Probabilistic forecasting and Demand Driven: Roughly right much better than precisely wrong

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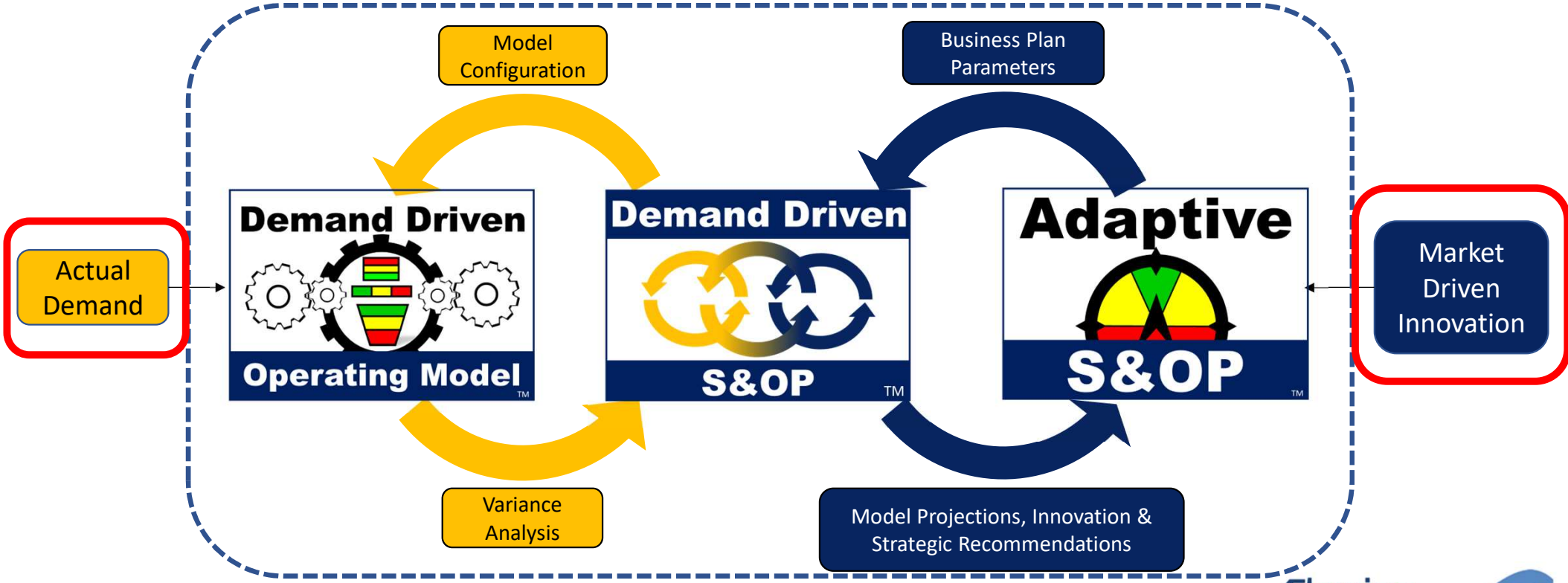
The need to forecast



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Demand Driven Adaptive Enterprise Model

FDU DEMAND PLAN

- Obviously in the future
- It is unavoidable to make predictions/fore casts/estimates: FDU and demand plans

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The uncertain nature of the future

- "If there's one thing that's safe in business, it's uncertainty." Stephen Covey
- "Trying to predict the future is like trying to drive on a country road, at night, without lights and looking in the rearview mirror." Peter Drucker
- “Maturity, one discovers, has everything to do with the acceptance of not knowing.” Mark Z. Danielewski,

And on and on…

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WHY: Current deterministic approaches: An ontological contradiction

- Ontology: “A set of concepts and categories in a subject area or domain that shows their properties and the relations between them”.
- A basic concept about the future is that it is inherently uncertain and probabilistic.
- Then, using a deterministic approach to explore the future is a clear ontological contradiction.
- The mathematical probability of hitting a single number forecast is equal to zero.
- “Roughly right is much better than precisely wrong”.

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Forecasts: Probabilistic vs. Deterministic

- Traditional forecasting models are based on time series, exponential smoothing, linear regression, etc.
- Even more, in recent years, they have been "improved" using AI, ML and neural networks.
- The result continues to be a single deterministic number.
- This is improving something that should not be done in the first place
- “Is much better to do the right things wrong than the wrong things right”: Peter Drucker

