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Predictive analytics in small business management: demand forecasting, waste reduction, and operational optimization.

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Predictive analysis in the management of small companies: demand forecast, waste reduction and operational optimization

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SUMMARY

This article examines the application of predictive analytics in small business management, with an emphasis on demand forecasting as a tool for reducing waste, preventing stockouts, and improving operational efficiency. The research adopts a qualitative, exploratory, and applied approach, based on a literature review on Business Analytics, time series, machine learning, inventory management, safety stock, and managerial adjustments in forecasting.

This paper discusses how restaurants, local retailers, and service companies can use transactional data, POS systems, spreadsheets, and accessible statistical methods to improve purchasing, production, replenishment, and staffing decisions. It concludes that forecasting integrated with costs, seasonality, supply reliability, and controlled managerial judgment increases decisional accuracy and reduces operational improvisation.

Keywords: Predictive analysis. Demand forecasting. Small businesses. Business analytics. Inventory Management. Waste. Operational Efficiency.

ABSTRACT

This article examines the application of predictive analytics in small business management, highlighting demand forecasting as a tool for waste reduction, stockout prevention, and operational efficiency improvement. The study adopts a qualitative, exploratory, and applied approach, grounded in a bibliographic review of Business Analytics, time series, machine learning, inventory management, safety stock, and judgmental adjustments in forecasting. It discusses how restaurants, local retailers, and service firms can use transactional data, POS systems, spreadsheets, and accessible statistical methods to improve purchasing, production, replenishment, and staffing decisions. It concludes that forecasts integrated with costs, seasonality, supply reliability, and controlled managerial judgment increase decision accuracy and reduce operational improvisation.

Keywords: Predictive Analytics. Demand Forecasting. Small Businesses. Business Analytics. Inventory Management. Waste Reduction—Operational Efficiency.

1 INTRODUCTION

The digitization of commercial transactions has increased the availability of operational data in

Small businesses. Point-of-sale systems, payment platforms, delivery apps.

Digital calendars, inventory spreadsheets, and financial reports began to record sales, schedules,

categories, customers, losses, payment methods, and seasonal patterns. However, the existence of these

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Data does not guarantee its conversion into a decision. In most smaller companies, the
Information remains scattered, underutilized, or limited to administrative controls, without being...
incorporated into the processes of forecasting, planning and resource allocation.
This mismatch becomes particularly relevant in restaurants, cafes, local markets,
Neighborhood stores, clinics, salons, workshops, and service companies. In these operations, decisions
Recurring purchases are made under constraints of time, capital, and personnel: one buys before knowing the...
Effective demand, prepare before observing the actual flow, scale the team based on standards.
Previous stock levels are replenished based on the owner's or manager's perception. Experience
Practice is indispensable, but when not systematized, it can lead to reactive decisions, lacking proper methodology.
comparable and vulnerable to memory biases.
Overestimating demand tends to lead to excessive purchases, stagnant inventory, waste, and loss.
of quality and commitment of working capital. Underestimation, in turn, causes disruptions,
Lost sales, delays, staff overload, and deterioration of customer experience. In
In food processing operations, the perishability of ingredients intensifies the impact of error: the surplus.
This can quickly turn into waste, reduced margins, or sanitary losses. In retail.
In other locations, the same problem manifests itself as low turnover of goods or unavailability of
Strategic items. In service companies, this manifests itself in the idleness of professionals or in...
inability to provide service during peak periods.
Demand forecasting offers a managerial response to this scenario by estimating likely patterns.
Search based on historical data, contextual variables, and statistical criteria. Its function
It's not about eliminating uncertainty, but reducing it to an operationally manageable level. (Purchasing,)
Production, replenishment, staffing levels, and loss control can be adjusted more effectively.
Precision is achieved when the manager stops relying solely on intuition and starts working with parameters.
verifiable.

