How Can Generative AI Assist in Business Forecasting Techniques?

The Learning Ideas Conference 2025
June 11-13

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Objectives of the Study

- Explore how Generative AI enhances business forecasting.
- Apply human-AI interaction through prompt engineering and domain knowledge.
- Compare traditional vs. Gen AI-enhanced forecasting using a 1982 HBS telecom case.
- Empower small businesses under uncertainty.
- Future Research directions

Introduction to Forecasting

- Importance in strategic decision-making
- Limitations of traditional methods: rigid, backward-looking
- Rise of Gen AI in predictive analytics

Literature Insights

Forecasting techniques: Time Series, Regression, ARIMA.

AI's role: Real-time data, predictive analytics, decision-making support.

Importance of human-AI synergy & domain knowledge

The Case Study – ETPH (1982)

Telecom firm seeking FCC license in Cleveland.

Product: Cellular radio (innovative at the time).

Need: Demand projection under uncertainty.

Traditional Forecasting in the Case Study

Conducted by Digitron

Relied on survey data + static growth models (0.7%, 0.9%, 1.2%).

Used hyperbolic demand curve, S-curve for penetration.

Table 4: Market Demand Forecast for Cleveland Business Expected in 1984

Metric	Expected Case
No. of businesses	41,173
Demand %	21.2%
Potential customers	8,728
Units per customer	2.9
Total units (market)	25,313
Penetration	17.5%
Total demand (units)	4,430
ETPH market share (50%)	2,215

Limitations of Traditional Approach

- Assumed stable conditions
- No account for volatility or shocks
- Dependent on fixed penetration curves

Adoption of Generative AI across Industries and Functions Worldwide 2024

	Technology	Professional services	Advanced industries	Media and telecom	Consumer goods and retail	Financial services	Healthcare, pharma, and medical products	Energy and materials	Overall (%)
Marketing and sales	55	49	48	45	46	40	20	33	42
Product and/or service development	39	41	39	26	21	25	22	17	28
IT	31	16	26	22	20	24	30	26	23
Service operations	30	23	24	37	13	26	14	13	22
Knowledge management	26	34	17	26	12	16	24	13	21
Software engineering	36	9	17	30	8	20	13	8	18
Human resources	16	17	13	22	8	11	7	16	13
Risk, legal, and compliance	12	9	6	6	11	21	5	9	11
Strategy and corporate finance	14	14	21	10	7	7	6	5	11
Supply chain/inventory management	10	4	15	3	14	4	2	6	7
Manufacturing	5	3	13	3	8	0	5	7	5
Using gen AI in at least one function	88	80	79	79	68	65	63	59	71

Source: Statista (2024) www.statista.com

“Prompt Engineering” Skills +Domain Knowledge

“Prompt engineering” refers to writing instructions, refining and accomplishing results from outputs of Generative AI applications.

Introducing AI-Based Forecasting

- Prompted GPT-4o for alternative methods
- Suggested ARIMA as more robust
- Simulated data used due to missing historical input

Role of Generative AI

Uses ChatGPT-4o for simulation, guidance, refinement

Prompt engineering as a skill to guide outputs

Overcomes traditional forecasting constraints

ARIMA-Based Forecast Steps

1. Simulate historical data (1970–83)
2. Check for stationarity
3. Fit ARIMA (1,1,1) model
4. Generate forecast (1984–1994)
5. Replace static values in original case model

AI Generated Step by Step Process with Data for Time Series Based ARIMA Forecasting Method

Step no.	Item of action	Process and data details
1	Gather Historical Time-Series Data	Ideally, actual monthly or annual business formation data for Cleveland SMSA (1970–1983) from U.S. Census or Bureau of Labor Statistics (BLS) should be used as historical data. In the absence of original data in the case study studied [6], simulated data has been used for generating time series based ARIMA forecasting. Please see Appendix.
2	Check for Stationarity	Apply the Augmented Dickey-Fuller (ADF) test. Details are provided in the Appendix.
3	Fit ARIMA model	Apply the ARIMA model. Details are provided in the Appendix.
4	Generate Forecasts (1984–1994)	Forecast the number of businesses for 11 years ahead. Details are provided in the Appendix.
5	Plug into Original Model of the case study	Replace the original fixed growth rates with ARIMA-predicted values. Keep other assumptions constant (e.g., units/customer = 2.9, price-demand curve, penetration curves). Details are provided in the Appendix.