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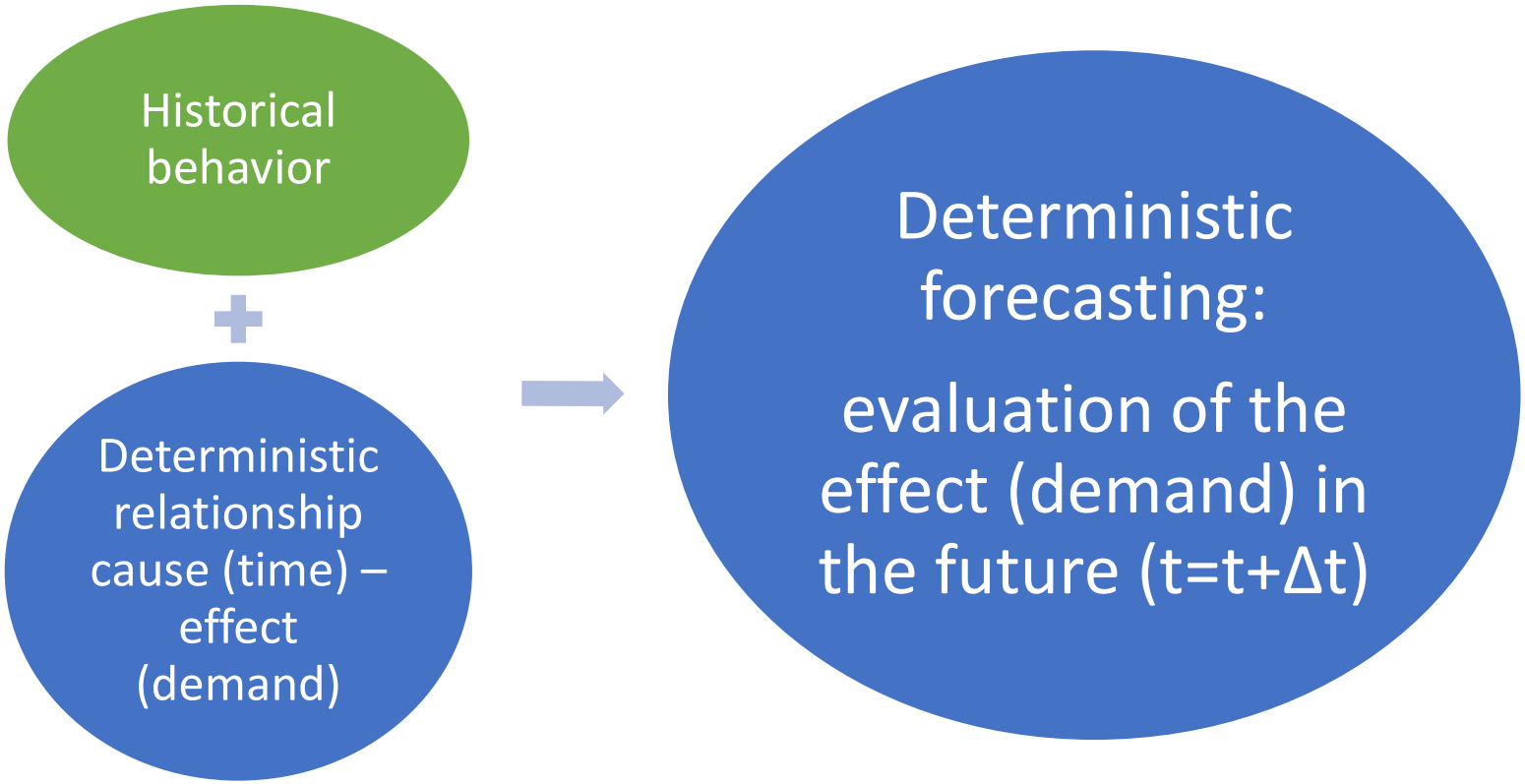
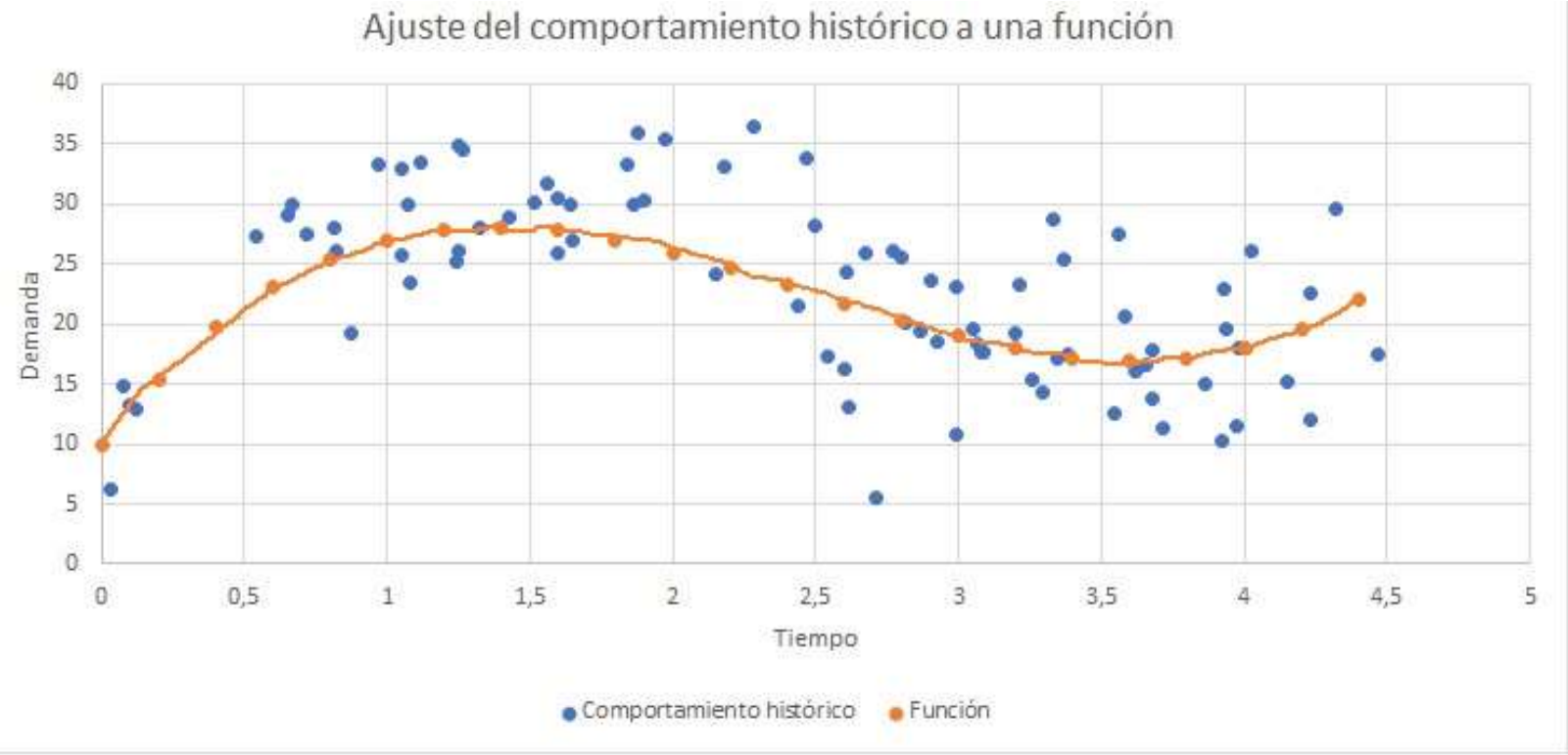
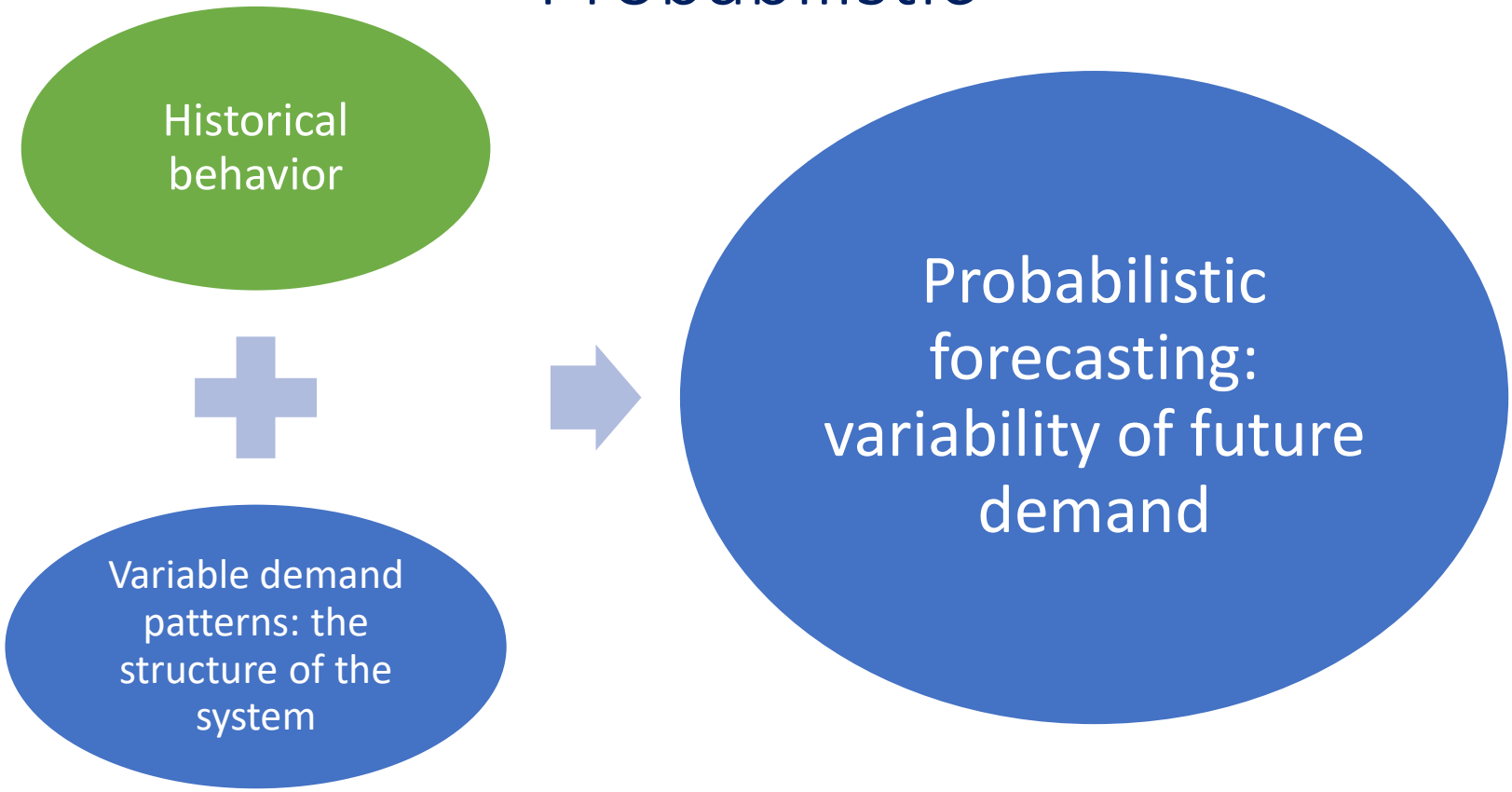
Deterministic versus probabilistic forecasting: Deterministic



