests
Rating Responses

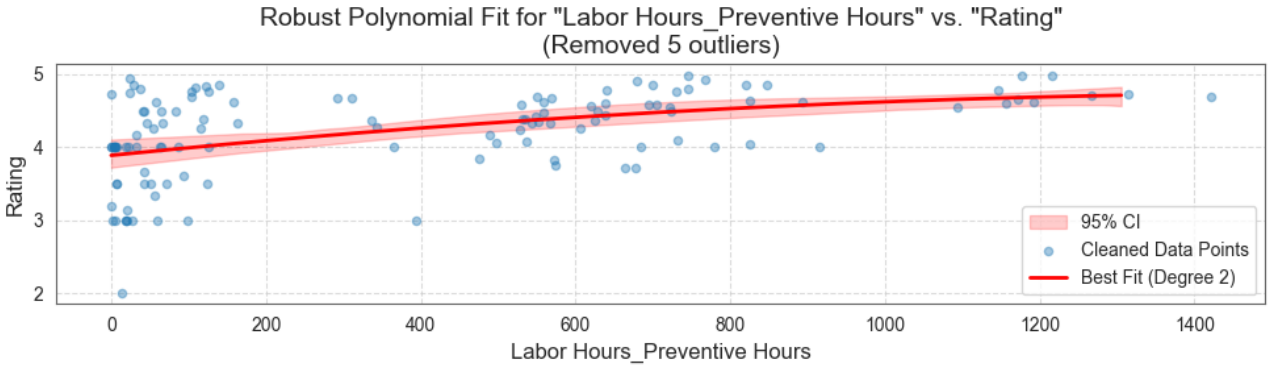
11.3 Appendix 3: Customer Relationship Analysis - Polynomial fit for Rating vs. Other matrixes

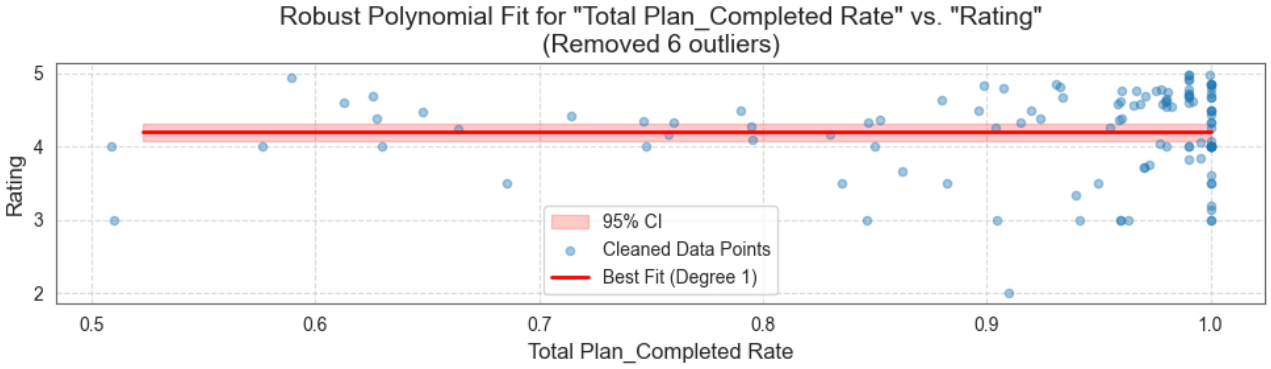


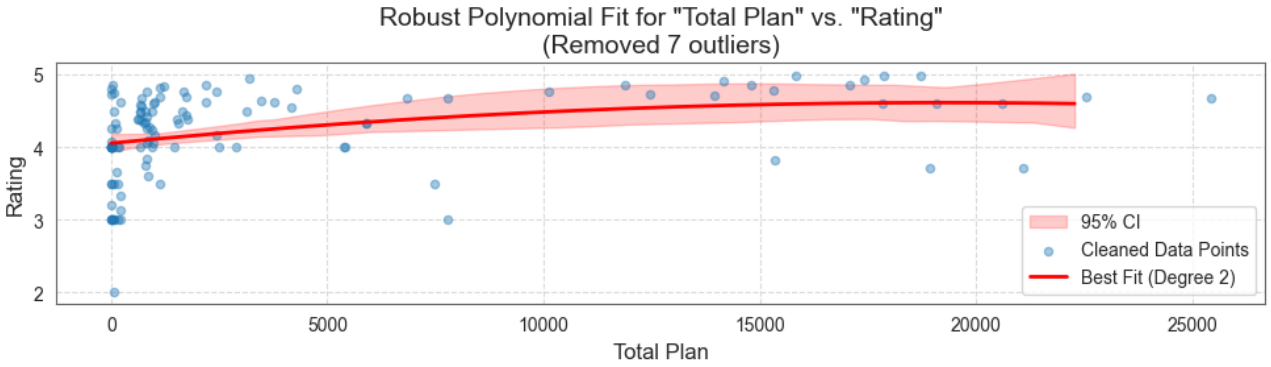


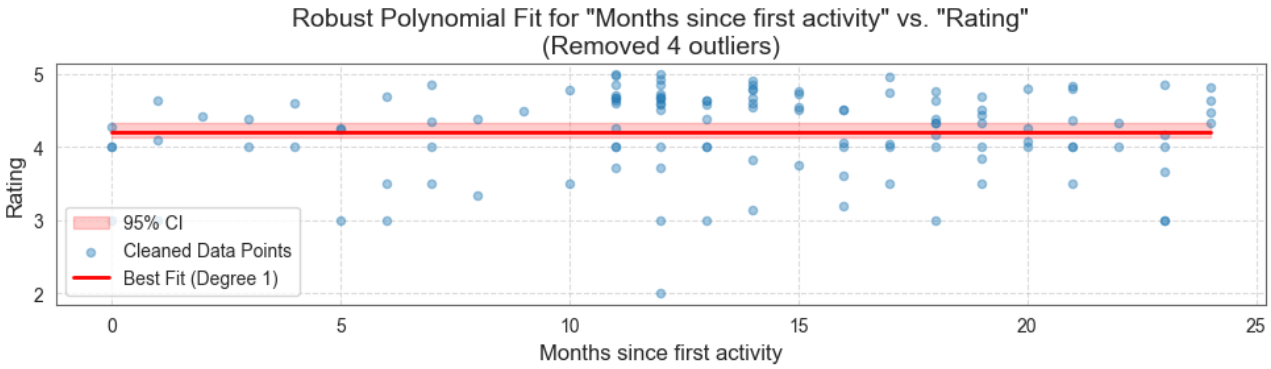





Robust Polynomial Fit for "Labor Hours_Preventive Hours" vs. "Rating"
(Removed 5 outliers)
Rating
Labor Hours_Preventive Hours
95% CI
Cleaned Data Points
Best Fit (Degree 2)


Robust Polynomial Fit for "Total Plan_Completed Rate" vs. "Rating"
(Removed 6 outliers)
Rating
Total Plan_Completed Rate
95% CI
Cleaned Data Points
Best Fit (Degree 1)


Robust Polynomial Fit for "Total Plan" vs. "Rating"
(Removed 7 outliers)
Rating
Total Plan
95% CI
Cleaned Data Points
Best Fit (Degree 2)


Robust Polynomial Fit for "Months since first activity" vs. "Rating"
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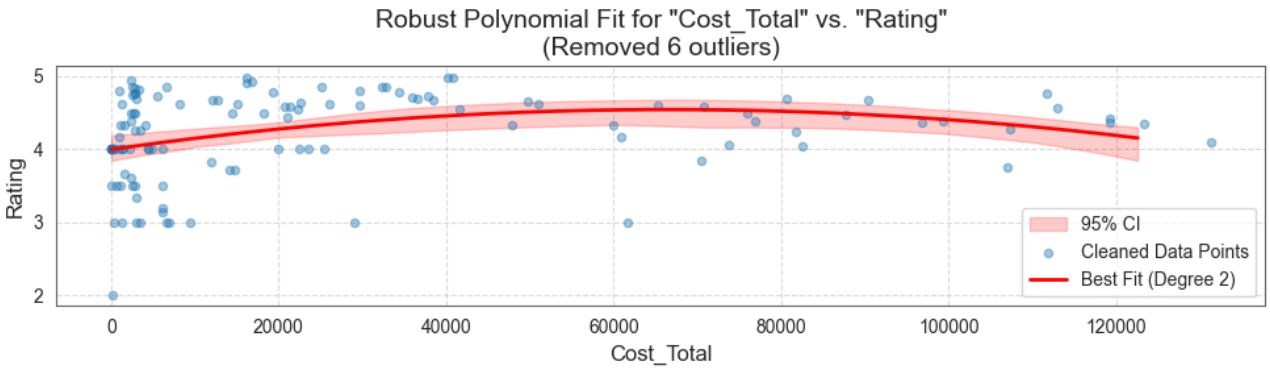
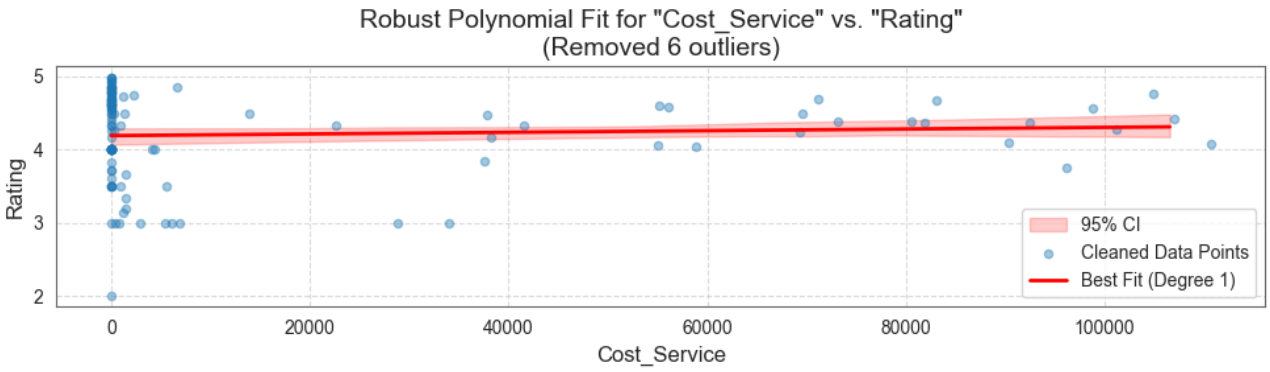
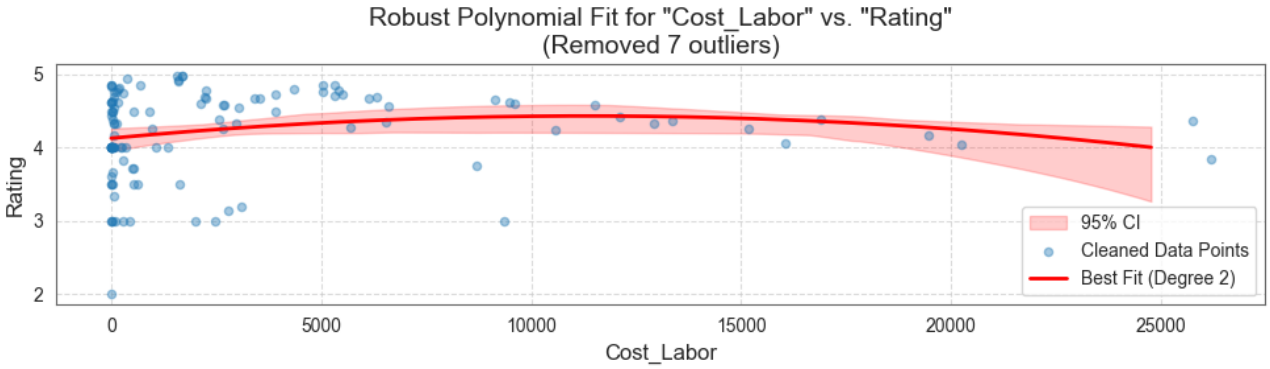
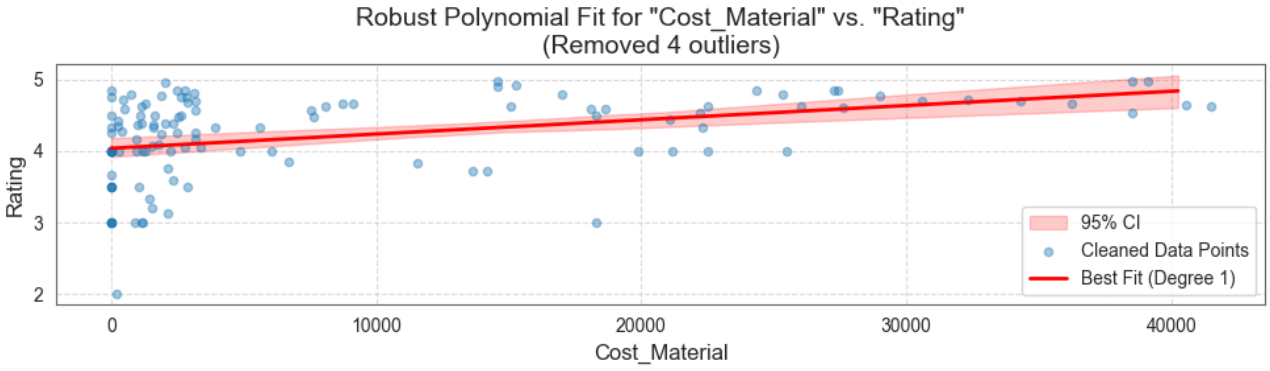
Rating
Months since first activity
95% CI
Cleaned Data Points
Best Fit (Degree 1)