In the literature on operations, forecasting, and supply chain management, forecasting is considered a...
an essential component of business planning, as it supports decisions about capacity,
inventory, production, logistics and customer service (MAKRIDAKIS; WHEELWRIGHT; HYNDMAN,
(1998; MENTZER; MOON, 2004; CHOPRA; MEINDL, 2019). Recent studies expand on this.
discussion relating demand forecasting to machine learning, to food waste, to
safety stock, supply reliability, and managerial judgment. Rodrigues et al.
(2024), in a study applied to food services, demonstrate that forecasting models of
In the short term, they can simultaneously reduce wasted meals and unmet demand.
Tadayonrad and Ndiaye (2023) emphasize that the evaluation of forecasts should consider not only the
statistical error, but also inventory costs, stockout risk, seasonality and...

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supply chain reliability. Fildes et al. (2009), in turn, show that adjustments
Humans in forecasting can improve or harm accuracy, depending on the quality of the analysis.
Contextual information and the control of decision-making biases.
Applying these principles to small businesses requires methodological proportionality.
Sophisticated models do not generate value when fed with weak data, interpreted in a way...
inaccurate or disconnected from operational routines. Conversely, simple methods, such as averages
Mobile analysis, exponential smoothing, regression analysis, and seasonality analysis can yield gains.
Consistent when associated with reliable records, error assessment, and decisional discipline.
Analytical maturity doesn't begin with the complexity of the algorithm, but with the ability to...
record, compare, learn and correct.
Given this context, this article analyzes how small businesses can use forecasting.
demand to reduce waste, avoid stockouts and optimize purchasing, inventory, production and
operational capacity. The aim is to understand how everyday data can be
transformed into useful decision-making parameters, especially in companies characterized by resources.
Limited resources, low levels of formal management, and a constant need for efficiency.

2. THEORETICAL FRAMEWORK

2.1 Business Analytics and Decision Making in Small Businesses

Business Analytics encompasses the systematic use of data, quantitative methods, and tools.
analytical tools to guide organizational decisions. In its managerial dimension, it goes beyond
Creating reports and dashboards involves converting information into action. Davenport
Harris (2007) associates analytics-based competition with the ability to make decisions.
superiors based on evidence, a logic that can be adapted to smaller companies, since
respecting their limitations in terms of capital, staff, and technological infrastructure.
In small businesses, decision-making is often concentrated in the hands of a few individuals.
The owner or manager combines financial, commercial, operational, and administrative functions.
which increases the reliance on practical experience and, at the same time, exposes the company to
poorly documented judgments. Data analysis reduces this vulnerability by transforming
Scattered records across operational behavior indicators. Sales by product, hours of operation.
higher flow, slow-moving items, recurring losses, and variations by day of the week cease to be...
Isolated perceptions then come together to form a minimum management system.

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This process can be understood in stages. Descriptive analysis organizes what occurred; the
Diagnostic analysis seeks to understand the probable causes; predictive analysis estimates future behaviors; and
Prescriptive reasoning guides actions. For small businesses, this progression does not necessarily depend on...
of complex platforms. Well-structured spreadsheets, POS systems and simple routines of
The consolidation already allows for the identification of patterns and the formulation of initial forecasts. The main barrier
This lies in data governance: products registered with conflicting names, losses not
registered issues, irregularly updated inventory, and sales not segmented by time of day.
They make any reliable modeling difficult.