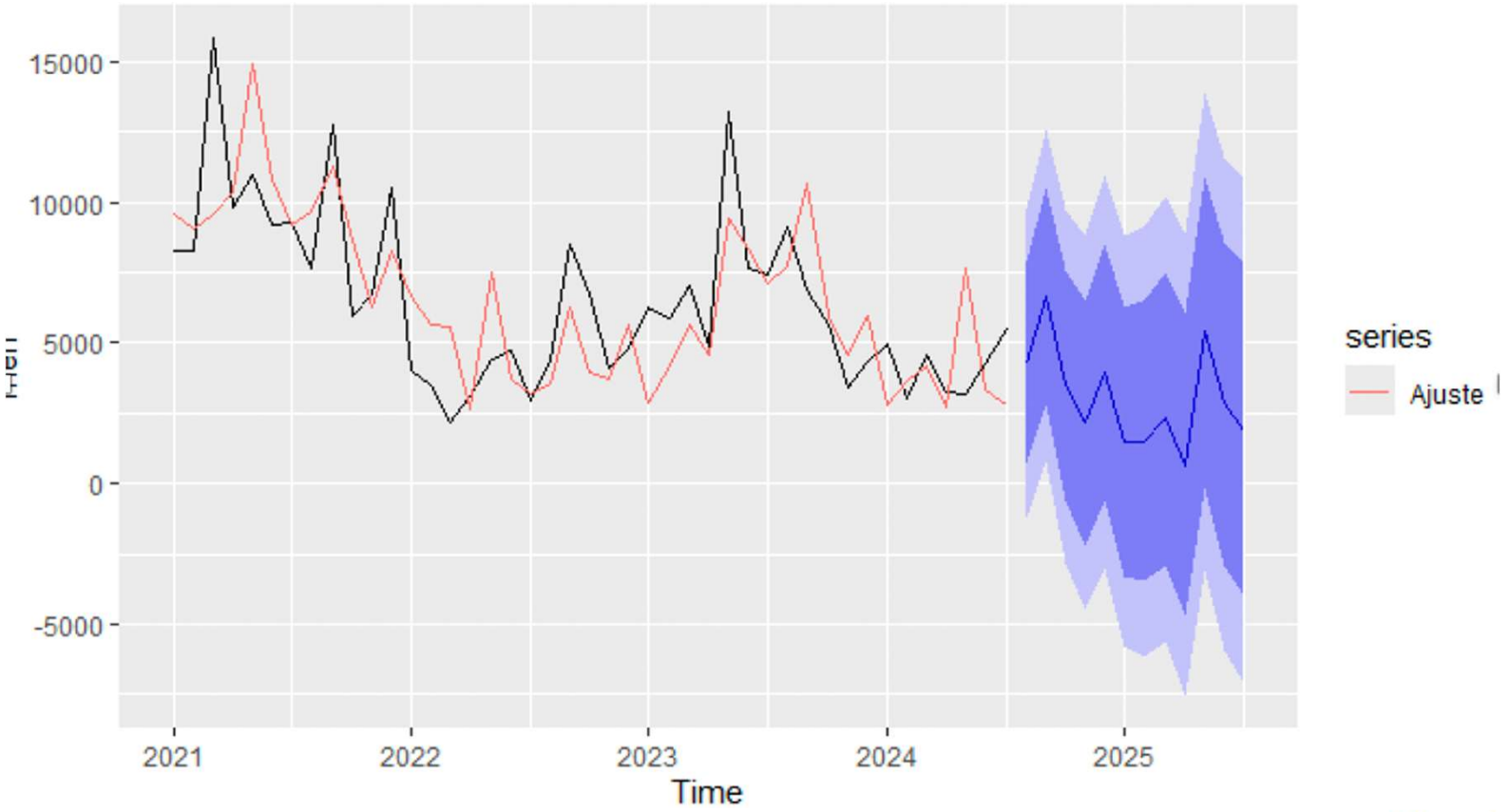
Deterministic nature of forecasting



Deterministic versus probabilistic forecasting: Probabilistic



Forecasts: the reality



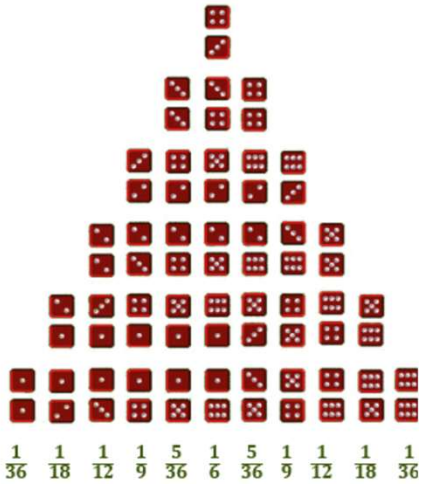
Deterministic versus probabilistic forecasting:

STATISTICAL

PROBABILISTIC

THROW 2 DICE

7



Error = 37%

Error = 0%

PRECISE

ACCURATE

Source: https://www.linkedin.com/pulse/primer-probabilistic-planning-forecasting-stefan-de-kok/

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WHAT: Probabilistic forecasts:

- Predictions about future events: there will always be uncertainty
- Based on the probability of occurrence of different outcomes
- Provide a probability distribution based in the identification of demand patterns
- This is what AI/ML do: identify and use patterns in order to predict the future
- Show the possible outcomes along with their probability of occurrence.

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HOW: Probabilistic forecasting – A systems dynamics approach

- Systems theory shows that systems behavior is determined largely by the system structure.
- In deterministic forecasting, the behavior is determined by time
- An analogy: if someone throws a stone in the air, is it time that defines its trajectory?
- It is defined by the initial impulse, the angle of launching, the force of gravity and the resistance of the air. NOT time.
- Time is simply the entity in which we perceive the behavior: it does not determine its behavior.

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Probabilistic forecasting – A systems dynamics approach

- The core question: what is the underlying structure of demand systems?
- From the same analogy of the stone: what determines the demand we perceive in time?
- The way customers buy
- It is materialized by the "Demand Patterns": quantity and frequency of each order.
- Then, we need to understand how those demand patterns are.