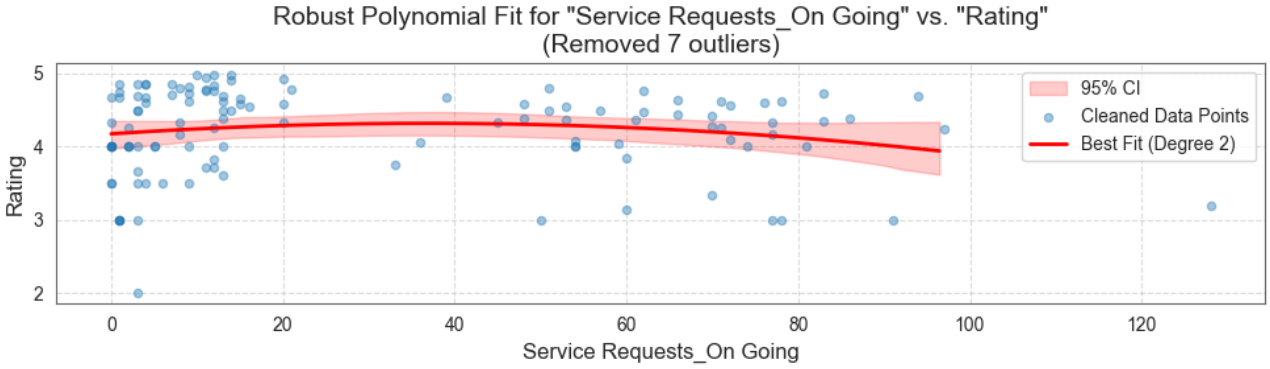

Robust Polynomial Fit for "Cost_Total" vs. "Rating"
(Removed 6 outliers)
Rating
Cost_Total
95% CI
Cleaned Data Points
Best Fit (Degree 2)

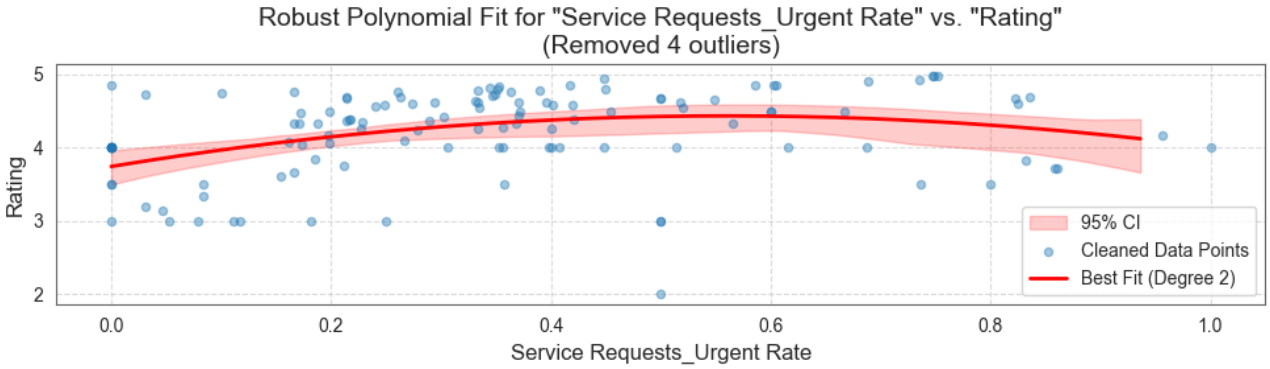

Robust Polynomial Fit for "Cost_Service" vs. "Rating"
(Removed 6 outliers)
Rating
Cost_Service
95% CI
Cleaned Data Points
Best Fit (Degree 1)

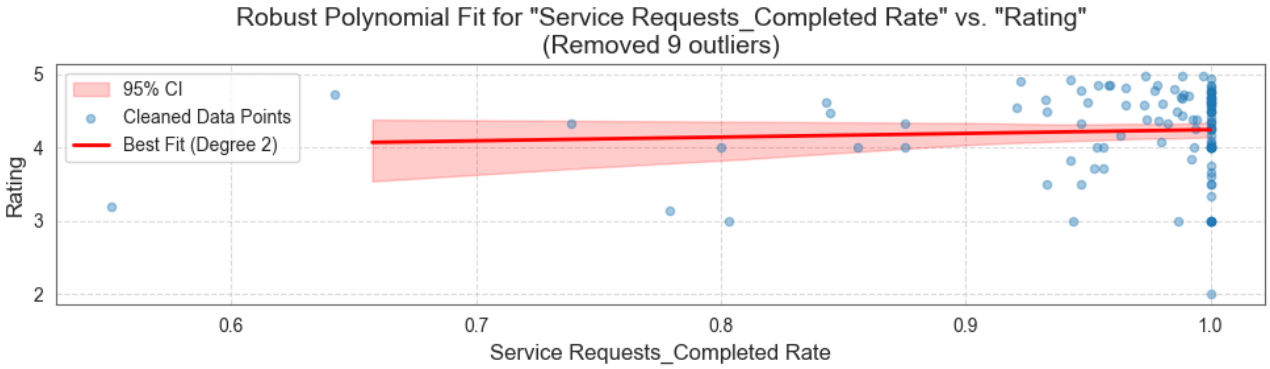

Robust Polynomial Fit for "Cost_Labor" vs. "Rating"
(Removed 7 outliers)
Rating
Cost_Labor
95% CI
Cleaned Data Points
Best Fit (Degree 2)

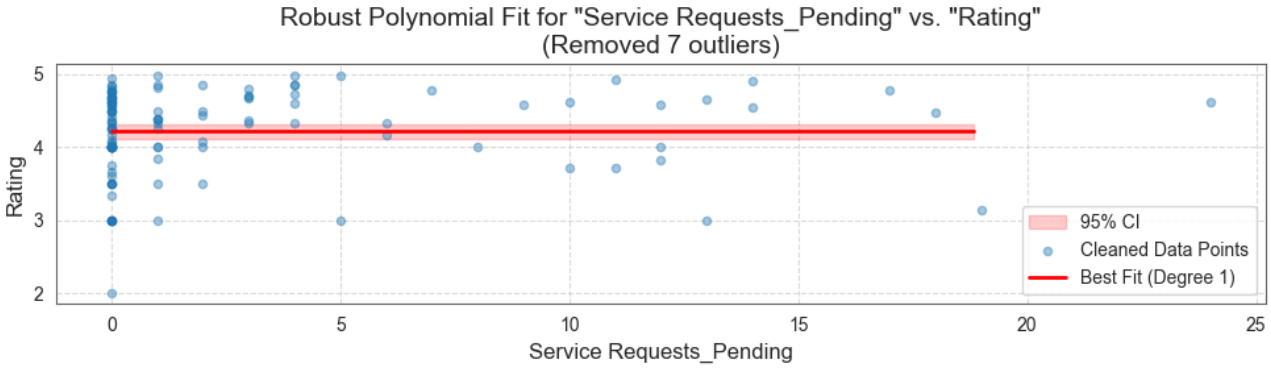

Robust Polynomial Fit for "Cost_Material" vs. "Rating"
(Removed 4 outliers)
Rating
Cost_Material
95% CI
Cleaned Data Points
Best Fit (Degree 1)

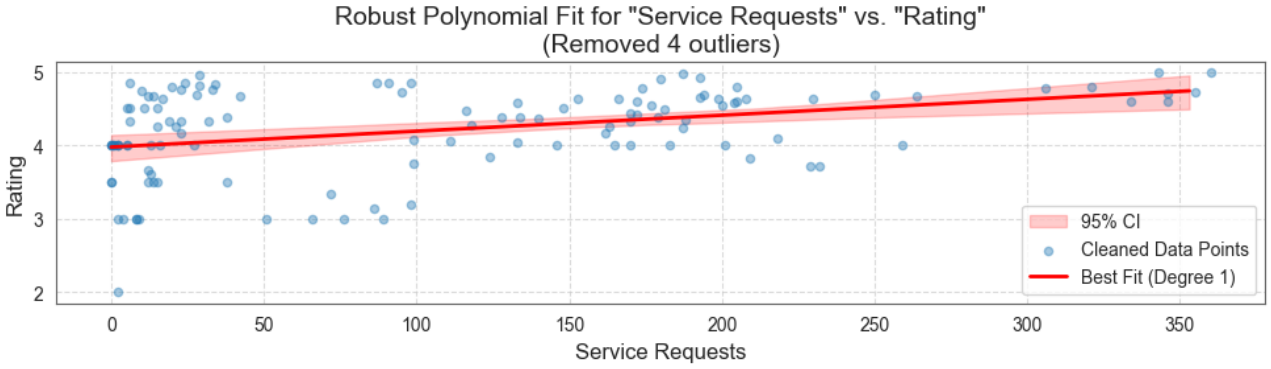

Robust Polynomial Fit for "Rating_Response Rate" vs. "Rating"
(Removed 6 outliers)
Rating
Rating_Response Rate
95% CI
Cleaned Data Points
Best Fit (Degree 1)

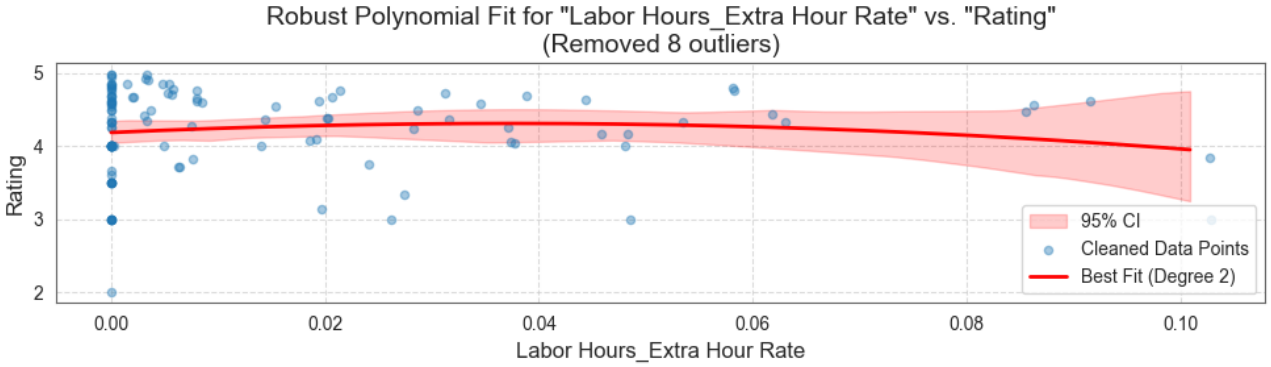

Robust Polynomial Fit for "Service Requests_On Going" vs. "Rating"
(Removed 7 outliers)
Rating
Service Requests_On Going
95% CI
Cleaned Data Points
Best Fit (Degree 2)