Cumulative Impact of Generative AI based ARIMA model forecast

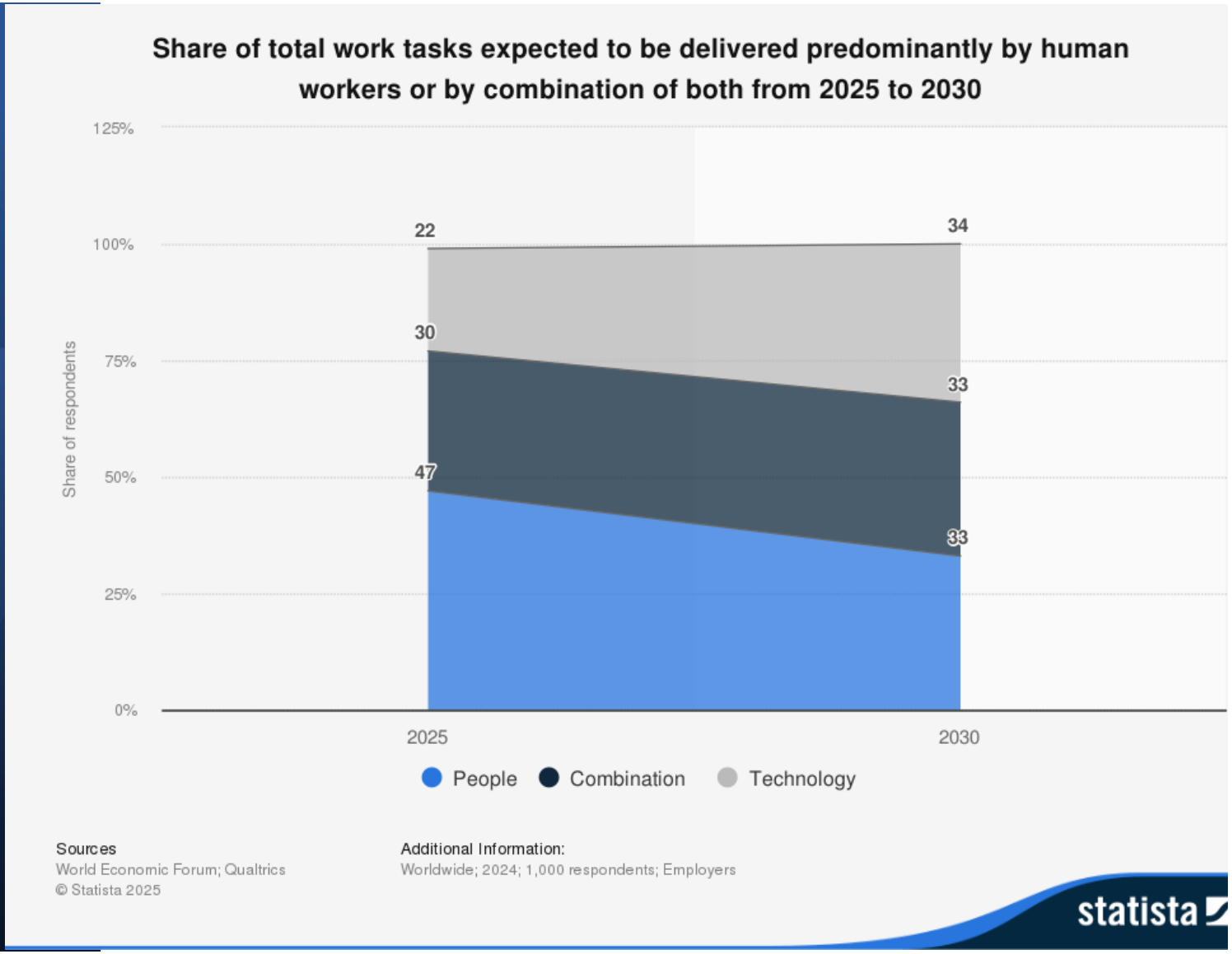
- Gen AI forecasts more conservative in early years
- Converges by 1994 with case study forecasts
- Realistic-Better suited to reflect Cleveland's economic downturn