2.2 Demand forecasting, time series and explanatory variables

Forecasting demand means estimating future demand for products, services, categories, or resources.
The usefulness of this estimate depends on the consistency between the time horizon, the granularity, and the...
a decision she supports. Restaurants and cafes need daily or shift-based forecasts for
Organize the purchase of perishable goods, pre-preparation, and service schedule. Local retailers.
They can work with weekly or monthly projections for replenishment, mix composition, and control.
of immobilized capital. Service companies tend to benefit from scheduling estimates, of
The schedule and type of service allow for adjusting capacity to the expected demand.
Much of this data takes the form of time series. Sales by day, traffic by hour,
Orders per week, losses per shift, monthly revenue, and consumption of supplies over time.
They allow us to identify trends, seasonality, cycles, and random variations (BOX et al., 2015;
(HYNDMAN; ATHANASOPOULOS, 2021). The trend indicates growth or contraction.
persistent; seasonality reveals recurring patterns; cycles follow oscillations
economic or sectoral factors; and noise corresponds to variations not explained by the others.
components.
Methods such as moving averages, exponential smoothing, Holt-Winters, and ARIMA are useful when
There are no identifiable temporal patterns. However, many small businesses are strongly
influenced by external factors: weather, holidays, local events, reservations, promotions, menu,
school calendar and payment dates. Rodrigues et al. (2024) distinguish series models
temporal models, based primarily on past values, and causal models, which incorporate
Independent variables to represent the decision environment. This distinction is important because
This demonstrates that predictions can be strengthened with simple data, provided they are recorded in a way that...
consistent way.

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2.3 Machine learning, waste and operational performance

The advancement of machine learning models has expanded the possibilities for prediction in various environments.
High variability. Algorithms such as Random Forest, gradient boosting, neural networks, and LSTM.
They capture non-linear relationships, interactions between variables, and patterns that traditional methods cannot.
They always identify them. Still, their adoption requires sufficient history, adequate validation, and
interpretation skills.
In a study with three food catering units, Rodrigues et al. (2024) compared Random
Forest, LightGBM, LSTM, and Transformer networks are reference models that simulate common practices.
estimation. The results indicated better performance of Random Forest in two cafeterias.
students and LSTM staff in a larger-scale corporate cafeteria with a more historical perspective.
Over time, the potential reduction in wasted meals ranged from 14% to 52%, while at the same time...
that unmet demand was also reduced in certain scenarios.
Two implications arise from these findings. Firstly, more accurate predictions may
To bring sustainability closer to economic performance, since reducing waste doesn't necessarily mean...
occurring at the cost of lost sales. Secondly, there is no universal algorithm. Each operation
It has its own characteristics in terms of volume, seasonality, stability, and availability of variables.
Small businesses should therefore avoid technological solutions adopted as a fad and prioritize...
Gradual validation, starting with interpretable methods and evolving as the maturity of the
data.

2.4 Inventory, costs and managerial judgment

Demand forecasting and inventory management are interdependent processes. Future estimation
It guides purchases and replenishment; safety stock protects against uncertainties in demand and...
supply. Tadayonrad and Ndiaye (2023) argue that forecast evaluation should incorporate
Inventory costs, seasonality, supplier reliability, and stockout risk. A model
Even though the average error rate may seem low, mistakes can still lead to losses if made on high-margin products.
Perishable items, peak periods, or slow-replenishment goods.
In small businesses, this integration is crucial. Dependence on a few suppliers, capital
Limited turnover and low storage capacity make inventory errors more costly.
Products with seasonal demand require different parameters over time. Suppliers with
Frequent delays necessitate greater protection. Perishable items, on the other hand, require caution.
Additionally, increasing inventory reduces the risk of shortages but increases the risk of waste. The appropriate point

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It depends on the combination of expected demand, validity, margin, lead time, and cost of...
The lack and the cost of excess.

Managerial judgment remains necessary because statistical models do not capture all the...
Contextual events. Climate change, nearby construction, unexpected bookings, local events,
Promotional campaigns and supplier failures may justify adjustments to the original forecast.
Fildes et al. (2009), however, demonstrate that human interventions can impair accuracy.
when performed without criteria, especially in small, intuitive, or biased adjustments. The
The challenge is to transform experience into a controlled variable: recording the original prediction,
Document the adjustment, explain the rationale, and then compare the result with the...
real demand.

3 METHODOLOGY

This study adopts a qualitative, exploratory, and applied approach, based on a review.
This is a narrative bibliographic study and a theoretical-applied analysis. It does not intend to empirically test a...
It's not about creating a model for a specific company, but rather about systematizing scientific and operational fundamentals.
capable of guiding the adoption of demand forecasting models in small businesses.
Works and articles related to Business Analytics, forecasting, and time series were examined.
machine learning, inventory management, safety stock, waste in food operations and
managerial judgment in forecasting. The selection prioritized publications with direct relevance to
Problem investigated, academic relevance, and applicability to the context of companies with resources.
limited.