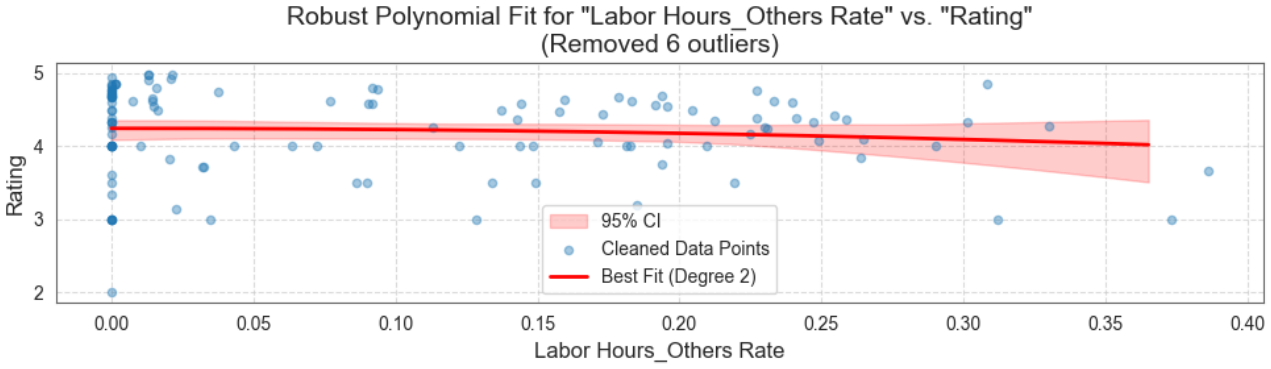

Robust Polynomial Fit for "Service Requests_Urgent Rate" vs. "Rating"
(Removed 4 outliers)
Rating
Service Requests_Urgent Rate
95% CI
Cleaned Data Points
Best Fit (Degree 2)

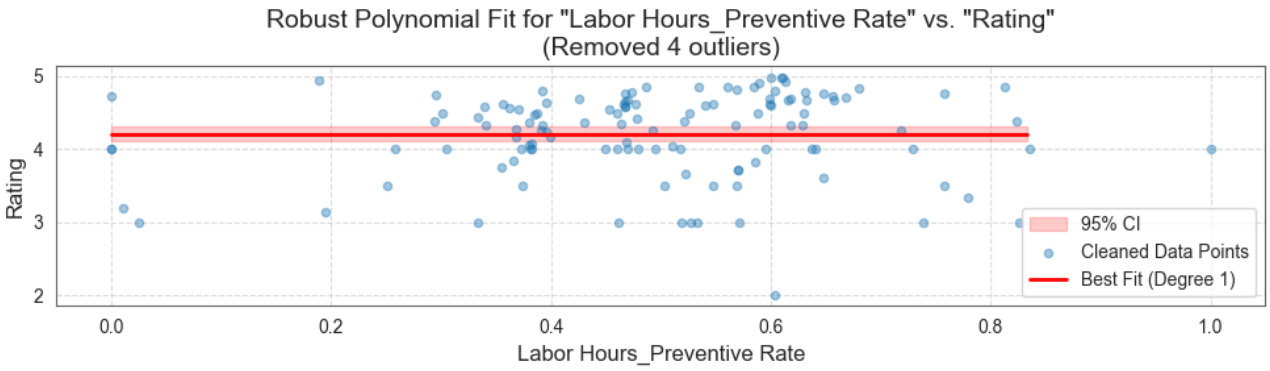

Robust Polynomial Fit for "Service Requests_Completed Rate" vs. "Rating"
(Removed 9 outliers)
Rating
Service Requests_Completed Rate
95% CI
Cleaned Data Points
Best Fit (Degree 2)

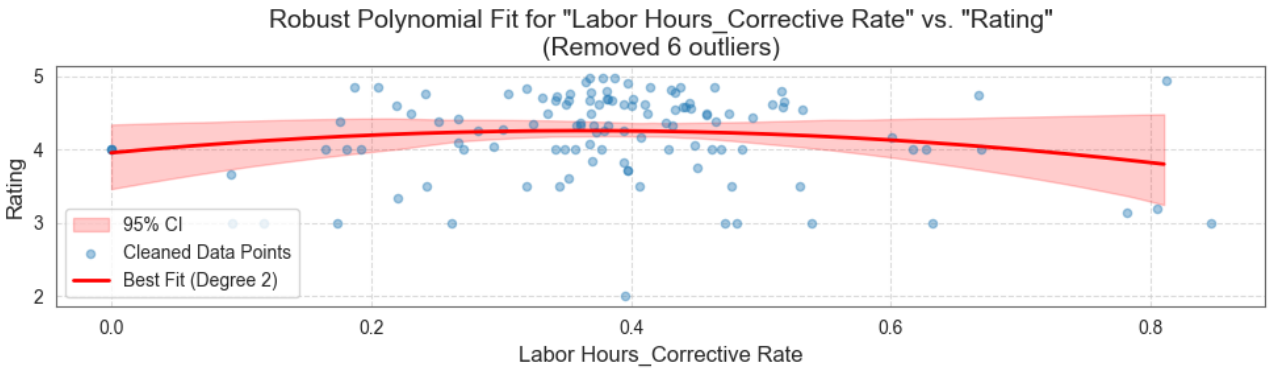

Robust Polynomial Fit for "Service Requests_Pending" vs. "Rating"
(Removed 7 outliers)
Rating
Service Requests_Pending
95% CI
Cleaned Data Points
Best Fit (Degree 1)

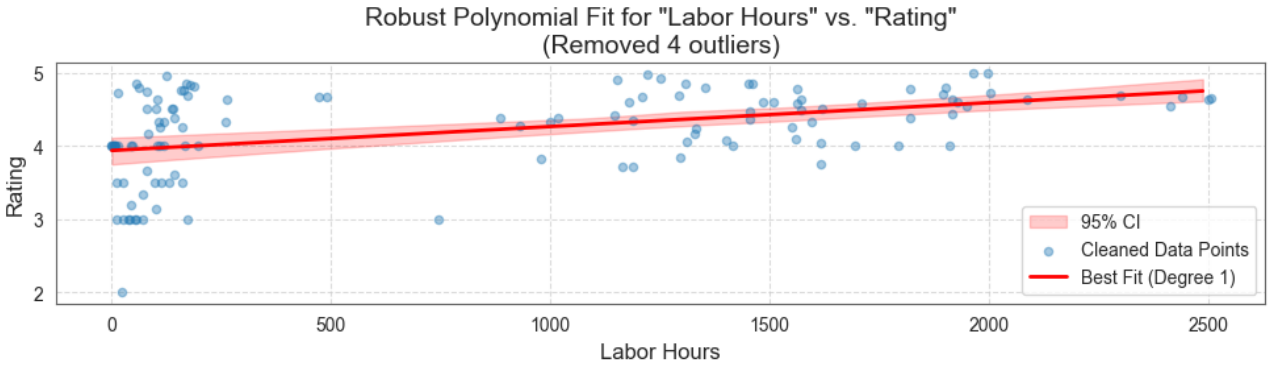

Robust Polynomial Fit for "Service Requests" vs. "Rating"
(Removed 4 outliers)
Rating
Service Requests
95% CI
Cleaned Data Points
Best Fit (Degree 1)

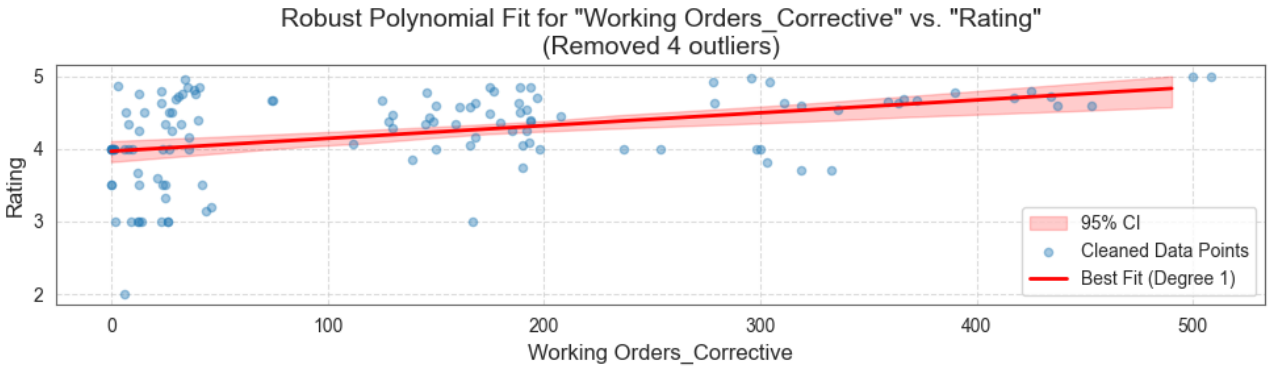

Robust Polynomial Fit for "Labor Hours_Extra Hour Rate" vs. "Rating"
(Removed 8 outliers)
Rating
Labor Hours_Extra Hour Rate
95% CI
Cleaned Data Points
Best Fit (Degree 2)

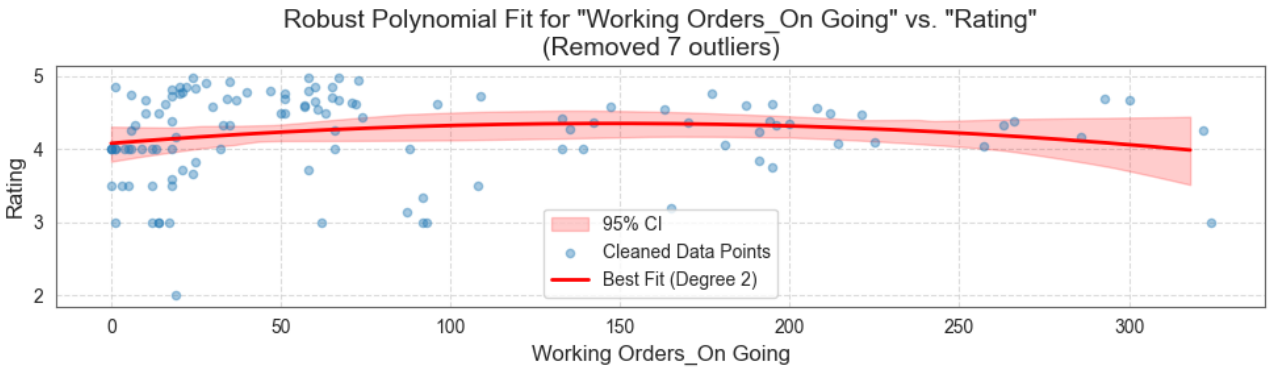

Robust Polynomial Fit for "Labor Hours_Others Rate" vs. "Rating"
(Removed 6 outliers)
Rating
Labor Hours_Others Rate
95% CI
Cleaned Data Points
Best Fit (Degree 2)

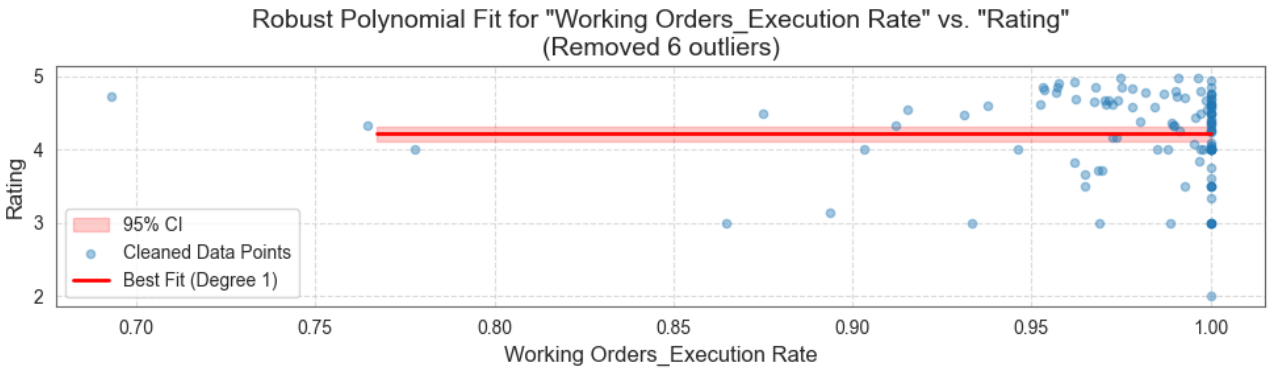

Robust Polynomial Fit for "Labor Hours_Preventive Rate" vs. "Rating"
(Removed 4 outliers)
Rating
Labor Hours_Preventive Rate
95% CI
Cleaned Data Points
Best Fit (Degree 1)