Critical for refining AI outputs- Prompt Engineering and Domain Knowledge

Iterative prompts led to model design, scenario building.

Human-AI synergy ≠ automation, it's augmentation.

Human – AI Interaction- From Automation to Augmentation



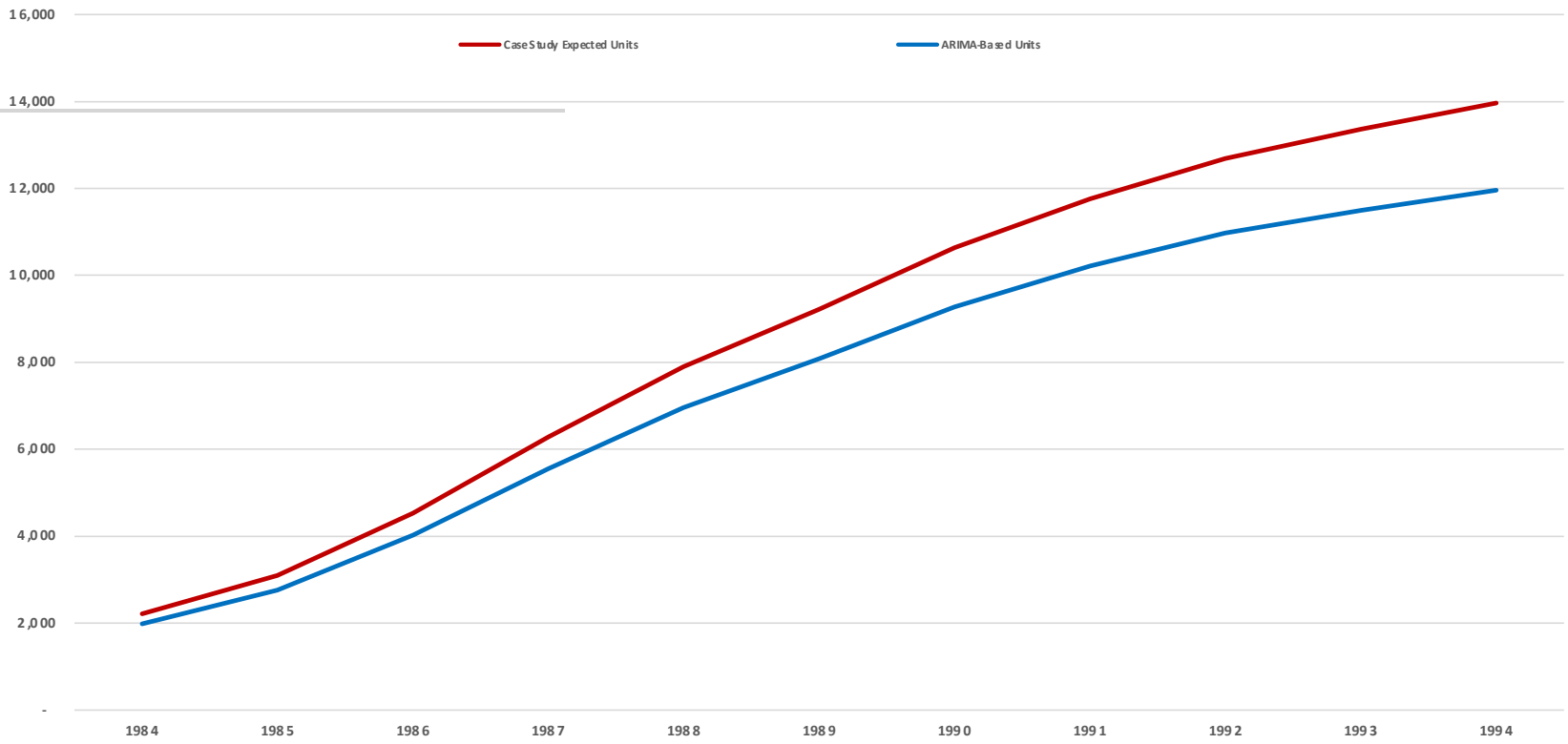
ETPH Forecast Model (original case study) with ARIMA-Based Business Projections (1984–1994).