Three studies received central attention. Rodrigues et al. (2024) provide the basis for the discussion on the
Short-term forecasting in food services and its effects on waste and demand
met. Tadayonrad and Ndiaye (2023) support the analysis on demand forecasting, costs of
inventory, seasonality, supply reliability, and safety stock. Fildes et al. (2009) provide guidance on
Reflections on managerial adjustments, biases, and governance of forecasting.
The interpretation was organized into four axes: quality of operational data; adequacy of
Predictive methods for business analytical maturity; integration between forecasting, inventory, and production.
and capacity; and control of human adjustments to statistical predictions. Because it is a study
Applied bibliography, the contribution lies in the critical articulation of the literature and in the proposition of
Guidelines compatible with restaurants, local retailers, and service businesses.

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4. THEORETICAL-APPLIED DISCUSSION

Small businesses operate with little margin for error. Limited capital, small teams,
Informalized processes, dependence on nearby suppliers, and strong exposure to the flow of information.
Daily customer logs make operational decisions proportionally sensitive. A bad purchase
An oversized problem can compromise cash flow; a one-off disruption can drive away repeat customers;
An inadequate scale can increase costs or impair service. In this environment, forecasting is crucial.
Demand management acts as a mechanism for managerial discipline, as it transforms perceptions into...
parameters and allows for comparison of hypotheses with results.
This transformation begins with data structuring. No predictive technique can compensate for a
Inconsistent database. Products registered in different ways, unrecorded losses, inventory.
Irregular updates and poorly defined categories reduce the reliability of the estimates.
POS systems offer a relevant starting point when recording product, time, quantity,
Value, payment method, and channel. Spreadsheets complement this process by consolidating purchases.
losses, beginning inventory, ending inventory, and operational observations. In restaurants, data on
Reservations, weather, events, and menu can enhance explanatory capacity; in services, scheduling,
Cancellations and average call duration become relevant variables.
The choice of method should reflect the analytical maturity of the business. Operations with a history.
Short and incomplete records can begin with moving averages and simple seasonality by day of the week. As
the baseline becomes more reliable, exponential smoothing, Holt-Winters and...
Regression patterns allow for the incorporation of trends, seasonality, and explanatory variables. In stages
More advanced machine learning models can be tested to capture complex relationships.
The central methodological question is not which algorithm is superior in absolute terms, but which...
This technique leads to better decisions in a given operational context.
It is also necessary to evaluate the forecast based on the economic effects of the error. Reduce waste without
Considering unmet demand can create a false sense of efficiency. A restaurant that prepares
A little discards less, but it can also mean selling less; a retailer that reduces inventory seems more
Lean, but may lose customers due to product unavailability. Metrics such as MAE, RMSE and
MAPE tools help measure accuracy, but should be complemented by indicators such as disruption,
Waste, margin, stagnant inventory, lost sales, and productivity per hour worked. The mistake.
Statistics matter, but their managerial implications matter even more.
Inventory management reinforces the need for economic analysis. Safety stock should reflect both
The uncertainty of demand as well as that of supply. Seasonal products require different parameters.

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depending on the period; unstable suppliers require greater protection; critical, high-margin items.
Products that are difficult to replace should not be treated as ordinary goods. Decisions based
Averages alone hide peaks and create distortions: there's a surplus on weak days, a shortage on strong days, and...
Inadequate capital allocation.
Operational capacity must also be incorporated into the predictive process. Demand is not...
It's limited not only by products, but also by time, attention, space, and labor. Predicting customer flow,
The number of transactions or the volume of services allows for adjusting scales and reducing both the...
Idleness versus overload. In restaurants, a lack of staff during peak hours leads to delays.
and errors; in stores, it reduces conversion and consultative service; in services, it compromises the
Punctuality increases cancellations. Forecasting by shift or by time of day brings Business closer
Analytics for workforce planning, even in small operations.
Human judgment, ultimately, needs to be preserved, but controlled. Owners and managers
They have access to information not captured by historical records: local events, climate change, reserves,
Menu changes, supplier delays, and the behavior of regular customers. This
Knowledge can improve forecasting when documented and evaluated. Without records, however,
Manual adjustments may only reproduce fear of disruption, excessive optimism, or recent memory.
Minimum governance requires comparing the original forecast, the adjustment made, the justification, and the...
subsequent real demand. With this, the experience ceases to be improvised and becomes integrated into the
organizational learning.