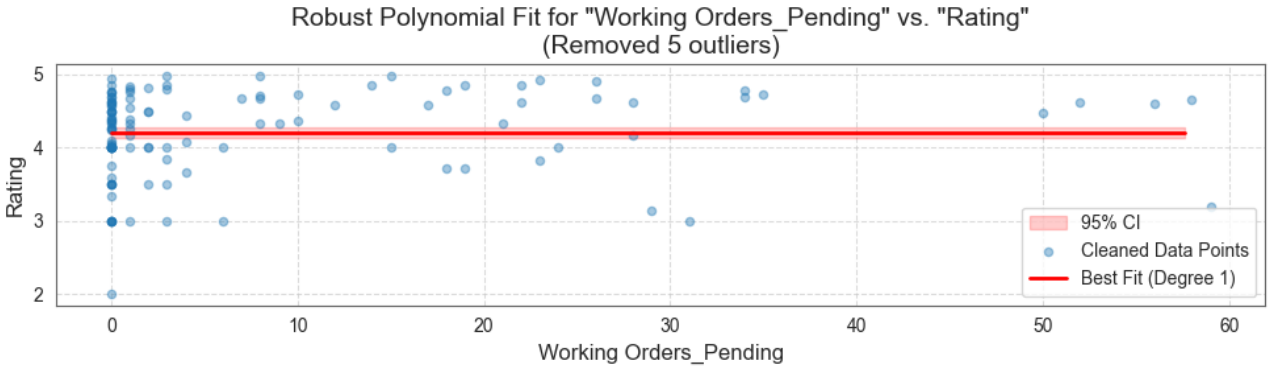

Robust Polynomial Fit for "Labor Hours_Corrective Rate" vs. "Rating"
(Removed 6 outliers)
Rating
Labor Hours_Corrective Rate
95% CI
Cleaned Data Points
Best Fit (Degree 2)

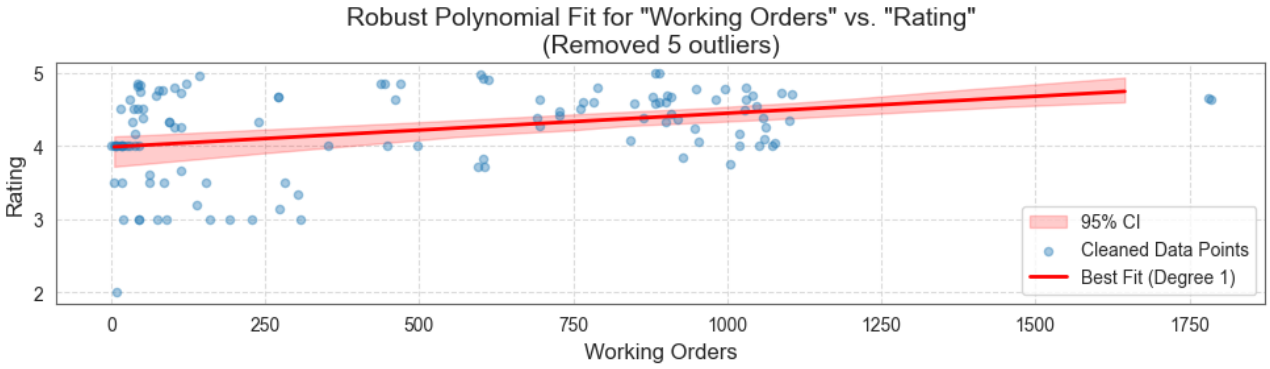

Robust Polynomial Fit for "Labor Hours" vs. "Rating"
(Removed 4 outliers)
Rating
Labor Hours
95% CI
Cleaned Data Points
Best Fit (Degree 1)

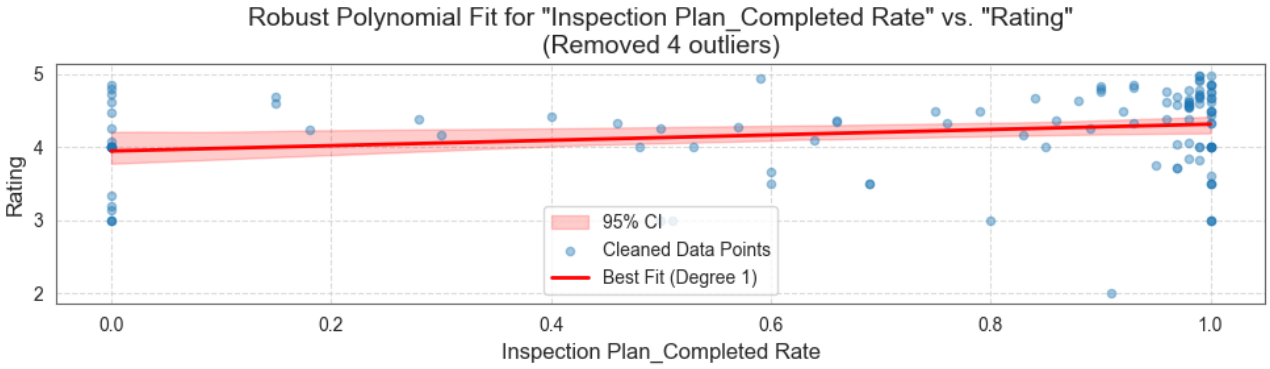

Robust Polynomial Fit for "Working Orders_Corrective" vs. "Rating"
(Removed 4 outliers)
Rating
Working Orders_Corrective
95% CI
Cleaned Data Points
Best Fit (Degree 1)

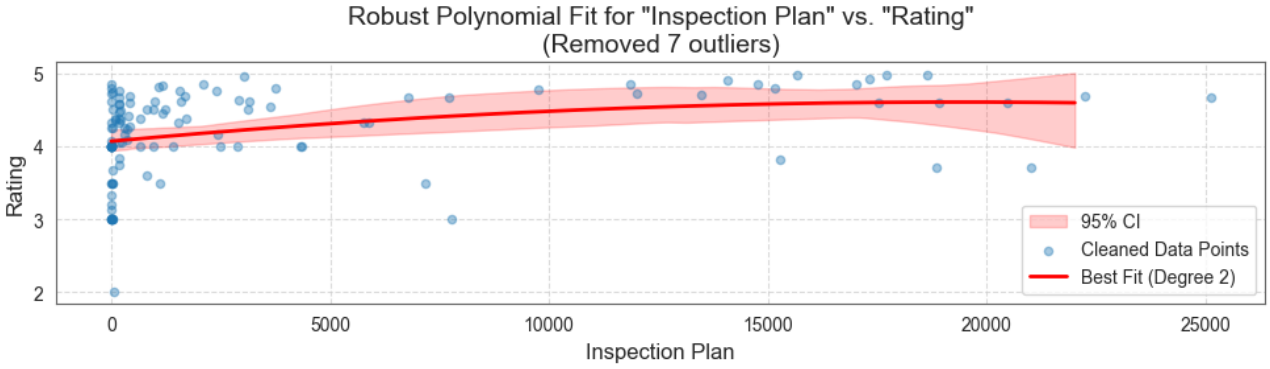

Robust Polynomial Fit for "Working Orders_On Going" vs. "Rating"
(Removed 7 outliers)
Rating
Working Orders_On Going
95% CI
Cleaned Data Points
Best Fit (Degree 2)

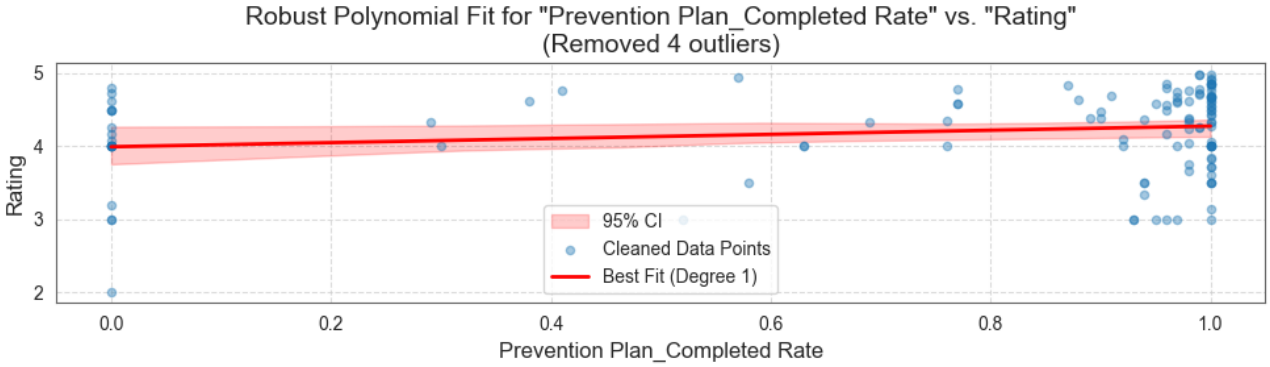

Robust Polynomial Fit for "Working Orders_Execution Rate" vs. "Rating"
(Removed 6 outliers)
Rating
Working Orders_Execution Rate
95% CI
Cleaned Data Points
Best Fit (Degree 1)

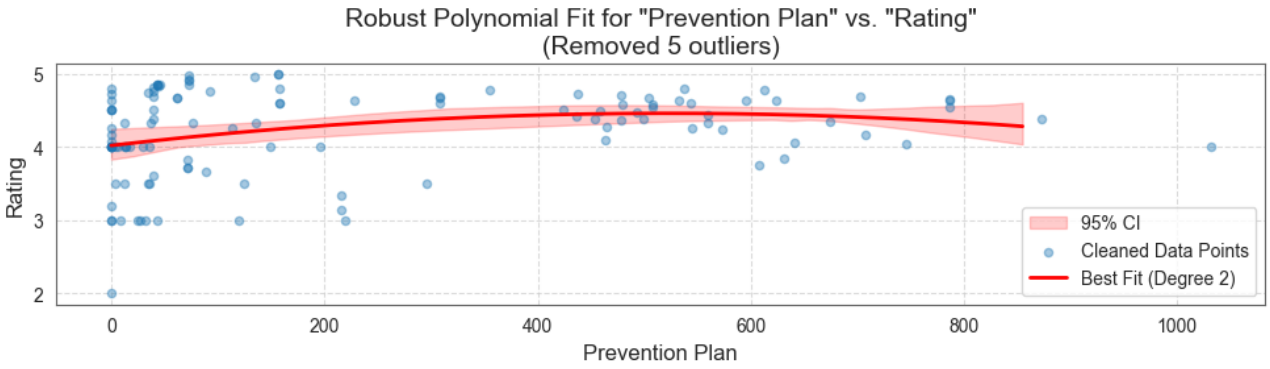

Robust Polynomial Fit for "Working Orders_Pending" vs. "Rating"
(Removed 5 outliers)
Rating
Working Orders_Pending
95% CI
Cleaned Data Points
Best Fit (Degree 1)


Robust Polynomial Fit for "Working Orders" vs. "Rating"
(Removed 5 outliers)
Rating
Working Orders
95% CI
Cleaned Data Points
Best Fit (Degree 1)


Robust Polynomial Fit for "Inspection Plan_Completed Rate" vs. "Rating"
(Removed 4 outliers)
Rating
Inspection Plan_Completed Rate
95% CI
Cleaned Data Points
Best Fit (Degree 1)


Robust Polynomial Fit for "Inspection Plan" vs. "Rating"
(Removed 7 outliers)
Rating
Inspection Plan
95% CI
Cleaned Data Points
Best Fit (Degree 2)