Year	Projected Businesses	% Demand	Potential Customers	Units/Customer	Total Potential Units	% Penetration	Estimated Market Demand	ETPH Market Share	ETPH Estimated Units
1984	36882.26867	21.2	7819.040958	2.9	22675.21878	17.5	3968.163286	50	1984.081643
1985	37061.93091	21.4	7931.253215	2.9	23000.63432	24	5520.152238	50	2760.076119
1986	37239.02399	21.6	8043.629182	2.9	23326.52463	34.5	8047.650997	50	4023.825499
1987	37413.58465	21.8	8156.161455	2.9	23652.86822	47	11116.84806	50	5558.424031
1988	37585.64911	22	8268.842804	2.9	23979.64413	58	13908.1936	50	6954.096798
1989	37755.25305	22.2	8381.666178	2.9	24306.83192	66.5	16164.04322	50	8082.021612
1990	37922.43167	22.5	8532.547126	2.9	24744.38667	75	18558.29	50	9279.145
1991	38087.21965	22.7	8645.79886	2.9	25072.81669	81.5	20434.3456	50	10217.1728
1992	38249.65116	23	8797.419767	2.9	25512.51733	86	21940.7649	50	10970.38245
1993	38409.75992	23.2	8911.064301	2.9	25842.08647	89	22999.45696	50	11499.72848
1994	38567.57913	23.5	9063.381095	2.9	26283.80518	91	23918.26271	50	11959.13136

Divergence in case study and AI- based ARIMA Forecasts of forecasted demand during 1984-1994

Year	Projected Businesses	Case Study Expected Units	ARIMA-Based Units	Difference (ARIMA - Case Study)
1984	36882.26867	2215	1984.081643	-230.9183568
1985	37061.93091	3094	2760.076119	-333.9238812
1986	37239.02399	4529	4023.825499	-505.1745015
1987	37413.58465	6284	5558.424031	-725.5759686
1988	37585.64911	7896	6954.096798	-941.9032018
1989	37755.25305	9217	8082.021612	-1134.978388
1990	37922.43167	10631	9279.145	-1351.855
1991	38087.21965	11760	10217.1728	-1542.827198
1992	38249.65116	12686	10970.38245	-1715.61755
1993	38409.75992	13362	11499.72848	-1862.27152
1994	38567.57913	13964	11959.13136	-2004.868645

Case study expected units vs ARIMA-based units



Time Series Methods for Small Businesses

Scalable, interpretable, cost-effective.

Tools: Exponential Smoothing, ARIMA and others.

Help businesses prepare for uncertainty.

Conclusion – Key Takeaways

- Forecasting can be made more realistic via AI.
- Historical models + Gen AI = new hybrid.
- Small businesses benefit from accessible forecasting.
- Prompt engineering and domain Knowledge bridge the gap.

Future Research Directions

Study	Compare	Build- Automation to Augmentation
Study profitability and performance under AI-based planning	Compare different Gen AI models and forecasting accuracy	Build prompt engineering curriculum and domain knowledge for business education

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Thank you

For Further questions/comments/collaboration please email : **smg6870@psu.edu**