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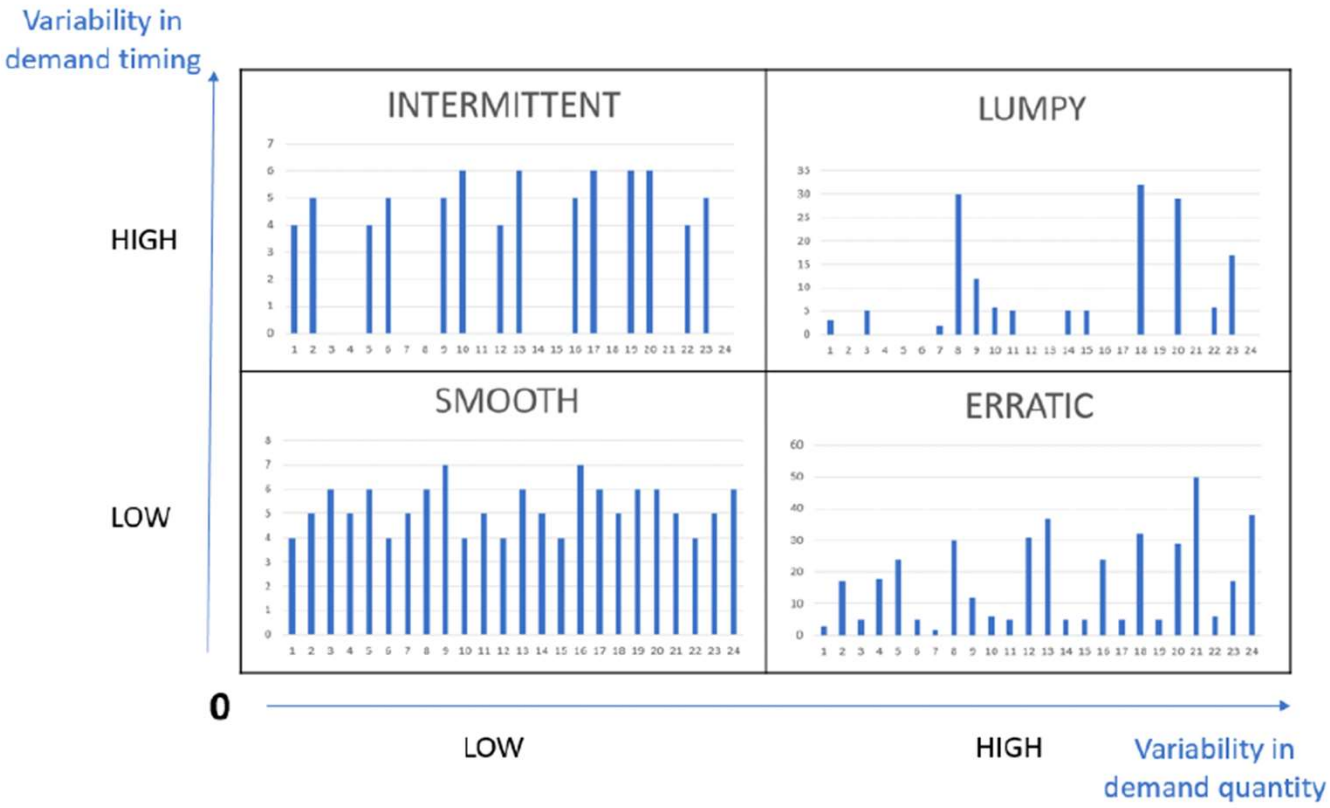
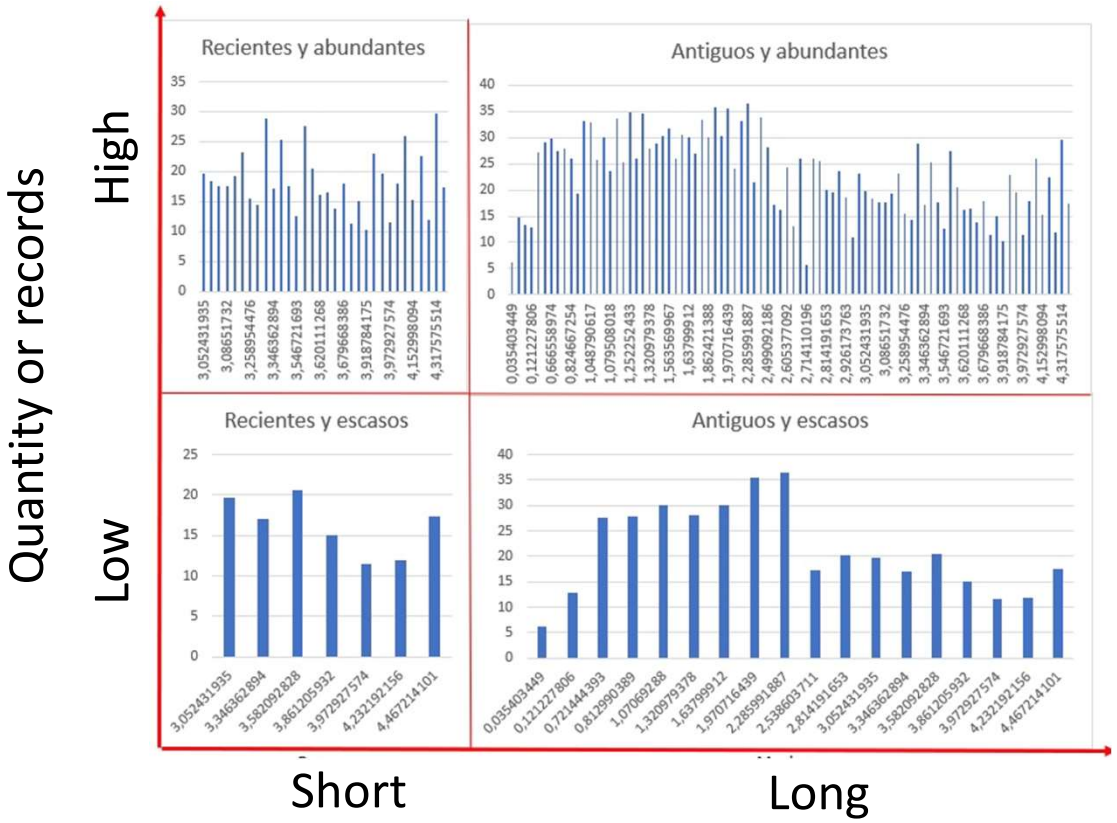
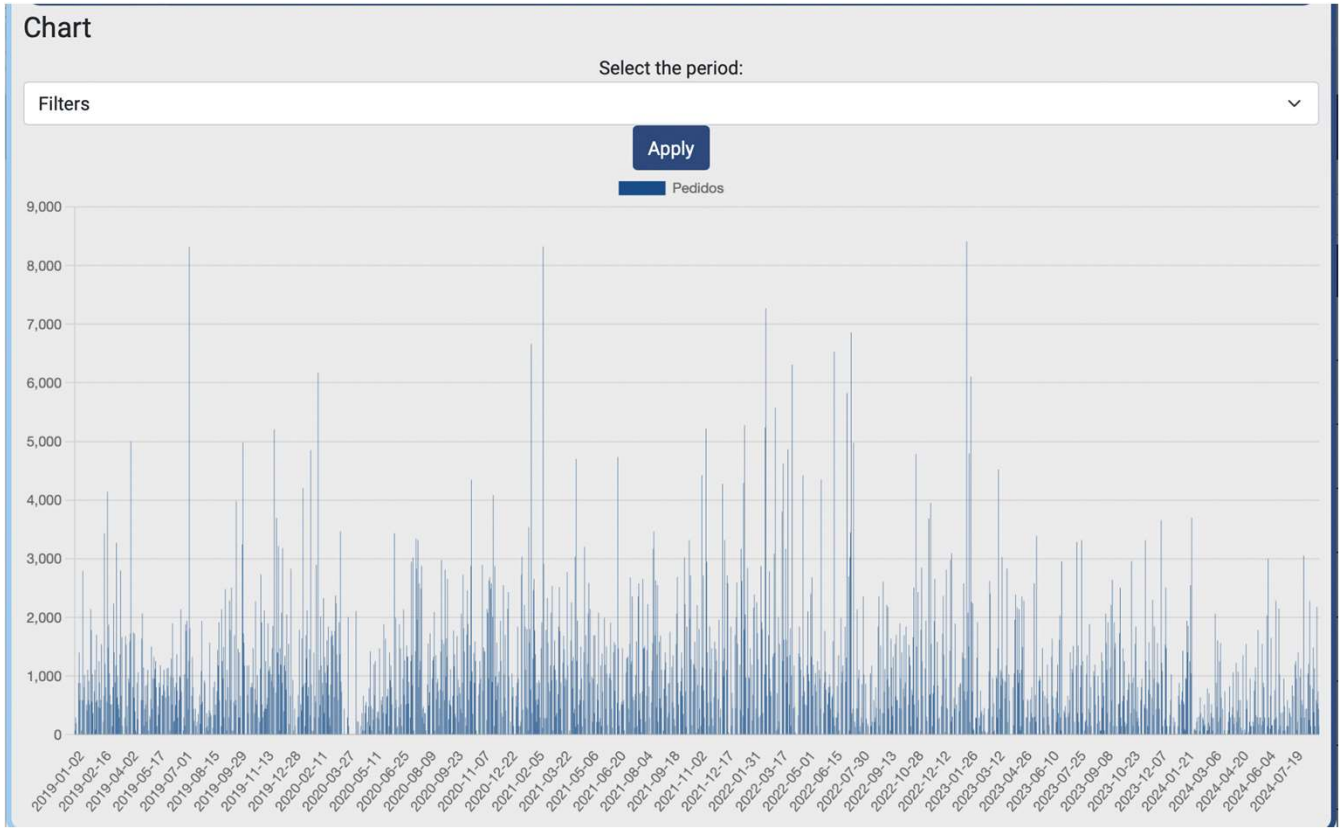
Probabilistic forecasting: demand patterns



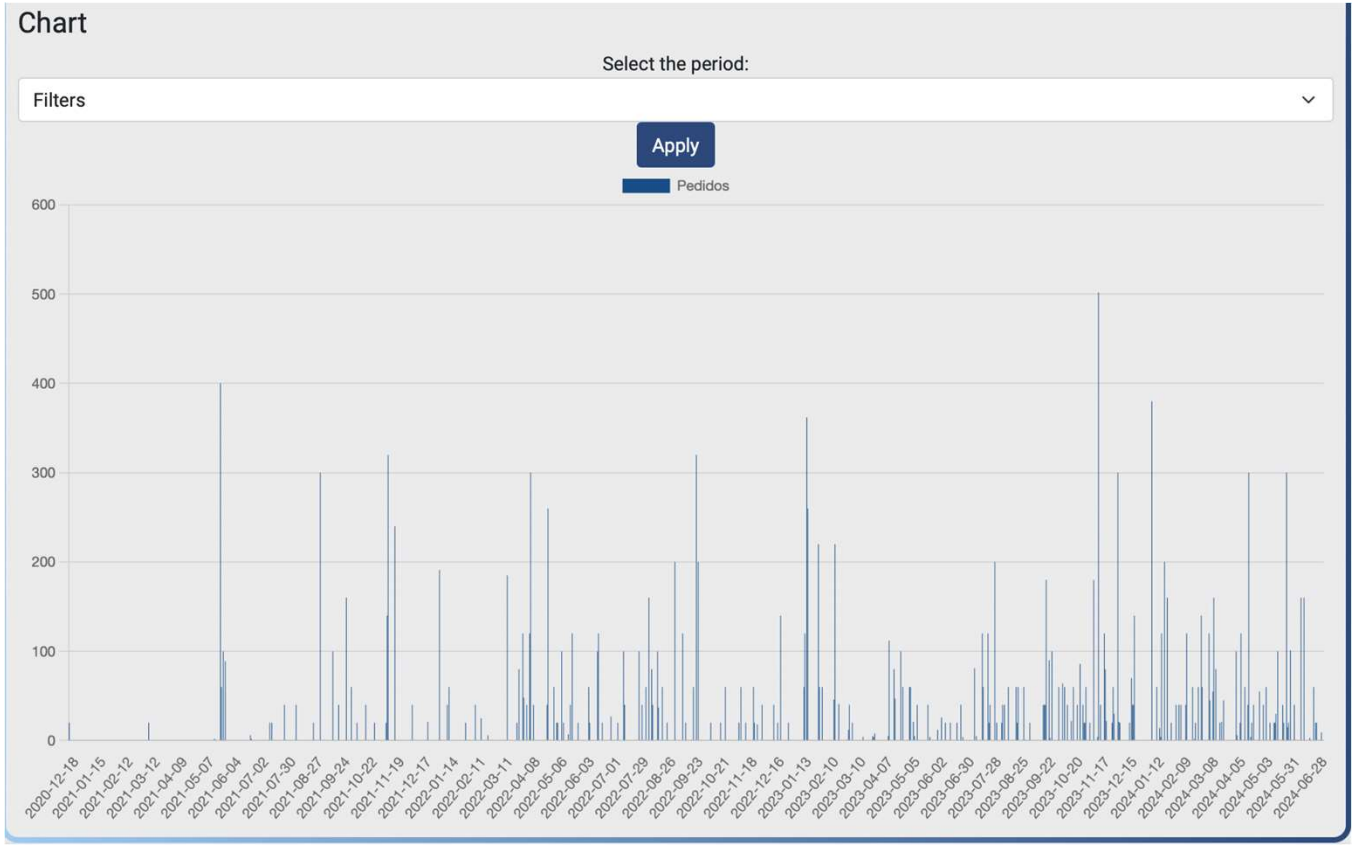
Probabilistic forecasting: demand patterns