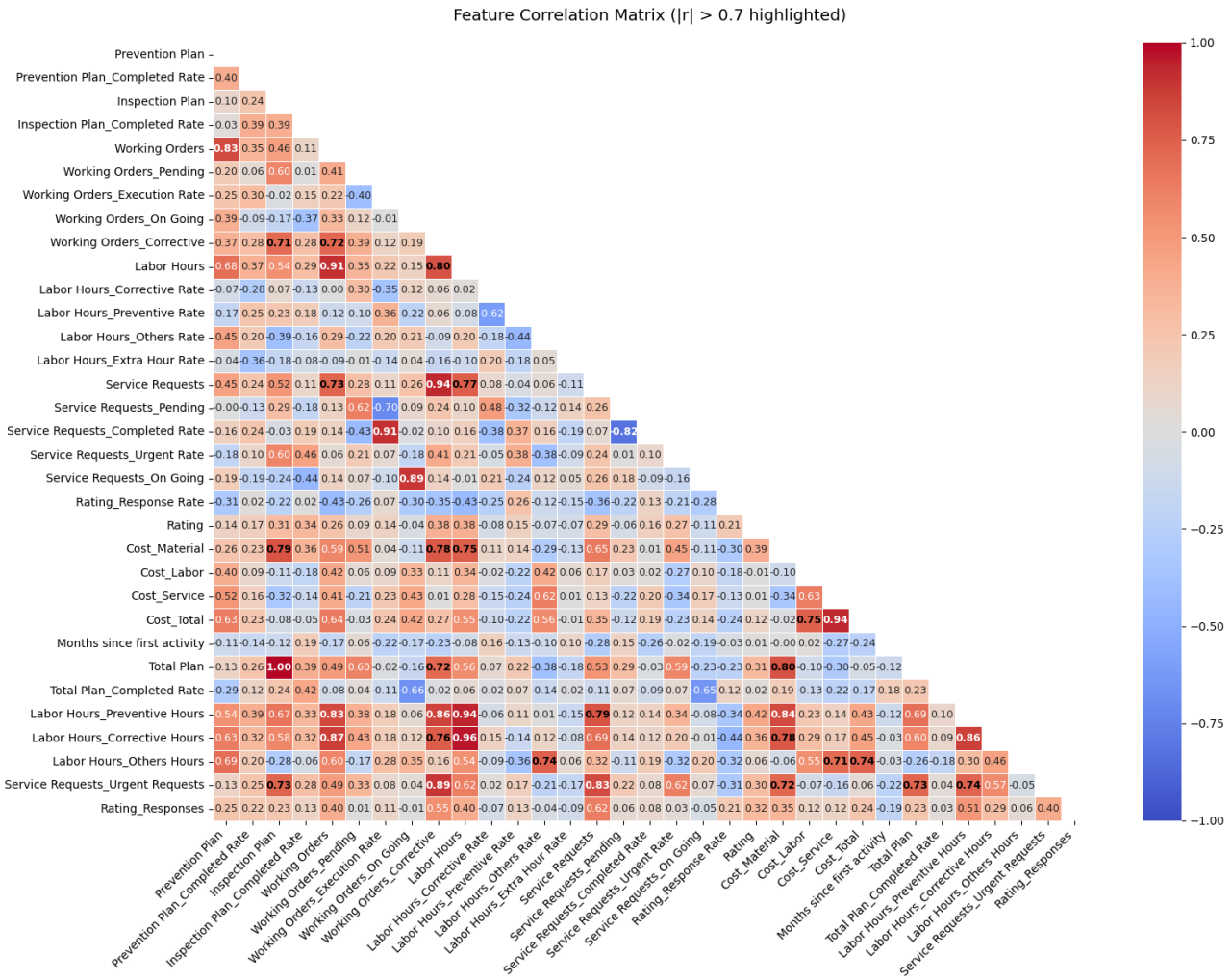

Robust Polynomial Fit for "Prevention Plan_Completed Rate" vs. "Rating"
(Removed 4 outliers)
Rating
Prevention Plan_Completed Rate
95% CI
Cleaned Data Points
Best Fit (Degree 1)


Robust Polynomial Fit for "Prevention Plan" vs. "Rating"
(Removed 5 outliers)
Rating
Prevention Plan
95% CI
Cleaned Data Points
Best Fit (Degree 2)

```
========================================
Optimized Regression Results Summary
========================================
```

Feature	Best MAE	Best MSE	Best Degree	Best Alpha	Outliers Removed
Rating	0.0000	0.0000	2	1.68e-06	4
Rating_Responses	0.4134	0.2707	2	4.15e-03	7
Labor Hours_Preventive Hours	0.3934	0.2720	2	1.68e-06	5
Labor Hours	0.4011	0.2751	1	2.07e-06	4
Labor Hours_Corrective Hours	0.4070	0.2795	2	1.19e-03	4
Service Requests_Urgent Requests	0.4022	0.2814	2	1.06e-02	6
Working Orders_Corrective	0.4082	0.2860	1	6.29e-03	4
Cost_Material	0.4106	0.2866	1	2.74e-03	4
Service Requests	0.4151	0.2941	1	2.74e-03	4
Service Requests_Urgent Rate	0.4243	0.2963	2	1.46e-03	4
Working Orders	0.4356	0.3072	1	2.74e-03	5
Total Plan	0.4293	0.3122	2	2.70e-02	7
Cost_Total	0.4310	0.3127	2	3.78e-04	6
Inspection Plan	0.4325	0.3151	2	2.70e-02	7
Inspection Plan_Completed Rate	0.4455	0.3203	1	1.63e-03	4
Prevention Plan	0.4330	0.3243	2	1.68e-06	5
Labor Hours_Others Hours	0.4624	0.3326	1	6.29e-03	4
Working Orders_Execution Rate	0.4614	0.3364	1	7.40e+01	6
Rating_Response Rate	0.4614	0.3369	1	7.40e+01	6
Prevention Plan_Completed Rate	0.4614	0.3370	1	2.74e-03	4
Labor Hours_Preventive Rate	0.4669	0.3378	1	7.40e+01	4
Months since first activity	0.4669	0.3378	1	7.40e+01	4
Service Requests_On Going	0.4662	0.3385	2	5.67e-03	7
Service Requests_Pending	0.4656	0.3391	1	7.40e+01	7
Labor Hours_Extra Hour Rate	0.4657	0.3392	2	1.68e-06	8
Labor Hours_Corrective Rate	0.4596	0.3392	2	1.98e-02	6
Service Requests_Completed Rate	0.4619	0.3407	2	5.61e-02	9
Working Orders_Pending	0.4693	0.3413	1	7.40e+01	5
Cost_Labor	0.4556	0.3414	2	1.06e-02	7
Cost_Service	0.4706	0.3435	1	2.07e-06	6
Labor Hours_Others Rate	0.4698	0.3437	2	1.78e-02	6
Working Orders_On Going	0.4606	0.3459	2	1.68e-06	7
Total Plan_Completed Rate	0.4734	0.3473	1	7.40e+01	6

11.4 Appendix 4: Customer Relationship Analysis - Features Correlation Matrix



Top Correlated Feature Pairs (absolute correlation > 0.7):

- Inspection Plan & Total Plan: Correlation = 1.00 (Abs: 1.00)

- Labor Hours & Labor Hours_Corrective Hours: Correlation = 0.96 (Abs: 0.96)

- Labor Hours & Labor Hours_Preventive Hours: Correlation = 0.94 (Abs: 0.94)

- Cost_Service & Cost_Total: Correlation = 0.94 (Abs: 0.94)

- Working Orders_Corrective & Service Requests: Correlation = 0.94 (Abs: 0.94)

- Working Orders & Labor Hours: Correlation = 0.91 (Abs: 0.91)

- Working Orders_Execution Rate & Service Requests_Completed Rate: Correlation = 0.91 (Abs: 0.91)

- Working Orders_On Going & Service Requests_On Going: Correlation = 0.89 (Abs: 0.89)

- Working Orders_Corrective & Service Requests_Urgent Requests: Correlation = 0.89 (Abs: 0.89)

- Working Orders & Labor Hours_Corrective Hours: Correlation = 0.87 (Abs: 0.87)

- Labor Hours_Preventive Hours & Labor Hours_Corrective Hours: Correlation = 0.86 (Abs: 0.86)

- Working Orders_Corrective & Labor Hours_Preventive Hours: Correlation = 0.86 (Abs: 0.86)

- Cost_Material & Labor Hours_Preventive Hours: Correlation = 0.84 (Abs: 0.84)

- Working Orders & Labor Hours_Preventive Hours: Correlation = 0.83 (Abs: 0.83)

- Prevention Plan & Working Orders: Correlation = 0.83 (Abs: 0.83)

- Service Requests & Service Requests_Urgent Requests: Correlation = 0.83 (Abs: 0.83)

- Service Requests_Pending & Service Requests_Completed Rate: Correlation = -0.82 (Abs: 0.82)

- Working Orders_Corrective & Labor Hours: Correlation = 0.80 (Abs: 0.80)

- Cost_Material & Total Plan: Correlation = 0.80 (Abs: 0.80)

- Service Requests & Labor Hours_Preventive Hours: Correlation = 0.79 (Abs: 0.79)

- Inspection Plan & Cost_Material: Correlation = 0.79 (Abs: 0.79)

- Working Orders_Corrective & Cost_Material: Correlation = 0.78 (Abs: 0.78)

- Cost_Material & Labor Hours_Corrective Hours: Correlation = 0.78 (Abs: 0.78)

- Labor Hours & Service Requests: Correlation = 0.77 (Abs: 0.77)

- Working Orders_Corrective & Labor Hours_Corrective Hours: Correlation = 0.76 (Abs: 0.76)

- Labor Hours & Cost_Material: Correlation = 0.75 (Abs: 0.75)

- Cost_Labor & Cost_Total: Correlation = 0.75 (Abs: 0.75)

- Labor Hours_Others Rate & Labor Hours_Others Hours: Correlation = 0.74 (Abs: 0.74)

- Labor Hours_Preventive Hours & Service Requests_Urgent Requests: Correlation = 0.74 (Abs: 0.74)

- Cost_Total & Labor Hours_Others Hours: Correlation = 0.74 (Abs: 0.74)

- Total Plan & Service Requests_Urgent Requests: Correlation = 0.73 (Abs: 0.73)

- Inspection Plan & Service Requests_Urgent Requests: Correlation = 0.73 (Abs: 0.73)

- Working Orders & Service Requests: Correlation = 0.73 (Abs: 0.73)

- Cost_Material & Service Requests_Urgent Requests: Correlation = 0.72 (Abs: 0.72)

- Working Orders & Working Orders_Corrective: Correlation = 0.72 (Abs: 0.72)

- Working Orders_Corrective & Total Plan: Correlation = 0.72 (Abs: 0.72)

- Cost_Service & Labor Hours_Others Hours: Correlation = 0.71 (Abs: 0.71)

