AI in Inventory Management

Demand Forecasting

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Step1: Prototype Selection

Abstract

Most of the small- medium business has seen a difficulty in investing in inventory management system since it is costly and skilled labour is needed. Large enterprises incorporates much more advanced systems that uses machine learning algorithms
to predict or forecast demand for the required product and optimize inventory levels. AI has become so advanced such that it could be extended as a better service to these small businesses to make better and faster decisions and execute quickly with less need for human interaction.

Demand Forecasting which is a crucial part of any business is able to predict demand which could in turn improve customer satisfaction and business profits. Because of the variability in demand and data complexity, AI induced demand forecasting has the ability to solve most of the problems faced by these businesses.

Here in this report, we discuss how machine learning and AI driven techniques has improved demand forecasting and consider the existing AI innovations that helped in demand forecasting to small scale businesses and generate a model idea from it.

Introduction

Inventory management, a critical element of supply chain refers to the tracking of inventory, which is the goods or materials a business intends to sell, from manufacturers to warehouses and from these

facilities to a point of sale. Its main purpose is to efficiently ensure that there is significant availability of goods or materials to meet the demand or customer needs without creating excess inventory. An Inventory is basically a company's important asset. Shortage in inventory can result in customer unsatisfaction and loss in sales and excess inventory can lead to risk of spoilage, cost to store, theft and damage. Effective inventory management system enables business to strike a balance between being understocked and overstocked for optimal profitability. Inventory management is important for any type of business regardless of its size. Small to medium enterprises may use spreadsheet formulas to keep track of their inventory manually and large businesses use specialised enterprise resource planning (ERP) software. Most of the management strategies vary depending on the industry. Since the whole management process is complex, depending on the type of business or product, a company may use various inventory management methods. A subset of inventory management termed as Inventory optimization refers more specifically to profit margins and minimizing loss. It's all about having the right inventory to meet the demand and buffer against unexpected disruption, while avoiding wasteful surplus. The main goal of inventory optimization is to best forecast demand and maximize the financial output of the inventory for the company.

One such practice in the inventory optimization is the Demand Forecasting. It is the process of predicting future demand for a product or service. It also helps to predict trends or risks and optimize inventory levels. Forecasting product demand is one of the core challenges faced in any business. Traditional forecasting

models such as ARIMA, Exponential smoothing methods, where only historical data is considered are getting outdated because of the huge increase in the amount of data generated from business and external sources. That is where AI plays a huge role. By implementing AI, machine learning enables enhanced forecast based on real time data using internal and external sources such as demographics, weather, online reviews, social media etc. AI yields very impressive results compared to traditional methods which leads us to believe that it has a significant impact on demand forecasting.

Problem Statement

Small to medium businesses faces a lot of challenges in inventory management. As technology is advanced, choosing not to invest in them may lead these businesses to face many challenges. Technological integrations have become a necessity as when your whole business depends on data from different sources, which is continuously changing and requires proper tracking and control.

One such challenge is demand volatility in relation with demand forecasting. Since data is generated more and more, customer demand patterns are becoming more and more complex and getting harder to predict. Lots of factors can influence demand ranging from weather conditions to social media leading customers to constantly change their minds. The solution to this problem is implementing Artificial Intelligence. By using AI, businesses can make use of machine learning algorithms as they can automatically recognize patterns and trends, identify relationships and influences in large datasets and predict demand behaviour with reasonable accuracy.

Customer, Market & Business needs

As mentioned earlier, AI use in demand forecasting can benefit and satisfy many small to medium business's needs. Some of them are:

1. Improvement in accuracy over time

Machine learning algorithms can learn from existing data or historical data giving much better forecasts or predictions each time it has access to new data.

2. Higher Customer Satisfaction

Since shortage in inventory or stock outs can lead to dissatisfaction in customers while being available with the right product boosts customer satisfaction.

3. Efficient Manpower

HR departments can make efficient trade-offs between part time or full-time employee mix and optimizing costs.

4. Improved Inventory Optimization

If certain products stay unsold for a longer time period, this may increase inventory costs and risk of damage and becoming obsolete. AI can help determine optimal inventory levels and such situations can be minimized with accurate forecasts results.

5. Increased efficient Supply Chain

AI can help teams to focus on strategic issues instead of having to manage unexpected fluctuations of stocks or problems in the supply chain. AI approaches have clear advantages over traditional spreadsheet based analytic methods since traditional approaches require constant manual updating of data and may not allow for agile

responses to changes in demand patterns. It is true that limited availability of data might be a problem for some business but most of the organizations have enough data to derive insights from AI induced Demand Forecasting.