5 THEORETICAL-APPLIED MODEL FOR SMALL BUSINESSES

The adoption of demand forecasting should be understood as a gradual capacity building process.
analytical. The starting point is to consolidate sales, purchase, and inventory records,
Losses, schedules, categories, and channels. The more consistent the database, the lower the risk of...
Unstable forecasts. In food service operations, it is advisable to add data on menus and ingredients.
Critics, reservations, weather, and events; in services, the schedule and duration of the event should be observed.
Customer service, cancellations, and peak demand periods.
With the foundation in place, the company needs to define which decision it intends to prioritize. Purchases require...
Forecast by product, category, or critical input; production requires reading by shift, day of...
week and item with the highest turnover; the team scale depends on the flow, the number of transactions, the
average service duration and peak hours. This definition avoids generic predictions, which
They may be statistically interesting, but not very useful in daily practice.

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The next step is to select a method that is compatible with the level of information maturity.
Moving averages, weighted averages, and weekly seasonality can support the initial cycles.
Then, exponential smoothing, Holt-Winters, and regression allow for further refinement.
in-depth. Machine learning models can be incorporated in later phases, provided that
There needs to be a large volume of data, relevant variables, and validation capabilities. At any level, prediction...
It should be evaluated based on statistical metrics and operational indicators.
The estimate must then be converted into action. Predicting high demand should guide purchases.
Adjustments, team reinforcement, adequate preparation, or review of safety stock. Anticipate the drop.
It should support production reduction, loss control, negotiation with suppliers, or...
Implementation of targeted promotions. When the decision is not altered, the forecast remains as is.
A technical exercise with little managerial utility.
This cycle must be continually reviewed. The company records data, estimates demand, and makes decisions.
It executes, measures the error, and refines the model. Human adjustments may be permitted when necessary.
Relevant contextual information, provided it is documented and subsequently compared to
real result. Thus, forecasting becomes a learning routine, not a procedure.
isolated.

FINAL CONSIDERATIONS

Predictive analytics applied to small businesses is a relevant tool for...
Operational efficiency, financial control, and improved decision-making. By transforming
Using historical data in demand estimates reduces reliance on improvisation and supports decision-making.
Recurring costs related to purchasing, production, inventory, staffing, and capacity.
The literature reviewed demonstrates that small businesses already have, in many cases,
Minimum infrastructure to begin forecasting practices. POS systems, spreadsheets, records of
Inventory, loss reports, and service histories can support simple and useful models.
The central challenge lies less in the technology itself than in the standardization of data, in analytical routines, and...
in the integration between forecasting and decision-making.
More accurate forecasts can reduce waste and unmet demand, especially in
food operations. However, the model evaluation must consider inventory costs,
Seasonality, supply reliability, risk of disruption, and the economic impact of error.
Statistical accuracy alone does not guarantee a better decision when the costs of overestimating and overestimating are significant.
Downward movements are asymmetrical.

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Managerial judgment remains indispensable, but it needs to be disciplined. Experience

The practice complements models by incorporating unrecorded contextual information; without control,

This can introduce biases and amplify errors. Recording, justifying, and evaluating adjustments transforms intuition into...

organizational knowledge.

It can be concluded that demand forecasting is strategic because it brings expected consumption closer to the actual figures.

Resource allocation. When applied gradually, it is interpretable and linked to indicators.

operational efficiency reduces waste, stockouts, idle capacity, and idle capital, strengthening the...

Competitiveness of companies with limited resources.

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