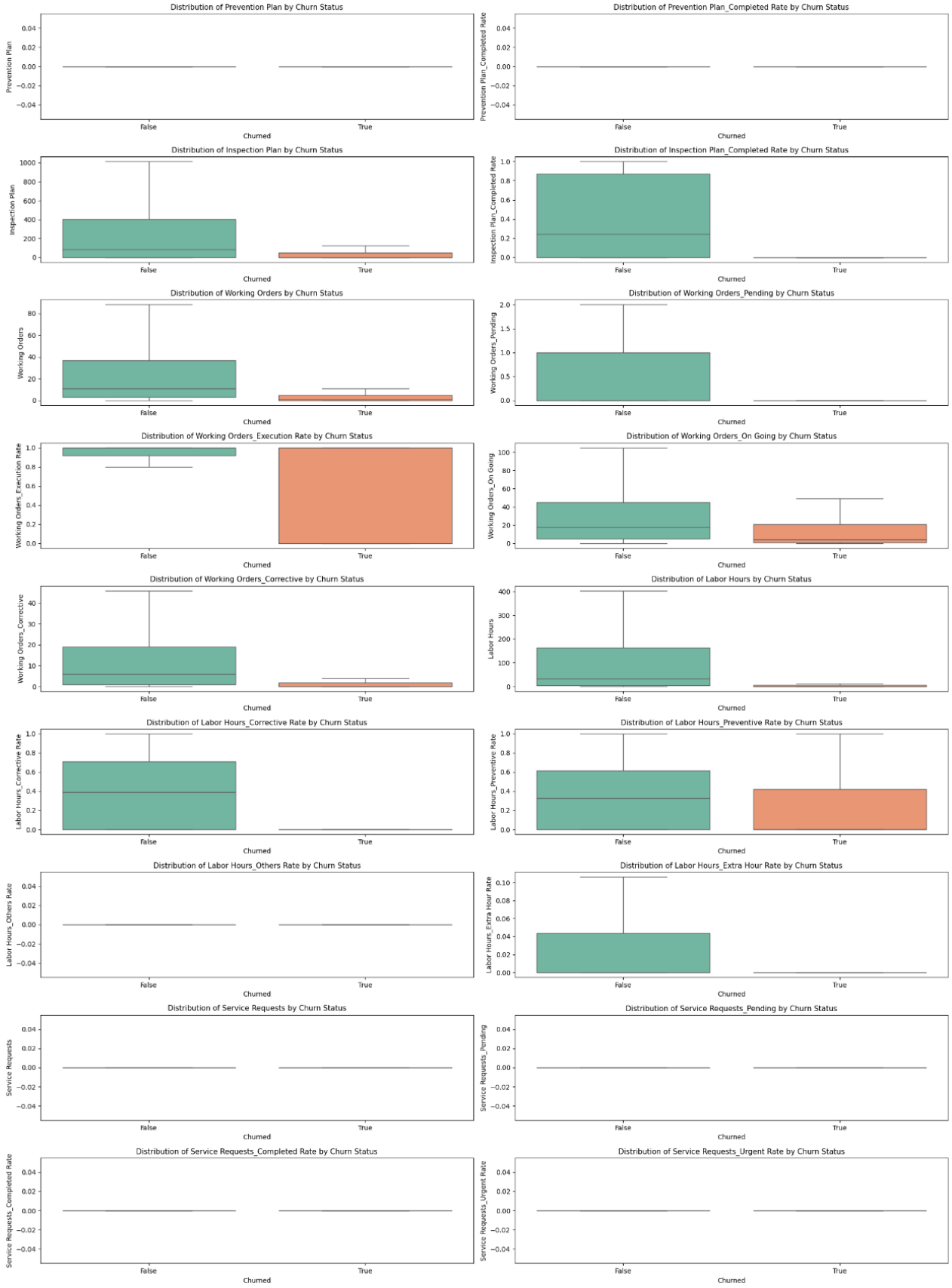
- Inspection Plan & Working Orders_Corrective: Correlation = 0.71 (Abs: 0.71)

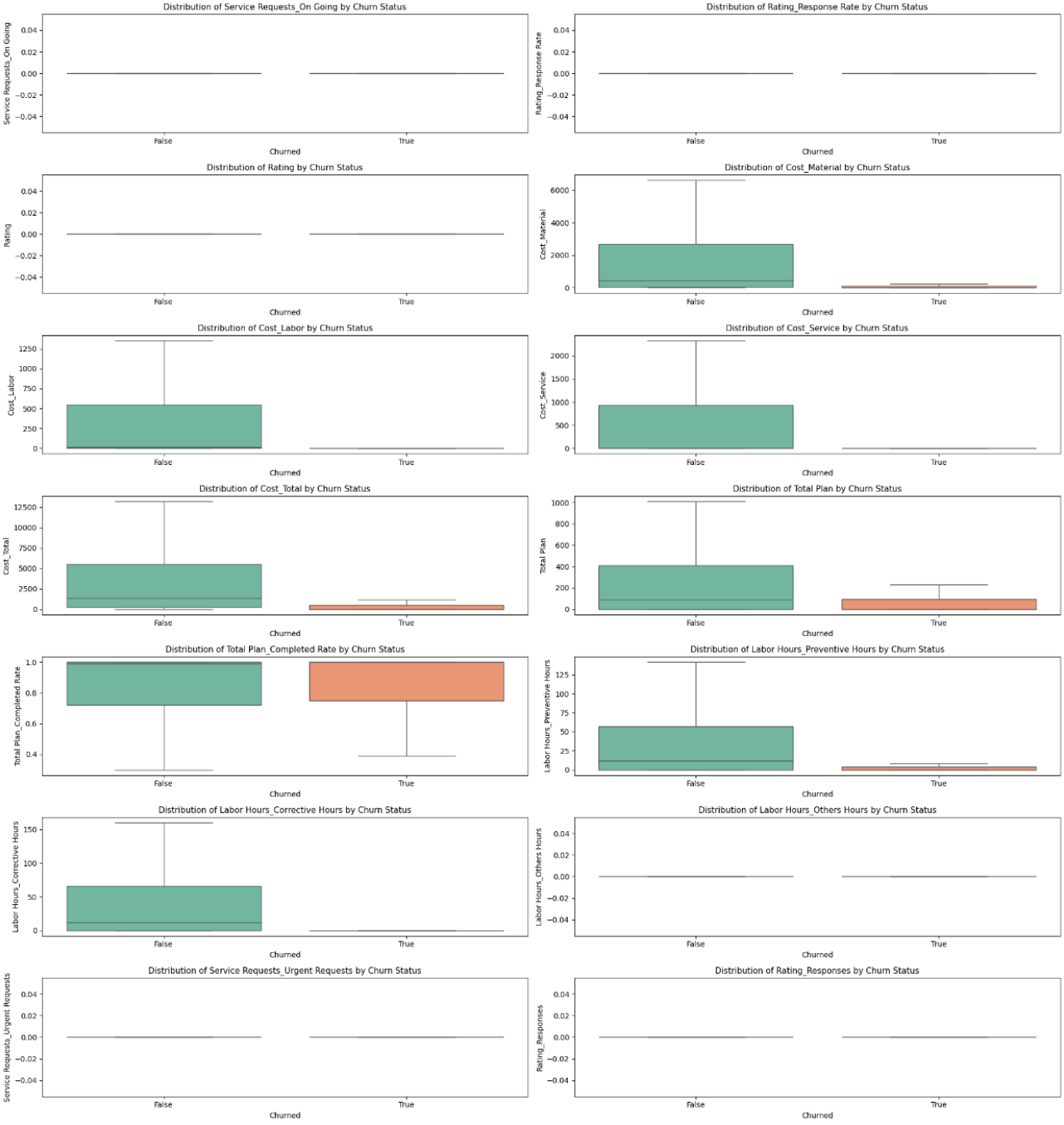
- Working Orders_Execution Rate & Service Requests_Pending: Correlation = -0.70 (Abs: 0.70)

11.5 Appendix 5: Customer Relationship Analysis - Rating OLS results

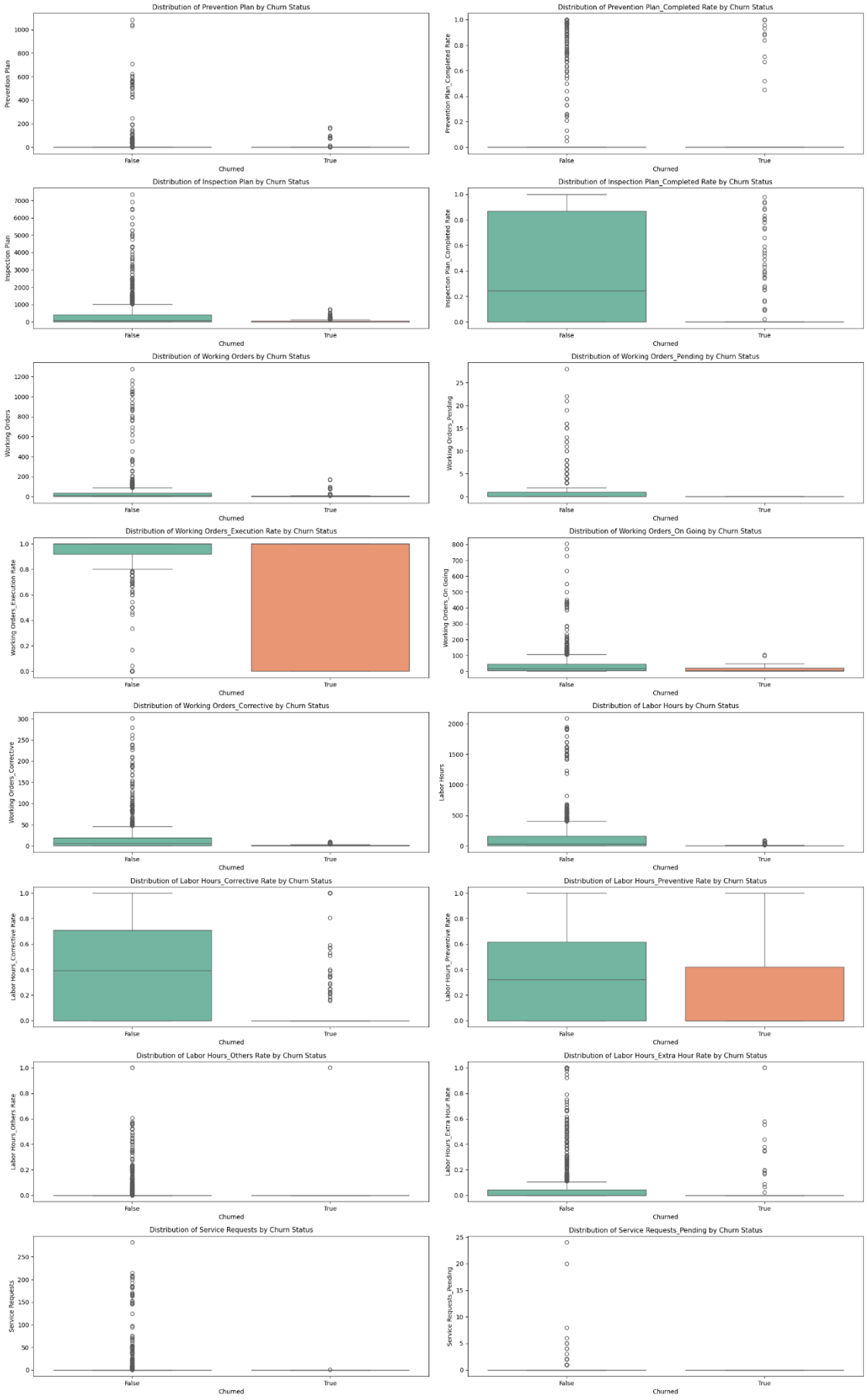
```
Correlation between Service Requests_Urgent Rate and Service Requests_Urgent Rate_deg2: 0.96

Variance Inflation Factors (VIF):
                          Feature        VIF
1  Service Requests_Urgent Rate_deg2  14.454977
0       Service Requests_Urgent Rate  14.278694
3                      Cost_Material   4.702201
2                    Inspection Plan   3.619193
4                        Labor Hours   2.612820
5           Rating_Response Rate_log   1.265018

=== Polynomial Relationship Analysis ===
Service Requests_Urgent Rate: inverted U-shaped relationship, vertex at ~0.60 SD units

=== Linear Relationships ===
Service Requests_Urgent Rate        | Coef:  0.6180 per SD unit
Inspection Plan                     | Coef: -0.0390 per SD unit
Cost_Material                       | Coef:  0.1192 per SD unit
Labor Hours                         | Coef:  0.1705 per SD unit
Rating_Response Rate_log            | Coef:  0.2423 per SD unit

Model Summary:
                            OLS Regression Results
==============================================================================
Dep. Variable:                 Rating   R-squared:                       0.476
Model:                            OLS   Adj. R-squared:                  0.443
Method:                 Least Squares   F-statistic:                     12.32
Date:                Sun, 01 Jun 2025   Prob (F-statistic):           3.05e-10
Time:                        10:39:09   Log-Likelihood:                -44.730
No. Observations:                 103   AIC:                             103.5
Df Residuals:                      96   BIC:                             121.9
Df Model:                           6
Covariance Type:                  HC3
=================================================================================================
                                    coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------------------------
const                             4.3171      0.040    108.973      0.000       4.239       4.395
Service Requests_Urgent Rate      0.6180      0.200      3.090      0.002       0.226       1.010
Service Requests_Urgent Rate_deg2  -0.5172      0.174     -2.979      0.003      -0.857      -0.177
Inspection Plan                  -0.0390      0.057     -0.689      0.491      -0.150       0.072
Cost_Material                     0.1192      0.068      1.748      0.080      -0.014       0.253
Labor Hours                       0.1705      0.059      2.867      0.004       0.054       0.287
Rating_Response Rate_log          0.2423      0.053      4.551      0.000       0.138       0.347
==============================================================================
Omnibus:                       18.498   Durbin-Watson:                   1.846
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               41.947
Skew:                          -0.631   Prob(JB):                     7.79e-10
Kurtosis:                       5.860   Cond. No.                         9.74
==============================================================================

Notes:
[1] Standard Errors are heteroscedasticity robust (HC3)

Significant Factors (p < 0.05):
const                               | Coef:   4.317 | p-value: 0.0000
Rating_Response Rate_log            | Coef:   0.242 | p-value: 0.0000
Service Requests_Urgent Rate        | Coef:   0.618 | p-value: 0.0020
Service Requests_Urgent Rate_deg2   | Coef:  -0.517 | p-value: 0.0029
Labor Hours                         | Coef:   0.171 | p-value: 0.0041
```