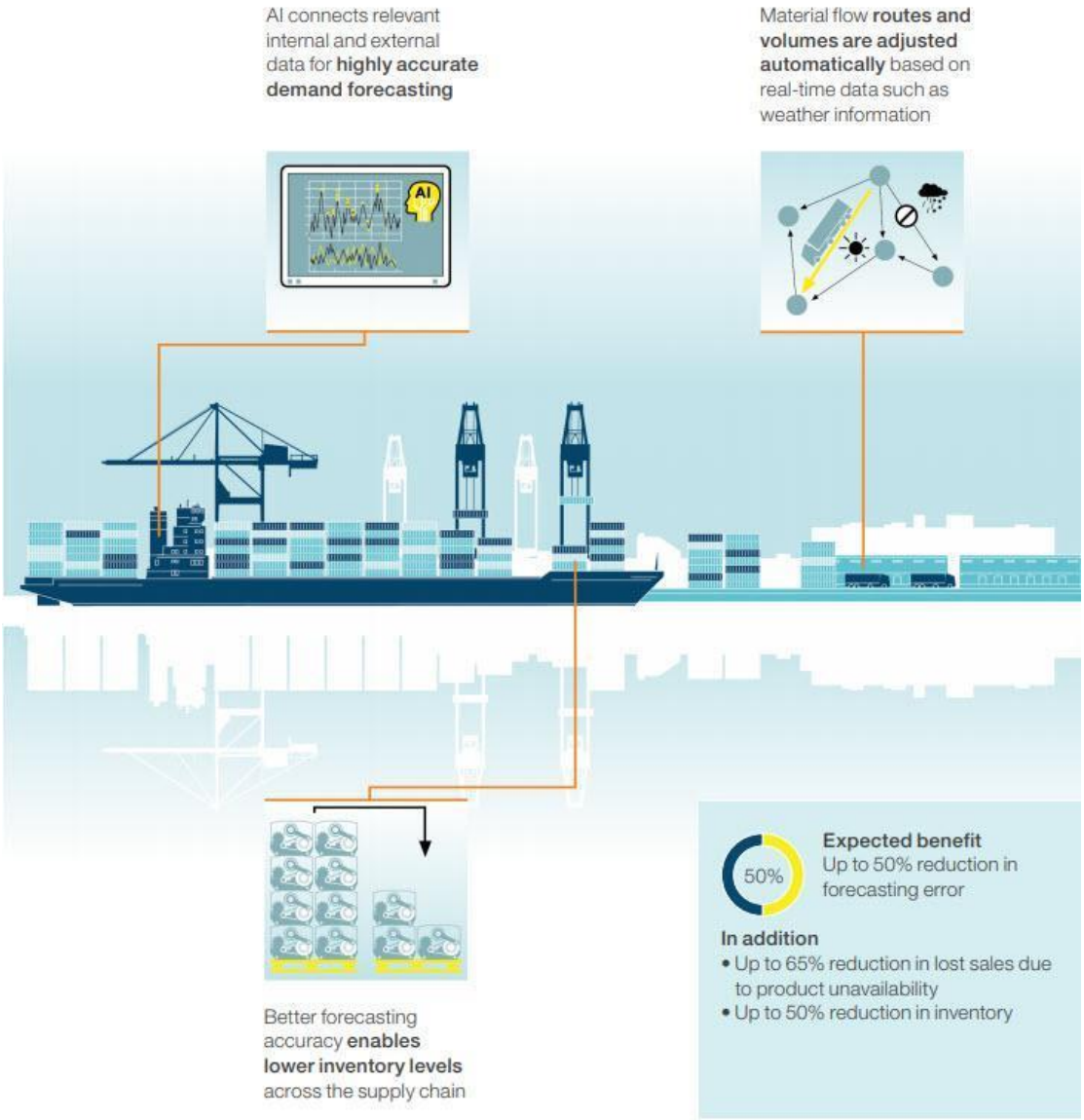

Fig: Source (Mckinsey)

Target Specifications

Unlike traditional forecasting, AI induced forecasting is much more

flexible. Manual or non-connected technologies cannot handle unstructured or disparate data. AI can bring enormous advantage here by autonomously selecting suitable forecasting models for the corresponding product levels without doing everything manually.