Demand patterns



Demand patterns



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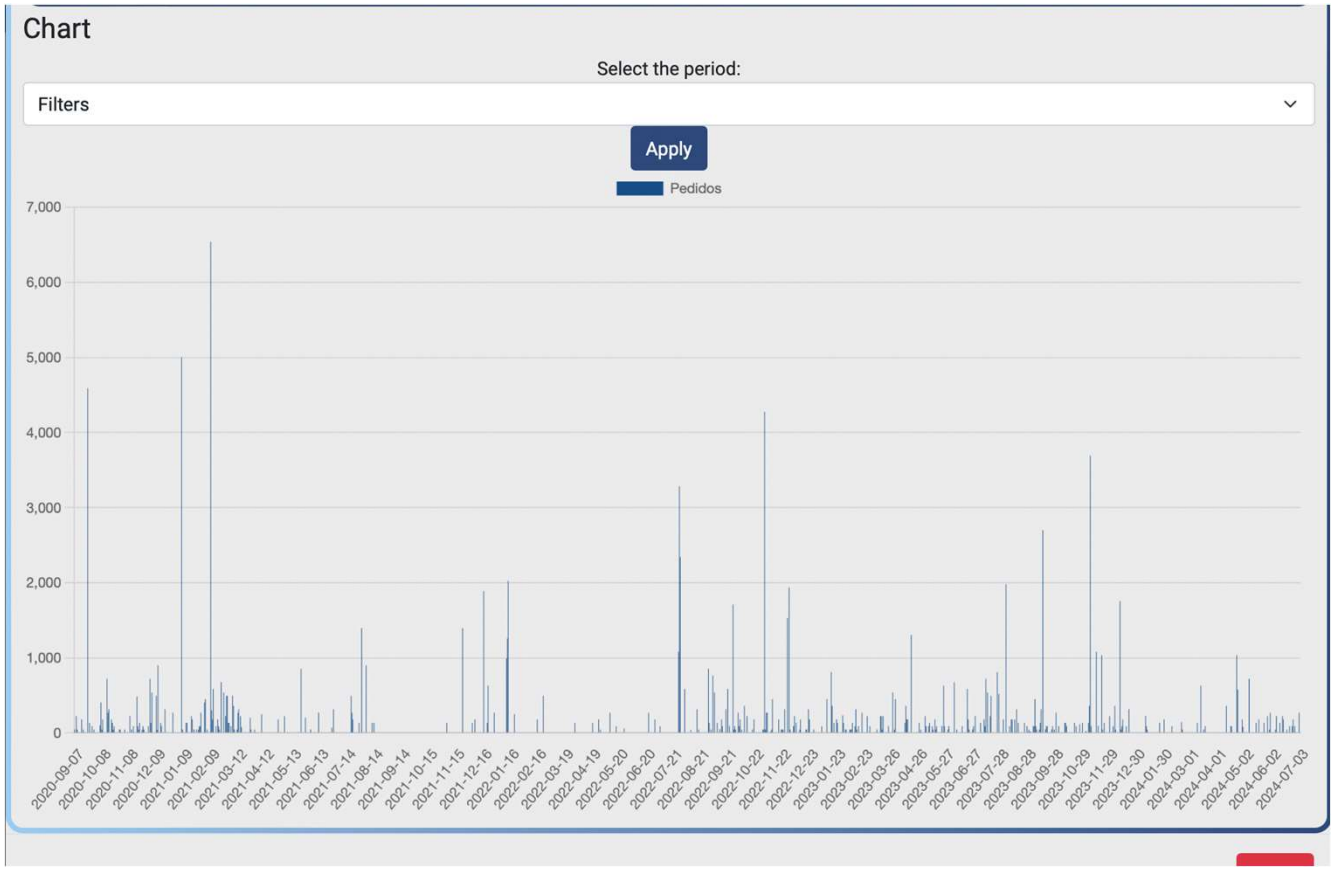
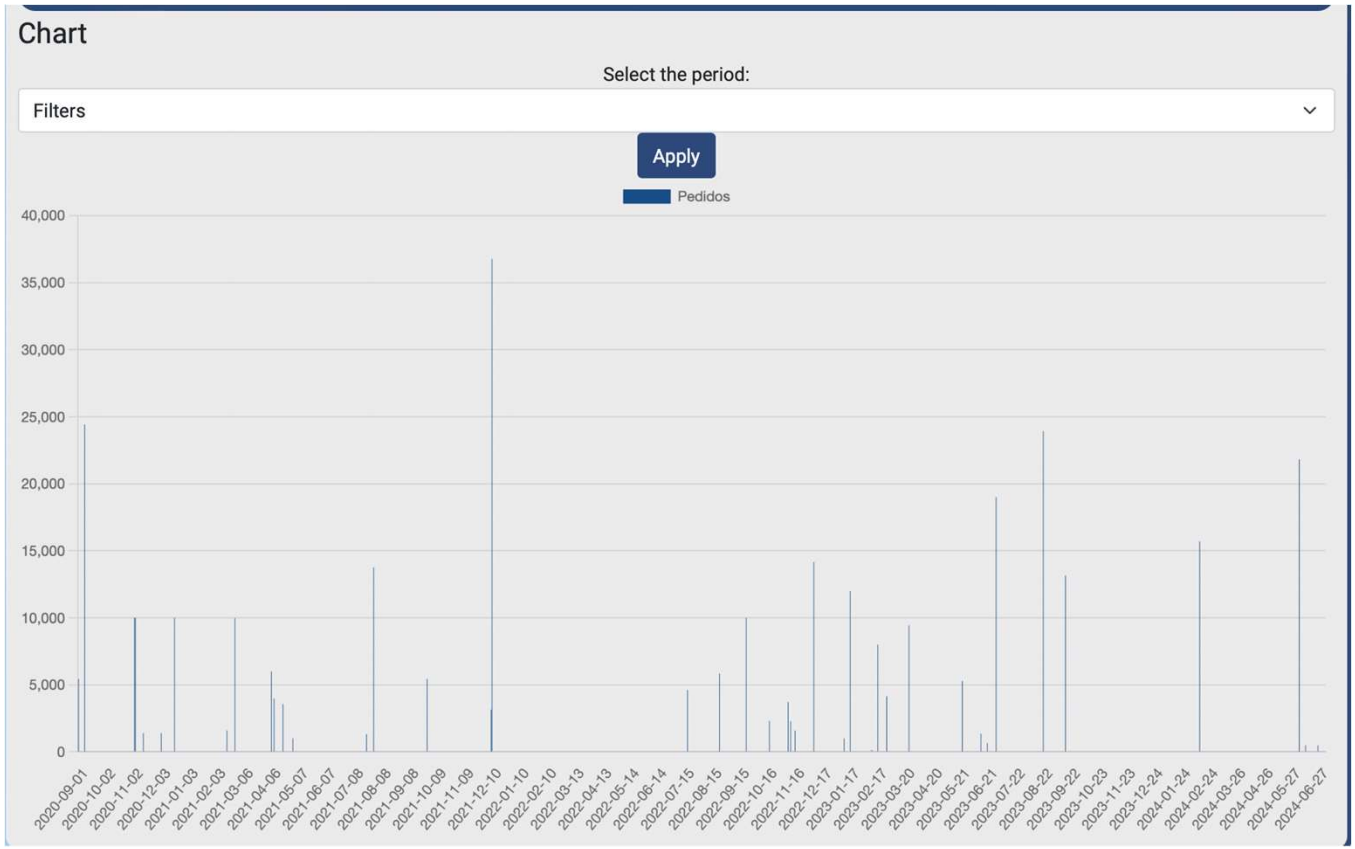
Demand patterns