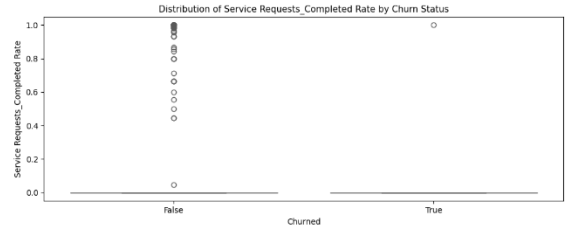
11.6 Appendix 6: Retention Analysis - Boxplots by churn status

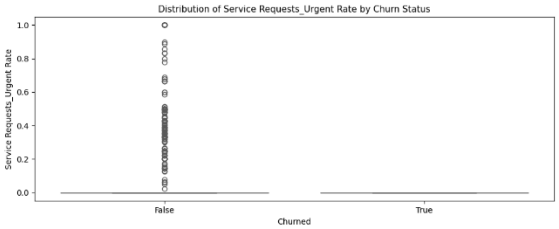


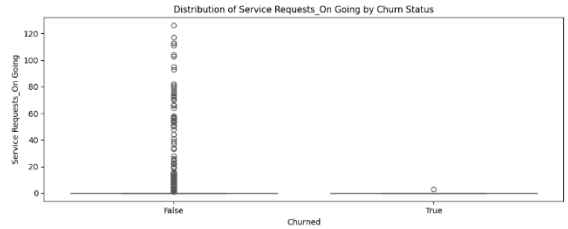

Distribution of Service Requests_On Going by Churn Status
Service Requests_On Going
Distribution of Rating_Response Rate by Churn Status
Rating_Response Rate
Distribution of Rating by Churn Status
Rating
Distribution of Cost_Material by Churn Status
Cost_Material
Distribution of Cost_Labor by Churn Status
Cost_Labor
Distribution of Cost_Service by Churn Status
Cost_Service
Distribution of Cost_Total by Churn Status
Cost_Total
Distribution of Total Plan by Churn Status
Total Plan
Distribution of Total Plan_Completed Rate by Churn Status
Total Plan_Completed Rate
Distribution of Labor Hours_Preventive Hours by Churn Status
Labor Hours_Preventive Hours
Distribution of Labor Hours_Corrective Hours by Churn Status
Labor Hours_Corrective Hours
Distribution of Labor Hours_Others Hours by Churn Status
Labor Hours_Others Hours
Distribution of Service Requests_Urgent Requests by Churn Status
Service Requests_Urgent Requests
Distribution of Rating_Responses by Churn Status
Rating_Responses
False
True
Churned

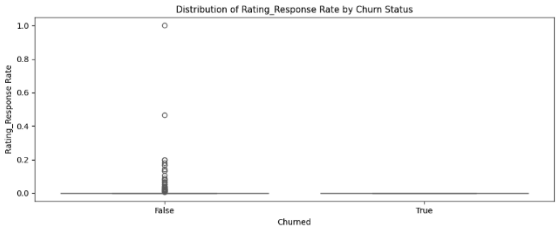
Distributions with outliers:

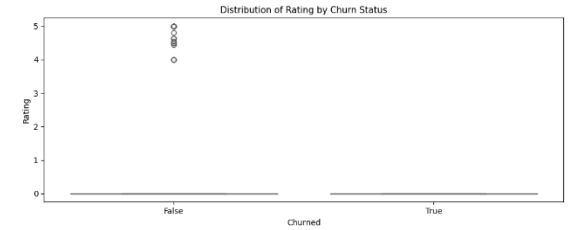


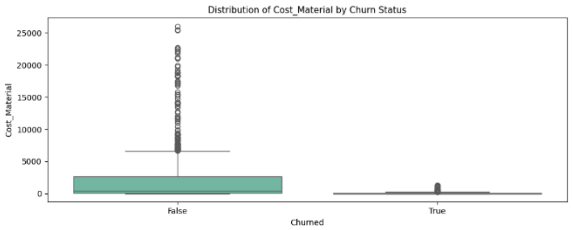

Distribution of Service Requests_Completed Rate by Churn Status
Service Requests_Completed Rate
Churned
False
True

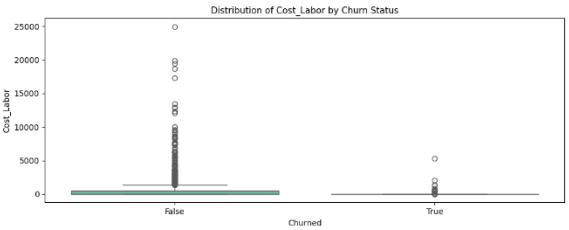

Distribution of Service Requests_Urgent Rate by Churn Status
Service Requests_Urgent Rate
Churned
False
True

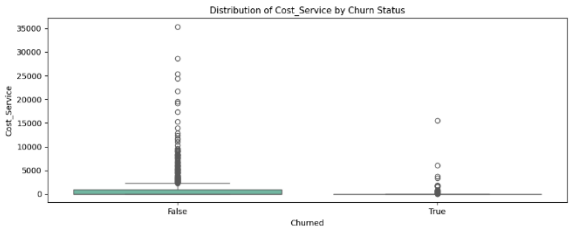

Distribution of Service Requests_On Going by Churn Status
Service Requests_On Going
Churned
False
True

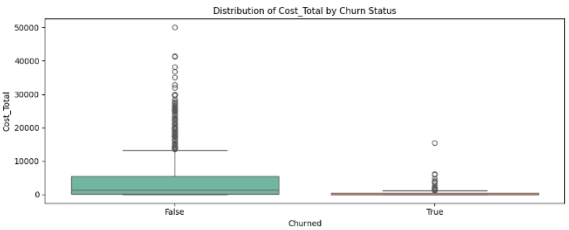

Distribution of Rating_Response Rate by Churn Status
Rating_Response Rate
Churned
False
True

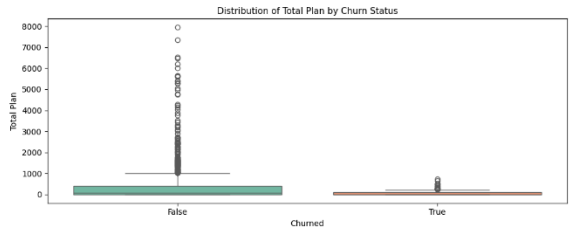

Distribution of Rating by Churn Status
Rating
Churned
False
True

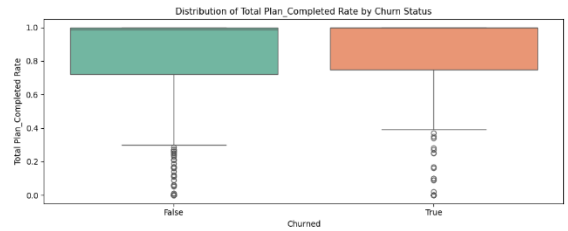

Distribution of Cost_Material by Churn Status
Cost_Material
Churned
False
True

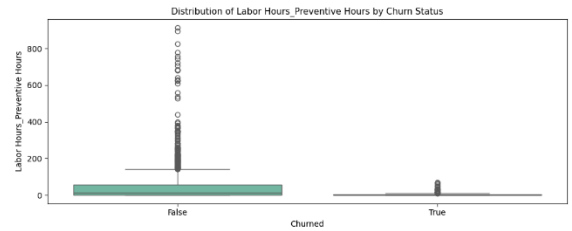

Distribution of Cost_Labor by Churn Status
Cost_Labor
Churned
False
True

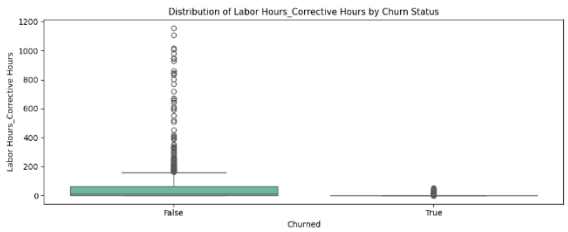

Distribution of Cost_Service by Churn Status
Cost_Service
Churned
False
True

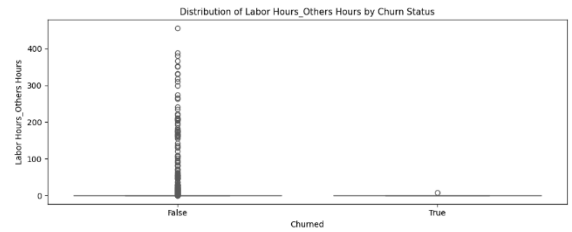

Distribution of Cost_Total by Churn Status
Cost_Total
Churned
False
True

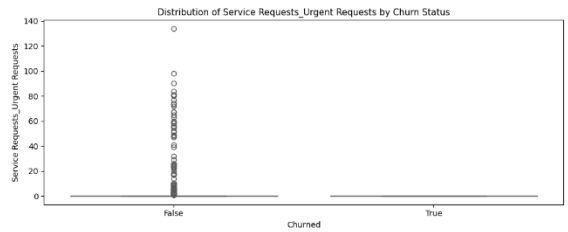

Distribution of Total Plan by Churn Status
Total Plan
Churned
False
True

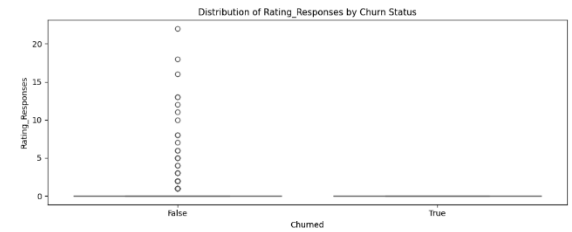

Distribution of Total Plan_Completed Rate by Churn Status
Total Plan_Completed Rate
Churned
False
True


Distribution of Labor Hours_Preventive Hours by Churn Status
Labor Hours_Preventive Hours
Churned
False
True


Distribution of Labor Hours_Corrective Hours by Churn Status
Labor Hours_Corrective Hours
Churned
False
True