Since both internal data like sales, purchase orders, inventory, websites reviews, marketing campaigns, crm data, and external data like weather, social media, macro-economic indicators, customer store receipts etc can all influence demand pattern, AI can include automatically all these data into forecast creation. Since fluctuations can occur at any time, AI can identify causal relationships between demand and external effects and provide customers of any business purchase all the needed products without waiting for delivery times thus causing increase in sales. By AI induced planning, it can result in high inventory turnover or optimal stock levels but also happier partners along the supply chain who will be able to plan more efficiently.

External Searches

Traditional vs AI induced Forecasting

Demand Forecasting is an extremely complex procedure having to face rapidly shifting consumer demand and forecasting challenges, often exacerbated by seasonality, sometimes new product introductions, causal factors etc. While Machine learning and demand forecasting may go together, to successfully implement this technology requires careful consideration and preparation.

Traditionally, Demand Forecasting is implemented by using a combination of statistical functions such as simple moving averages, linear regression, Holt's winter method, Croston method etc. Demand Forecasting is often done for multiple time horizons such as short-term like a month, medium-term like a quarter and long term like a year. Shortterm demand numbers are finalized based on multiple inputs via statistical predictions, mostly entered by sales team manually. Most of the organizations will have an approval step where demand numbers are verified and modified by supply chain management (SCM) managers after considering other factors such as business targets. These demand numbers are then finalized and are released to next module which is the supply planning. At its core, SNP or supply network planning involves generating and solving a large mathematical optimization problem using mixed integer linear programming (MILP) technique from the operational research repository. The optimization problem is generated based on various configurations, master data, constraints such as production capacity and of course demand numbers. The output i.e., is the optimal supply plan is released to the next Production Planning module. Output of SNP is used for production planning and detail scheduling based on specific constraints in the production environment. Generation of deliveries is prioritized to avoid stockouts at endpoints, generation of truckload etc. This are all integrated with the transactional ERP system. Leading vendors like SAP, ORACLE are among them. Although these leading vendors does offer many functionalities such as regression modelling or causal analysis for

demand forecasting, if a more rigorous and advanced approach is desired one can forecast demand using machine learning algorithms involving advance modelling and upload them back to the SCM system. Algorithms like regression with derived, non-linear, ridge, lasso etc, ensemble methods like random forests, XGBoost, deep learning models like artificial neural networks (ANN) and long short-term memory (LSTM) models performs better than those embedded in the SCM system. One can even implement a weighted average approach to consolidate demand numbers through modelling entered by sales team etc. Generally, ABC analysis of SKUs i.e., stock keeping unit is mainly done for classifying products based on their importance. Such classification is used for configuring, applying and implementing a customized strategy for every class. A better approach via machine learning will be segmenting SKUs based on clustering such as K- Means and then applying different strategies to each segment.