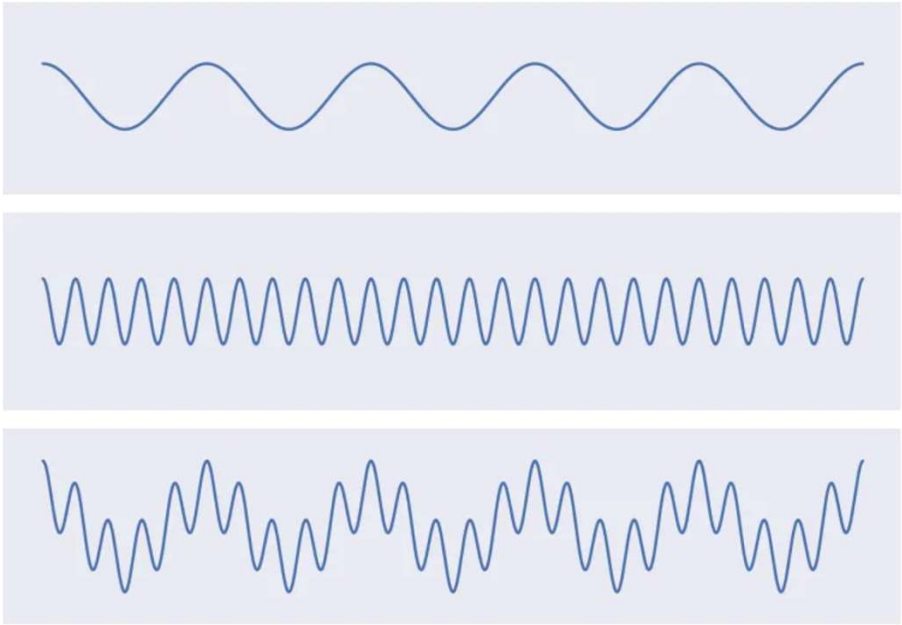


Demand patterns

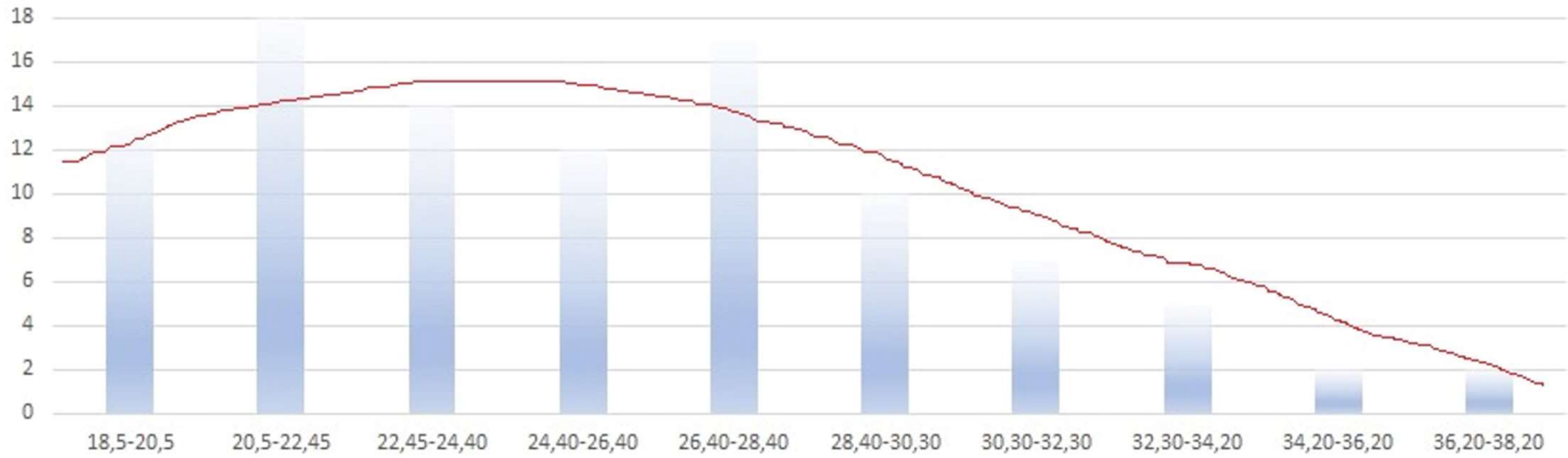


Probabilistic forecasting: demand patterns

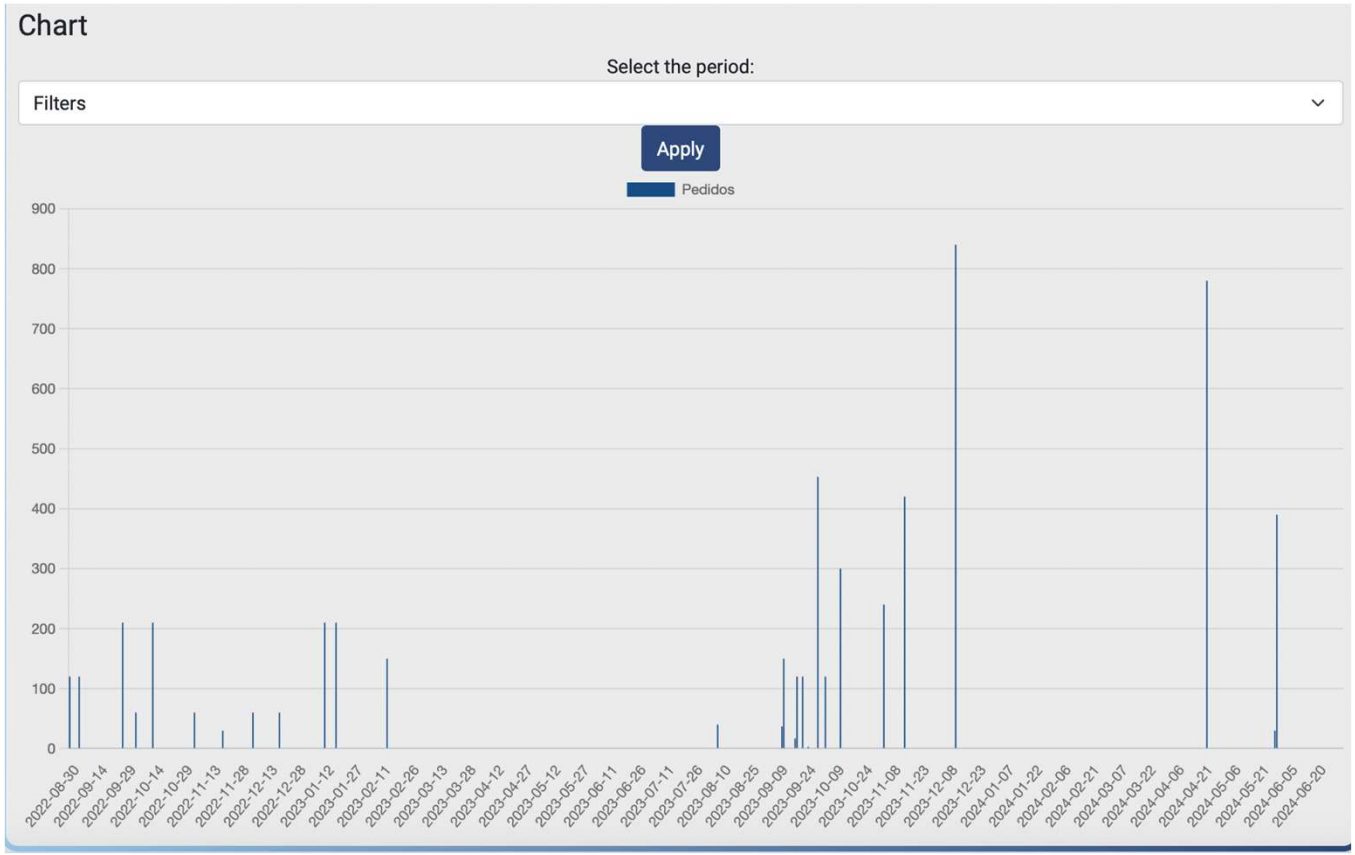
- Total SKU demand is the aggregation of all client's demand
- Each client has its demand pattern.
- A seemingly complicated wave function can be expressed as the sum of simpler functions



Historic Demand Histogram



¿What is forecastable?