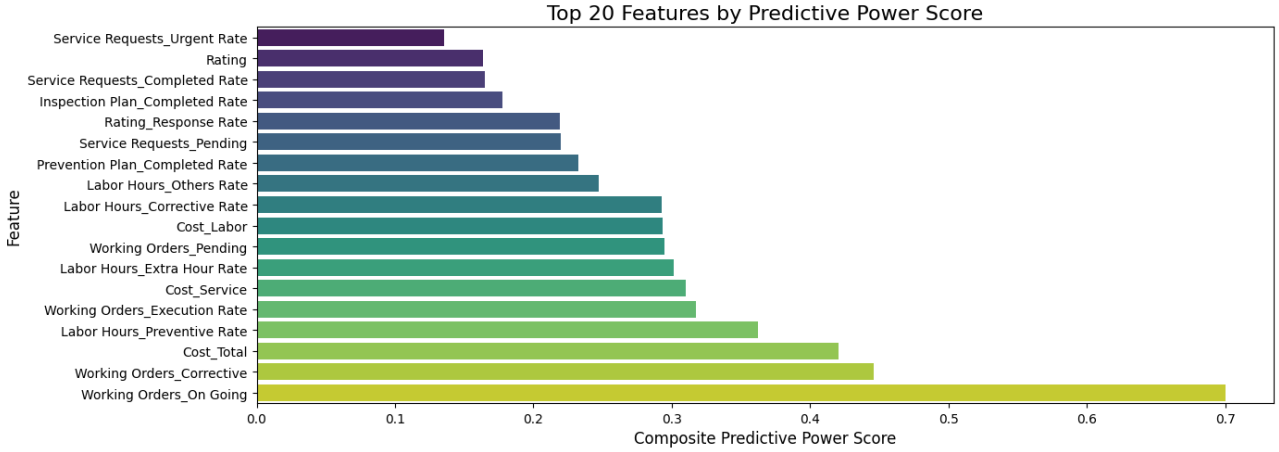

Distribution of Labor Hours_Others Hours by Churn Status
Labor Hours_Others Hours
Churned
False
True

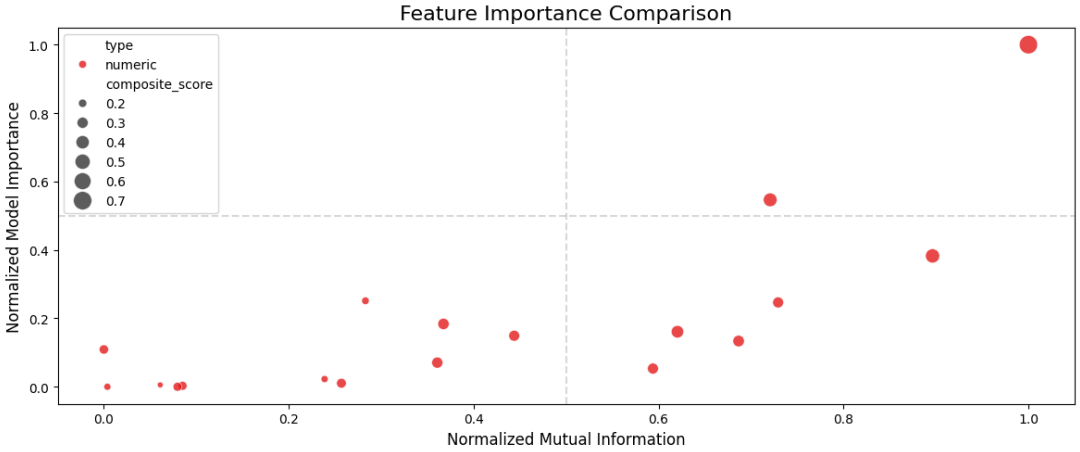

Distribution of Service Requests_Urgent Requests by Churn Status
Service Requests_Urgent Requests
Churned
False
True


Distribution of Rating_Responses by Churn Status
Rating_Responses
Churned
False
True

11.7 Appendix 7: Retention Analysis - Feature Importance Analysis

```
Calculating univariate statistics...
Calculating mutual information...
Training Random Forest for feature importance...
```






```
Top Predictive Features:
                         feature     type  composite_score  mutual_info  \
4          Working Orders_On Going  numeric         0.700045     0.103625
5        Working Orders_Corrective  numeric         0.445837     0.092877
17                     Cost_Total  numeric         0.420556     0.074678
7     Labor Hours_Preventive Rate  numeric         0.362120     0.064288
2   Working Orders_Execution Rate  numeric         0.317652     0.071139
16                   Cost_Service  numeric         0.309966     0.038062
9     Labor Hours_Extra Hour Rate  numeric         0.301624     0.037371
3           Working Orders_Pending  numeric         0.294432     0.061540
15                    Cost_Labor  numeric         0.293384     0.045990
6     Labor Hours_Corrective Rate  numeric         0.292747     0.075569

    importance     t_p_value
4     0.300399  1.858622e-06
5     0.114895  1.511903e-09
17    0.164170  3.987666e-12
7     0.048346  7.521949e-07
2     0.040157  3.913944e-19
16    0.055201  7.688325e-04
9     0.021231  1.167122e-02
3     0.015998  2.763207e-06
15    0.044825  2.441130e-05
6     0.074069  1.705299e-22
```

```
--- Comprehensive Feature Power Analysis Results ---
                           feature     type  t_statistic     t_p_value  \
4           Working Orders_On Going  numeric    -4.794397  1.858622e-06
5         Working Orders_Corrective  numeric    -6.095673  1.511903e-09
17                      Cost_Total  numeric    -7.016845  3.987666e-12
7       Labor Hours_Preventive Rate  numeric    -4.976543  7.521949e-07
2     Working Orders_Execution Rate  numeric    -9.108530  3.913944e-19
16                     Cost_Service  numeric    -3.373339  7.688325e-04
9       Labor Hours_Extra Hour Rate  numeric    -2.526212  1.167122e-02
3            Working Orders_Pending  numeric    -4.712586  2.763207e-06
15                     Cost_Labor  numeric    -4.238519  2.441130e-05
6       Labor Hours_Corrective Rate  numeric    -9.978202  1.705299e-22
8           Labor Hours_Others Rate  numeric    -2.797835  5.235582e-03
0    Prevention Plan_Completed Rate  numeric    -1.376072  1.690832e-01
12         Service Requests_Pending  numeric    -1.362452  1.733376e-01
14            Rating_Response Rate  numeric    -1.282000  2.001163e-01
1    Inspection Plan_Completed Rate  numeric    -8.649220  1.837431e-17
10  Service Requests_Completed Rate  numeric    -5.309613  1.331777e-07
13                          Rating  numeric    -2.476139  1.343271e-02
11    Service Requests_Urgent Rate  numeric    -4.167713  3.321321e-05

    u_statistic     u_p_value  cohens_d  churned_mean  not_churned_mean  \
4       48228.5  3.787896e-13 -0.524810     12.271605         44.021598
5       30154.5  1.976352e-34 -0.676507      1.450617         19.968683
17      30808.5  2.455935e-33 -0.763918    537.598765       4358.610151
7       52214.5  1.702435e-10 -0.413848      0.213057          0.362230
2       66286.0  7.377096e-03 -0.638868      0.604938          0.864459
16      54344.5  4.640749e-10 -0.345987    308.240741       1115.427646
9       56108.0  6.143697e-10 -0.235403      0.034308          0.073294
3       52164.0  8.260078e-16 -0.523820      0.000000          0.889849
15      44840.0  1.223840e-18 -0.462953     95.574074        867.669546
6       36720.0  1.922795e-26 -0.925919      0.120276          0.418788
8       60173.0  1.335273e-09 -0.255926      0.006173          0.028917
0       71888.5  1.283989e-01 -0.124066      0.066975          0.098769
12      72090.0  1.076717e-02 -0.151441      0.000000          0.122030
14      72252.0  1.328984e-02 -0.142499      0.000000          0.004034
1       47383.5  6.030396e-16 -0.856296      0.106049          0.399590
10      63253.5  1.193687e-07 -0.578853      0.006173          0.156062
13      72252.0  1.328617e-02 -0.275231      0.000000          0.175129
11      65448.0  1.594911e-06 -0.463255      0.000000          0.054455

    mutual_info  importance  mutual_info_norm  importance_norm  cohens_d_norm  \
4      0.103625    0.300399          1.000000         1.000000       0.500227
5      0.092877    0.114895          0.896284         0.382476       0.311044
17     0.074678    0.164170          0.720658         0.546507       0.202033
7      0.064288    0.048346          0.620388         0.160940       0.638610
2      0.071139    0.040157          0.686505         0.133680       0.357985
16     0.038062    0.055201          0.367300         0.183759       0.723240
9      0.037371    0.021231          0.360634         0.070678       0.861151
3      0.061540    0.015998          0.593876         0.053256       0.501463
15     0.045990    0.044825          0.443815         0.149220       0.577370
6      0.075569    0.074069          0.729253         0.246570       0.000000
8      0.026622    0.003134          0.256908         0.010432       0.835555
0      0.000000    0.032767          0.000000         0.109078       1.000000
12     0.008820    0.000839          0.085112         0.002794       0.965860
14     0.008251    0.000000          0.079620         0.000000       0.977013
1      0.029315    0.075508          0.282897         0.251359       0.086828
```

```
10     0.024735    0.006794          0.238700         0.022615       0.432830
13     0.000395    0.000000          0.003808         0.000000       0.811480
11     0.006316    0.001665          0.060946         0.005543       0.576993

    cramers_v_norm  max_churn_diff_norm  composite_score
4                0                    0         0.700045
5                0                    0         0.445837
17               0                    0         0.420556
7                0                    0         0.362120
2                0                    0         0.317652
16               0                    0         0.309966
9                0                    0         0.301624
3                0                    0         0.294432
15               0                    0         0.293384
6                0                    0         0.292747
8                0                    0         0.247313
0                0                    0         0.232723
12               0                    0         0.219544
14               0                    0         0.219289
1                0                    0         0.177643
10               0                    0         0.164961
13               0                    0         0.163438
11               0                    0         0.135345
```

11.8 Appendix 8: Retention Analysis - Churn Logit Regression Analysis

```
--- Performing Undersampling ---
Data after undersampling: 324 observations.
Churned observations after undersampling: 162
Not Churned observations after undersampling: 162

--- Fitting Logistic Regression Model with Undersampled Data ---

--- Logistic Regression Model Summary ---
                           Logit Regression Results
==============================================================================
Dep. Variable:                Churned   No. Observations:                  324
Model:                          Logit   Df Residuals:                      316
Method:                           MLE   Df Model:                            7
Date:                Wed, 28 May 2025   Pseudo R-squ.:                  0.3015
Time:                        18:44:55   Log-Likelihood:                -156.86
converged:                       True   LL-Null:                       -224.58
Covariance Type:            nonrobust   LLR p-value:                 4.583e-26
==============================================================================
==========
                                   coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
----------
const                            -0.9967      0.347     -2.873      0.004      -1.677
-0.317
Working Orders_On Going           0.3605      0.193      1.869      0.062      -0.017
0.738
Working Orders_Corrective        -4.3298      1.174     -3.688      0.000      -6.631
-2.029
Labor Hours_Corrective Rate      -0.4811      0.190     -2.528      0.011      -0.854
-0.108
```

```
Total Plan                      -0.7716      0.516     -1.496      0.135      -1.783
0.239
Labor Hours_Preventive Rate     -0.5415      0.175     -3.098      0.002      -0.884
-0.199
Working Orders_Execution Rate    0.3191      0.180      1.773      0.076      -0.034
0.672
Total Plan_Completed Rate       -0.4663      0.159     -2.927      0.003      -0.779
-0.154
==========================================================================================
==========

--- Odds Ratios and their 95% Confidence Intervals ---
                              Odds Ratio  Lower CI (95%)  Upper CI (95%)
Working Orders_On Going         1.433979        0.982697        2.092501
Working Orders_Corrective       0.013170        0.001319        0.131499
Labor Hours_Corrective Rate     0.618112        0.425689        0.897517
Total Plan                      0.462284        0.168200        1.270549
Labor Hours_Preventive Rate     0.581864        0.413100        0.819573
Working Orders_Execution Rate   1.375847        0.966975        1.957604
Total Plan_Completed Rate       0.627297        0.459030        0.857246

--- Final Multicollinearity Check (VIF) for Fitted Model Variables ---
                        feature       VIF
6  Working Orders_Execution Rate  1.707048
4                    Total Plan  1.608918
2      Working Orders_Corrective  1.550323
3    Labor Hours_Corrective Rate  1.545625
5    Labor Hours_Preventive Rate  1.527234
1        Working Orders_On Going  1.485232
7      Total Plan_Completed Rate  1.105993

Multicollinearity is within acceptable limits (all VIFs <= 5).

--- Statistically Significant Variables (p < 0.05) ---
Working Orders_Corrective: p = 0.0002
Labor Hours_Corrective Rate: p = 0.0115
Labor Hours_Preventive Rate: p = 0.0019
Total Plan_Completed Rate: p = 0.0034
```