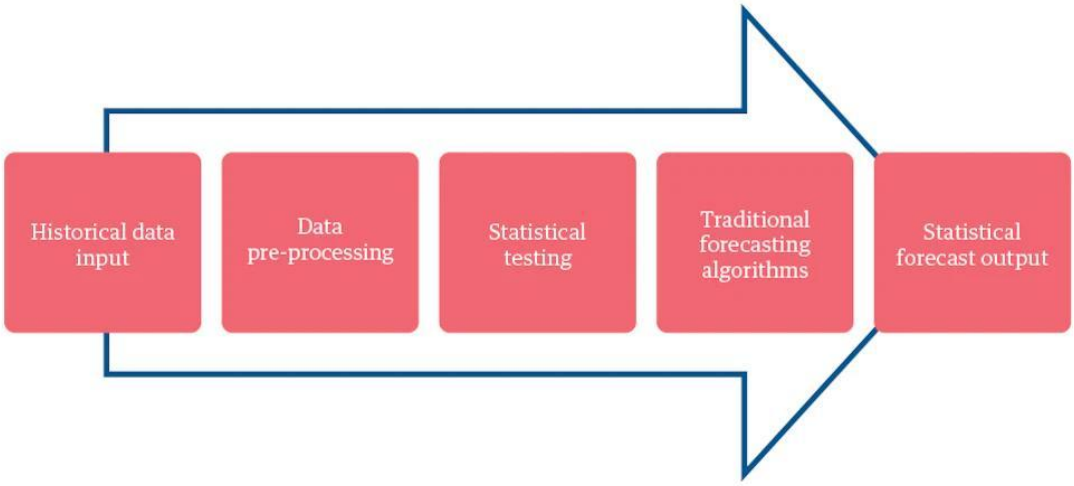

Fig: Traditional Forecasting Process

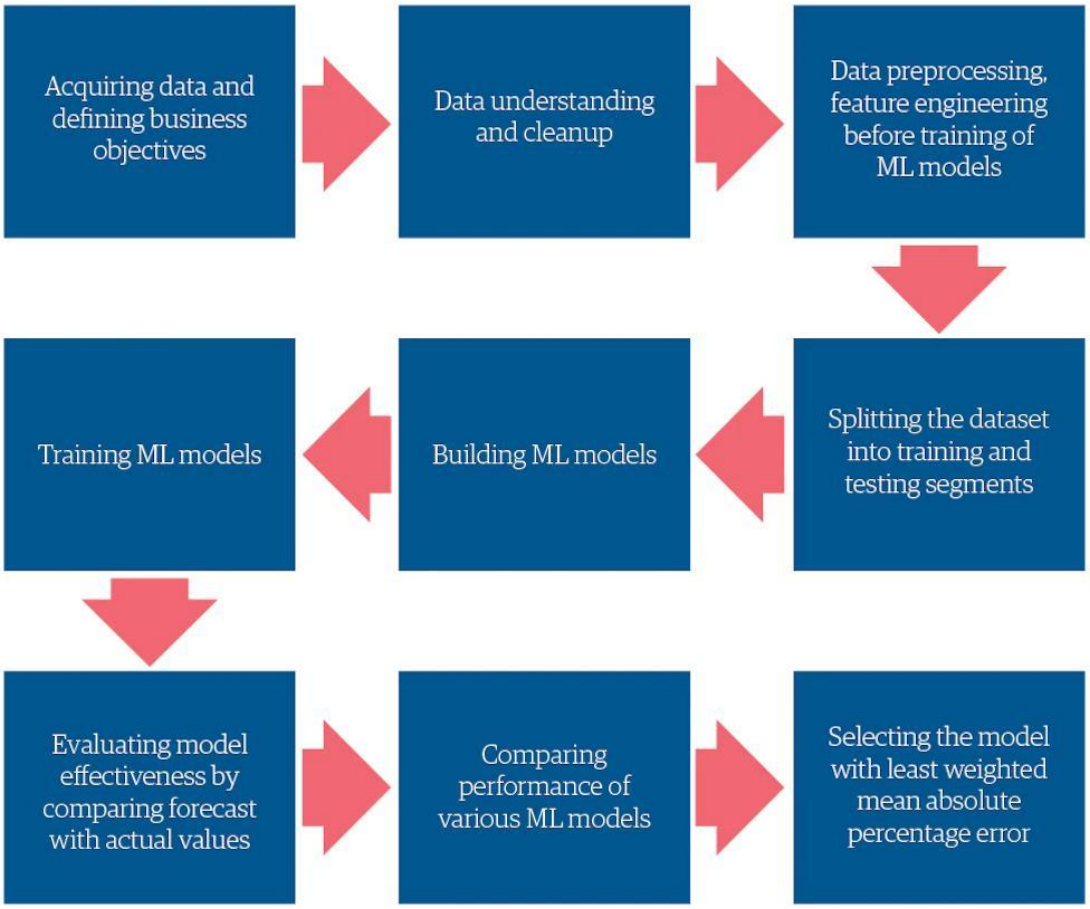

Fig: Machine Learning Forecasting Process

Bench marking alternate products

GMDH Streamline Software

GMDH is an innovative global provider of supply chain management planning and predictive analytics solutions. They create advanced software solutions which bring the power of GMDH modelling and forecasting algorithms to non-mathematicians, providing accurate, flexible forecasting for business. GMDH Streamline product is a demand forecasting and inventory replenishment planning solution, which allows business to maximize return on their capital investments. Streamline's AI-powered software platform helps small to medium businesses to track and

forecast demand with high accuracy. Since AI technology encompasses a broad range of techniques such as machine learning and expert systems, they have implemented a combination of approaches to provide a somewhat conservative but stable and reliable forecast, rather than a focused result which can be unstable due to market fluctuations. Their AI strategy includes testing with millions of different patterns and combinations of input parameters, providing confidence in the reliability of forecasts generated by streamline. It's an efficient and effective software and also allows us to pull data from
the sales system to streamline as well as automatically export the forecasted order
information back to ERP system. GMDH streamline comes with an application programming interface (API) which facilitates integration with several third-party platforms such as QuickBooks, Unleashed, Microsoft Excel, Spire etc. Pricing is available on request and support is extended via phone, email and other online platforms.