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Improvements in demand planning process with the probabilistic approach

- The purpose of the demand planning process is to make decisions about the amount of supply.
- Having different levels of probability of demand allows the planners to observe which percentile has been consolidating recently
- Allows planners to make a much more informed decision
- Allows companies to set policies to deal with risk: Take a risk position

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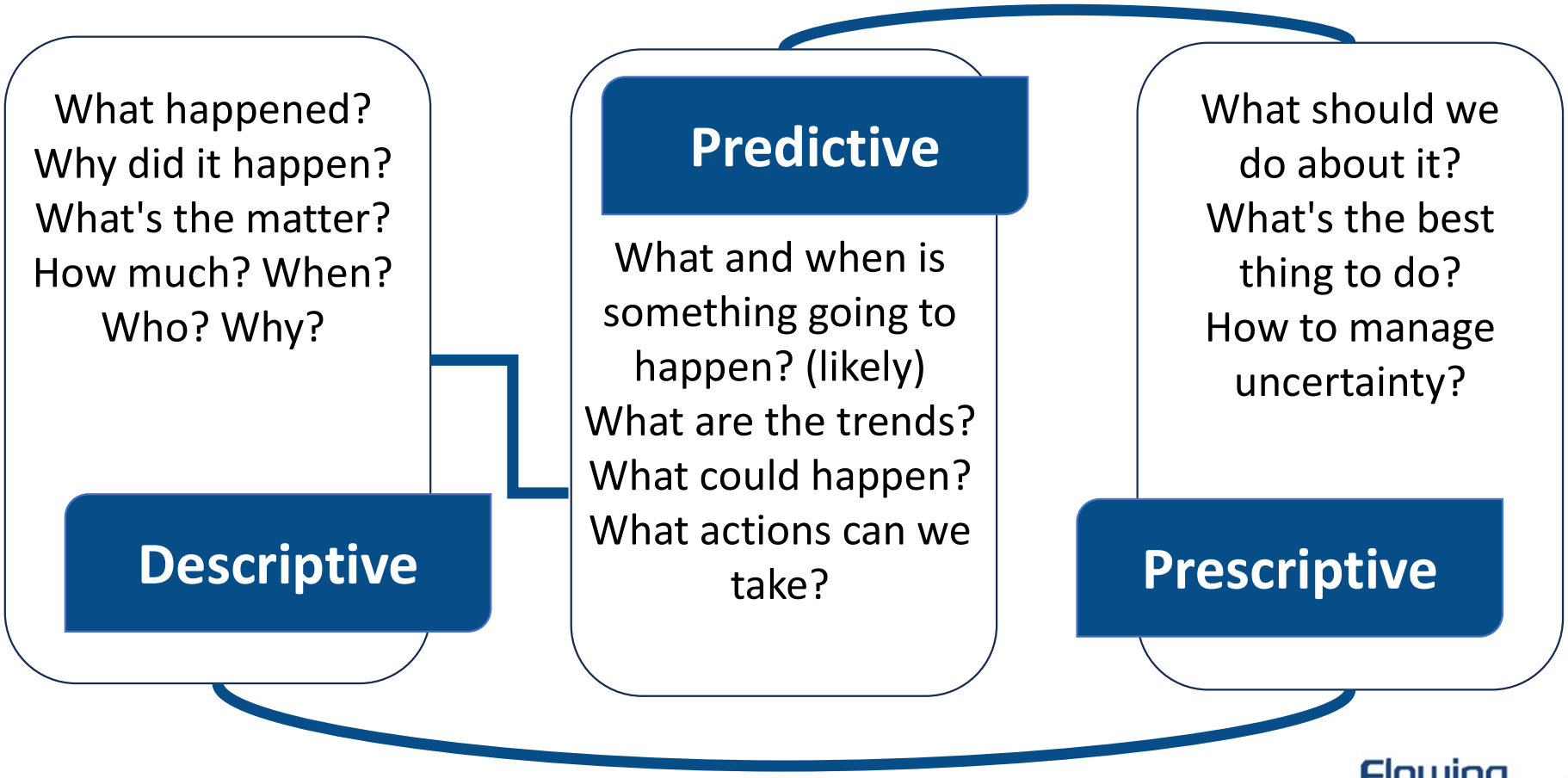
Types of analytics



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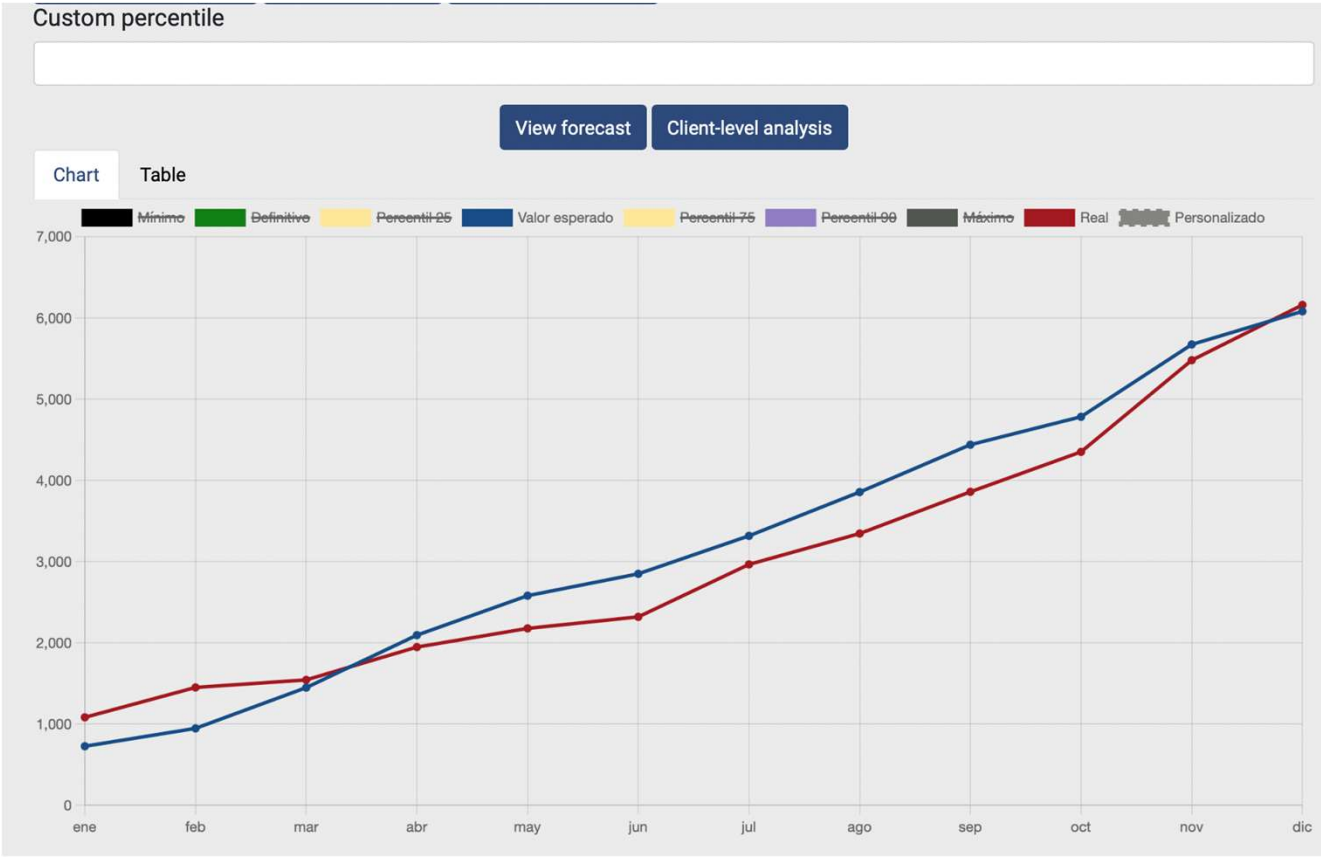
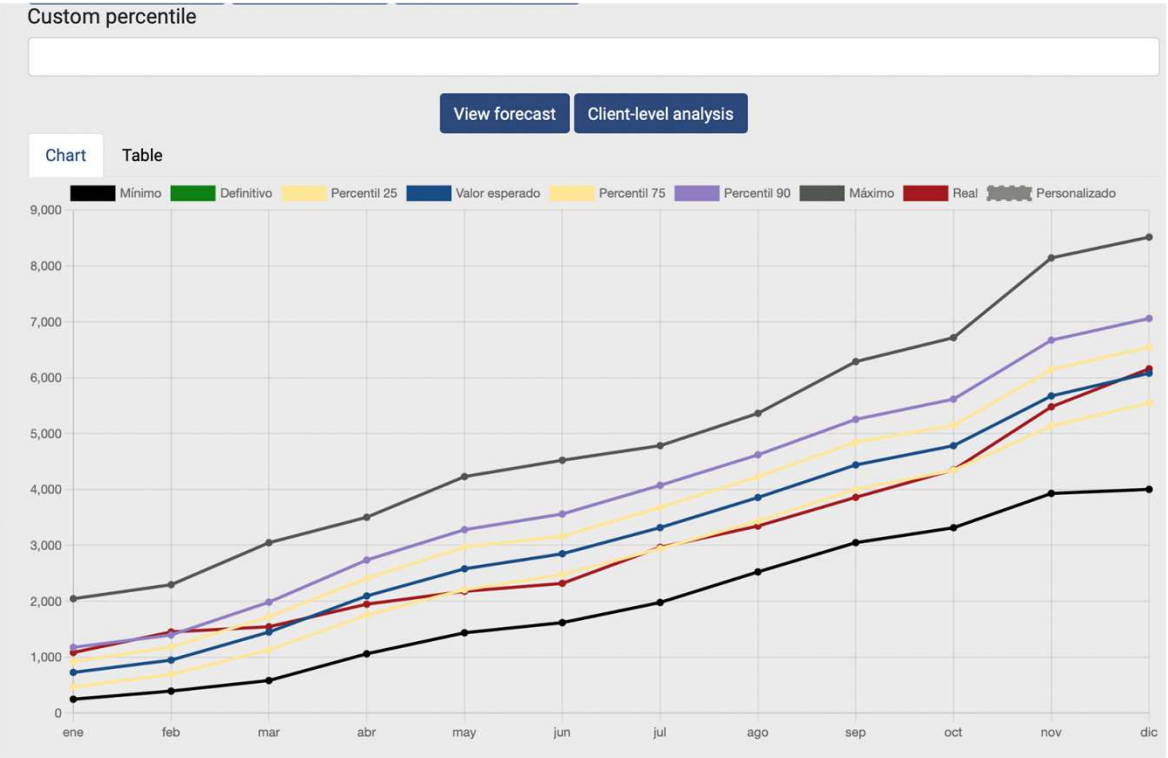
Deterministic: predictive