Logility Digital SC platform

Logility helps companies seize new opportunities, sense and respond to changing market dynamics and more profitably manage their complex global business. Logility Digital Supply chain platform leverages artificial intelligence (AI), machine learning (ML) and automation to continuously sense, analyse and update activity in digital supply chain, ensuring peak operational performance at all times. Its autonomous engine continuously senses, analyses and

updates supply chain planning parameters in real time to help ensure peak operational performance. By making use of AI and ML, it leverages more data and achieve dramatic forecast accuracy improvements at enterprise scale, build forecasts at the individual SKU level, incorporating pricing history, discounts, essential product information such as ingredients, raw materials
packaging etc., removes human bias from planning where machine learning learns, grades itself and gets smarter over time. Logility's causal forecasting solution augments core demand forecasting and provides a more proactive approach versus basing inventory positions and replenishment schedules solely on shipment data. It uses machine learning techniques to uncover complex patterns that are often missed by helping supply chain professionals to focus on data which matters and improves forecast accuracy by incorporating information from external demand signals, thereby increasing their ability to predict demand patterns.

Business Opportunity

Just like mentioned above, there are many more software and platforms available for proper inventory management and demand forecasting since small to medium businesses may not need to adopt large ERP systems such as SAP or Oracle because of cost prohibition for inventory management but still want to forecast demand and keep track of inventory, these platforms make it possible for them in just one click and accurate reports will be generated for them. Since AI and ML plays a huge part in producing

these solutions, it thus provides a greater opportunity for small-medium business owners to get all the benefits and features like everyone else. Here, I am just taking a part of the existing ideas and practices to build a product model explaining AI or ML techniques used in case of a ML based demand forecasting software.

Concept Development

The first thing to take into consideration in any model development is gathering the necessary data and briefly reviewing its structure, accuracy and consistency. Look through the statistical summary as it can give an idea about the various features that we should take into consideration. After gathering right amount of data, setting of the business objective should be the next step. Since each business may have unique goals, having clear baseline metrics may provide smooth machine learning approaches. Before starting to develop a solution, a software development team needs to agree with the business owners on the metrics. Statements like What you want to improve on or why it is essential should be asked at this stage. Now its time for data understanding and preparation. As complex as it is, data can be of any form hence data quality is a critical component in any prediction or forecasting problem. Here, we go for cleaning and filtering the data, checking for anomaly detection and gaps, check its relevance, accessibility etc. Data visualizations can be performed in order to get a clear understanding of the demand patterns or trends. Mostly seasonality components or other factors can be understood easily through visualization. Since there is no perfect set of machine

learning algorithms, several types of machine learning algorithms can be considered. Best approach is to leverage both probability-based forecasting and machine learning techniques as these two may work together at most granular level on different time zones. Since probability based uses more historical data, external data sources such as weather to traffic data can be used by machine learning techniques which can enhance the overall forecasting procedure. After training with the appropriate data, Validation is done by cross-validation tuning methods where training dataset is split into several equal parts and forecasting models are trained with different sets of hyper-parameters. This is to get an idea about the model's parameters having the most accurate forecast. More improvement can be done after getting the results and after researching the best business solutions, we can choose the ones that cover the project's requirements accurately. In the deployment stage, it assumes the forecasting model(s) integration into production use. Setting a pipeline to aggregate new data to use for next AI features is recommended since it can save a lot of time used for data preparation in the future projects. It is important to use models that are self-adaptive and do not require continuous tuning by experts, otherwise changing business environments will make them unreliable.

Final Product Prototype Modelling Using AI/ML

Product Details

Datasets

As discussed earlier, large and varied types of datasets can be used in demand forecasting procedures since the process is complex and are influenced by lots of factors, we may have to consider different types of sources. The more robust, the more accurate outcomes will be. The below figure gives us an idea.

Algorithms

Different types of machine learning algorithms are used in demand forecasting. The main methods used are:

1. Time series methodology

Sequence of data points taken at successive, equally spaced points in time. Most applicable models are:

• **ARIMA** (auto-regressive integrated moving average) models aim to describe the auto-correlations in the time series data. When planning short-term forecasts, ARIMA can make accurate predictions.

• **SARIMA** (Seasonal Autoregressive Integrated Moving Average) models are the extension of the ARIMA model that supports uni-variate time series data involving backshifts of the seasonal period.

• **Exponential Smoothing** models generate forecasts by using weighted averages of past observations to predict new values. 2. Regression Models

Regression models like **Random Forest $ XGBoost** can also be used to forecast demand. Random forest can be used for both classification and regression problems. It is developed by constructing a multitude of decision trees at training time and

outputting the mean prediction of the individual trees. That is by taking average of all individual decision tree estimates, random forest model results in more reliable forecasts. Whereas XGBoost is an implementation of gradient boosting ensemble algorithm. It is an ensemble of decision trees algorithm where new trees fix errors of the existing trees in the model and trees are added until no further improvement can be made to the model. It works efficiently on tabular datasets although it can be used for time series forecasting.

3. Deep Learning Models

Models like **Artificial Neural Network and Long Short-Term Memory** models can be implemented when there is presence of large datasets especially unstructured datasets. ANN are forecasting methods that are based on simple mathematical model of the brain where it allows non linear complex relationships between the response variable and its predictors. LSTM used in deep learning can process entire sequences of data. Due to its ability to learn long term sequences of observations, it is a trending approach adopted in forecasting models.

Team Required

- Software developers
- AI Engineers
- Data Scientists
- Business Analyst

Step2: Prototype Development

Github link for the same:
https://github.com/piyushkothari123/Fyenn_labs_task_3_step_2

Step3: Business Modeling

Target Market:

Target busy professionals, working parents, and health-conscious individuals who prioritize convenience, quality ingredients, and home-cooked meals.

Value Proposition:

Offer a time-saving solution with pre-portioned ingredients and easy-to-follow recipes, enabling customers to enjoy delicious meals, reduce food waste, and develop their cooking skills.

Revenue Streams:

a. Subscription Model: Offer various subscription plans (weekly, bi-weekly, or monthly) with different meal options and serving sizes, charging a recurring fee.

b. Upsells and Add-ons: Provide opportunities for customers to purchase additional items such as desserts, snacks, or premium ingredients.

c. Partnerships: Collaborate with local farmers, specialty food suppliers, or kitchenware brands to promote their products and earn affiliate or partnership revenue.

Key Activities:

a. Menu Development: Create diverse and appealing meal options each week, taking into account customer preferences, dietary restrictions, and seasonal availability of ingredients.
b. Sourcing and Procurement: Establish relationships with local farmers, food suppliers, and distributors to ensure the availability of high-quality ingredients.
c. Packaging and Logistics: Pack and ship meal kits efficiently, ensuring the freshness and safety of ingredients during transit.
d. Customer Support: Provide responsive and helpful customer service for order modifications, recipe clarifications, and issue resolution.
e. Continuous Improvement: Gather customer feedback, analyze data, and iterate on recipes, packaging, and delivery processes to enhance the overall customer experience.

Key Resources:

a. Culinary Team: Employ professional chefs or recipe developers to create innovative and tasty recipes that cater to a variety of dietary preferences.
b. Procurement Network: Establish relationships with reliable suppliers to source fresh and high-quality ingredients.
c. Operational Infrastructure: Invest in a well-equipped kitchen facility, inventory management systems, and a delivery network to ensure timely and efficient order fulfillment.

Key Partnerships:

a. Ingredient Suppliers: Form partnerships with local farmers, organic food suppliers, and specialty ingredient producers to source quality ingredients.
b. Delivery and Logistics Partners: Collaborate with courier services or logistics companies to ensure reliable and timely delivery of meal kits.
c. Marketing and Promotional Partners: Collaborate with influencers, food bloggers, or health and wellness brands to expand the customer base and reach new audiences.

Customer Relationships:

a. User-Friendly Platform: Develop a user-friendly website or mobile app where customers can easily browse recipes, customize their meal selections, manage subscriptions and provide feedback.
b. Personalization: Offer customization options to accommodate dietary preferences, allergies, or specific meal requirements.
c. Communication and Engagement: Regularly engage with customers through newsletters, social media, and blog content, providing cooking tips, recipe inspiration, and updates on new offerings.
d. Feedback and Reviews: Encourage customers to provide feedback and reviews, and use this information to improve the service and address any concerns.

Channels:

a. Online Platform: Develop a robust e-commerce platform where customers can explore and purchase meal kits, manage subscriptions, and access additional resources.
b. Digital Marketing: Utilize digital marketing channels such as search engine optimization (SEO), social media advertising, and content marketing to attract and acquire new customers.
c. Referral Program: Implement a referral program that rewards existing customers for referring new customers to encourage word-of-mouth marketing.

Cost Structure:

a. Ingredient Costs: Allocate a significant portion of the budget for sourcing high-quality ingredients while maintaining cost efficiency.
b. Operations and Logistics: Cover costs associated with meal preparation, packaging, and delivery logistics.
c. Marketing and Advertising: Allocate a budget for digital marketing campaigns, social media advertising, and influencer collaborations.
d. Technology Infrastructure: Invest in website or app development, maintenance, and data security.
e. Customer Support: Allocate resources for a responsive and knowledgeable customer support team.

Financial equation
Total Revenue = (Number of Subscriptions * Subscription Price) + Upsell Revenue + Partnership Revenue

Costs = Ingredient Costs + Operations and Logistics Costs + Marketing and Advertising Costs + Technology Infrastructure Costs + Customer Support Costs

Profit = Total Revenue - Costs

In this equation:

The total revenue is calculated by multiplying the number of subscriptions by the subscription price and adding any additional revenue generated from upsells and partnerships. Costs include ingredient costs (cost of procuring fresh and high-quality ingredients), operations and logistics costs (meal preparation, packaging, and delivery logistics), marketing and advertising costs (digital marketing campaigns, social media advertising), technology infrastructure costs (website or app development, maintenance, and data security), and customer support costs. Profit is calculated by subtracting the total costs from the total revenue.

Step4: Financial Modeling

Financial Modeling for AI-Driven Demand Forecasting Service

Assumptions:

1. The demand forecasting service is offered as a subscription-based model.

2. The target market consists of small and medium-sized businesses (SMBs).
3. The service aims to improve demand forecasting accuracy by leveraging AI and machine learning algorithms.

Revenue Projection:

1. Determine the pricing strategy: Based on market research and competition analysis, set a monthly subscription fee for the demand forecasting service.
2. Estimate the total addressable market (TAM) for the service by considering the number of SMBs in the target market that can benefit from demand forecasting.
3. Estimate the market penetration rate: Determine the percentage of the TAM that can be captured in the initial years, considering the value proposition of the AI-driven service.
4. Calculate the expected monthly recurring revenue (MRR) by multiplying the subscription fee by the estimated number of subscribers.

Cost Structure:

1. Development and maintenance costs: Consider the expenses associated with building and maintaining the AI-driven demand forecasting system, including software development, infrastructure, and ongoing updates.
2. Marketing and sales costs: Account for the expenses related to marketing the service, acquiring customers, and providing customer support.

3. Operations costs: Include the costs associated with managing the service, such as server hosting, data storage, and system administration.
4. Skilled labor costs: Determine the resources and expertise required to develop and operate the AI system and allocate appropriate salaries or contractor fees.
5. Overhead costs: Consider general overhead expenses, such as office space, utilities, and administrative costs.

Profitability Analysis:

1. Calculate the gross profit by subtracting the total costs from the monthly recurring revenue.
2. Assess the breakeven point by determining the number of subscribers required to cover the total costs and start generating profits.
3. Analyze the scalability potential by evaluating the ability to increase the subscriber base and the corresponding impact on costs and profitability.
4. Monitor customer retention rate and the average customer lifetime value (CLTV) to ensure long-term profitability.

Sensitivity Analysis:

1. Perform sensitivity analysis by varying key factors such as subscription fee, market penetration rate, and operational costs to understand their impact on profitability.

2. Identify potential risks and uncertainties, such as market competition, technological advancements, and changing customer needs, and assess their influence on the financial model.

Cash Flow Projection:

1. Develop a cash flow projection model by considering the inflows from subscription fees and outflows from various costs and investments.
2. Monitor cash flow to ensure adequate liquidity for operational expenses and future growth opportunities.

The above financial modeling outline provides a high-level overview of the process and factors to consider. The specific numbers, calculations, and assumptions will depend on the detailed analysis of the market, costs, pricing, and other relevant factors specific to the AI-driven demand forecasting service for small-scale businesses.

Links for the same:
https://github.com/mlv1997/feynnlabs-project3
https://github.com/him-prad/Feynn_labs_final_task