Probabilistic has richer information: prescriptive

Deterministic: predictive



Probabilistic has richer information: prescriptive



MAPE for different percentiles

CV de los pedidos (%)	CV de la frecuencia (%)	MAPE Acumulado (Enero - Julio)						
		MAPE mínimo	MAPE percentil 25	MAPE valor esperado	MAPE percentil 75	MAPE máximo	Menor MAPE	Percentil correspondiente
94.32	59.93	11.5%	37.3%	44.3%	51.9%	78.6%	11.5%	MAPE minimo
109.83	65.09	17.4%	1.3%	6.7%	11.7%	36.9%	1.3%	MAPE percentil 25
96.27	56.20	12.5%	37.4%	44.5%	51.1%	79.1%	12.5%	MAPE minimo
87.59	57.15	30.8%	59.9%	68.1%	75.2%	108.1%	30.8%	MAPE minimo
82.07	59.92	9.2%	26.9%	32.1%	37.5%	55.8%	9.2%	MAPE minimo
82.68	59.42	8.8%	5.7%	10.5%	15.1%	29.4%	5.7%	MAPE percentil 25
122.75	96.18	13.4%	83.8%	107.3%	129.9%	200.4%	13.4%	MAPE minimo
74.78	58.65	6.3%	10.0%	14.6%	19.3%	38.9%	6.3%	MAPE minimo
68.80	51.69	7.9%	3.3%	7.2%	11.2%	26.7%	3.3%	MAPE percentil 25
68.43	51.35	15.4%	2.9%	0.7%	4.2%	17.2%	0.7%	MAPE valor esperado
114.13	69.04	13.5%	0.3%	5.9%	11.3%	46.2%	0.3%	MAPE percentil 25
107.38	85.77	28.2%	8.6%	2.5%	3.3%	28.1%	2.5%	MAPE valor esperado
96.79	70.38	20.7%	2.5%	2.8%	7.8%	24.7%	2.5%	MAPE percentil 25
112.30	111.48	49.1%	7.6%	10.4%	26.1%	124.7%	7.6%	MAPE percentil 25
92.92	68.10	12.7%	11.3%	16.6%	22.0%	42.9%	11.3%	MAPE percentil 25
93.11	59.13	1.4%	13.9%	19.4%	24.2%	45.8%	1.4%	MAPE minimo
152.09	101.57	5.5%	61.7%	85.2%	108.7%	181.4%	5.5%	MAPE minimo
95.27	71.61	2.2%	15.4%	20.6%	26.3%	46.4%	2.2%	MAPE minimo
97.93	66.58	8.3%	12.9%	19.7%	25.8%	51.5%	8.3%	MAPE minimo
67.40	51.02	16.0%	5.3%	1.7%	1.6%	12.2%	1.6%	MAPE percentil 75
171.28	78.58	23.5%	4.2%	12.7%	21.3%	47.6%	4.2%	MAPE percentil 25
124.73	75.18	29.8%	12.4%	6.5%	1.1%	20.0%	1.1%	MAPE percentil 75
126.57	100.38	12.0%	54.9%	81.0%	107.6%	242.8%	12.0%	MAPE minimo

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MAPE for different percentiles: Forecastability

Días histórico	Días con pedido	CV de los pedidos (%)	CV de la frecuencia (%)	MAPE Acumulado (Enero - Agosto)					Menor MAPE	Percentil correspondiente
				MAPE mínimo	MAPE percentil 25	MAPE valor esperado	MAPE percentil 75	MAPE máximo		
2,068	1,554	94.43	59.72	6.5%	27.9%	34.0%	40.1%	60.0%	6.5%	MAPE minimo
2,066	1,443	110.00	65.04	23.9%	6.3%	1.4%	3.2%	24.8%	1.4%	MAPE valor esperado
2,067	1,637	96.29	55.95	6.8%	28.9%	35.0%	40.8%	64.1%	6.8%	MAPE minimo
2,067	1,635	87.77	56.89	32.3%	53.1%	60.0%	66.3%	92.4%	32.3%	MAPE minimo
2,067	1,615	82.13	59.65	6.7%	23.8%	28.6%	33.3%	49.3%	6.7%	MAPE minimo
2,066	1,563	82.32	59.38	13.3%	1.1%	5.3%	9.4%	23.5%	1.1%	MAPE percentil 25
2,053	681	123.36	95.89	18.4%	88.8%	111.1%	134.3%	221.2%	18.4%	MAPE minimo
2,066	1,590	74.65	58.52	3.0%	9.4%	13.7%	17.7%	33.8%	3.0%	MAPE minimo
2,069	1,679	68.81	51.47	9.2%	0.6%	4.4%	8.4%	21.9%	0.6%	MAPE percentil 25
2,068	1,651	68.39	51.22	15.5%	3.1%	0.3%	3.3%	16.4%	0.3%	MAPE valor esperado
2,066	1,411	113.77	68.89	15.2%	0.4%	5.0%	10.2%	35.3%	0.4%	MAPE percentil 25
2,068	1,375	107.19	85.35	24.2%	7.3%	1.5%	3.8%	25.2%	1.5%	MAPE valor esperado
2,067	1,493	96.36	70.35	18.1%	2.4%	2.2%	6.7%	22.7%	2.2%	MAPE valor esperado
2,066	467	111.43	111.15	46.3%	0.5%	19.1%	35.3%	116.7%	0.5%	MAPE percentil 25
2,066	1,450	92.67	68.00	15.1%	5.1%	10.0%	14.7%	30.6%	5.1%	MAPE percentil 25
2,068	1,574	93.24	58.96	0.8%	15.8%	20.2%	24.6%	44.1%	0.8%	MAPE minimo
2,060	546	152.80	101.21	27.8%	26.3%	44.1%	63.3%	132.2%	26.3%	MAPE percentil 25
2,067	1,474	95.28	71.35	4.5%	17.7%	23.4%	29.0%	47.7%	4.5%	MAPE minimo
2,066	1,450	97.99	66.54	3.1%	17.2%	23.2%	28.8%	52.2%	3.1%	MAPE minimo
2,068	1,671	67.42	50.81	17.3%	5.9%	2.6%	0.3%	9.9%	0.3%	MAPE percentil 75
2,068	1,144	175.89	78.44	22.7%	0.1%	8.0%	15.4%	41.1%	0.1%	MAPE percentil 25
2,068	1,515	123.96	74.96	30.1%	9.2%	3.3%	2.5%	23.1%	2.5%	MAPE percentil 75
2,067	603	126.41	99.81	17.7%	34.6%	56.6%	78.4%	181.8%	17.7%	MAPE minimo

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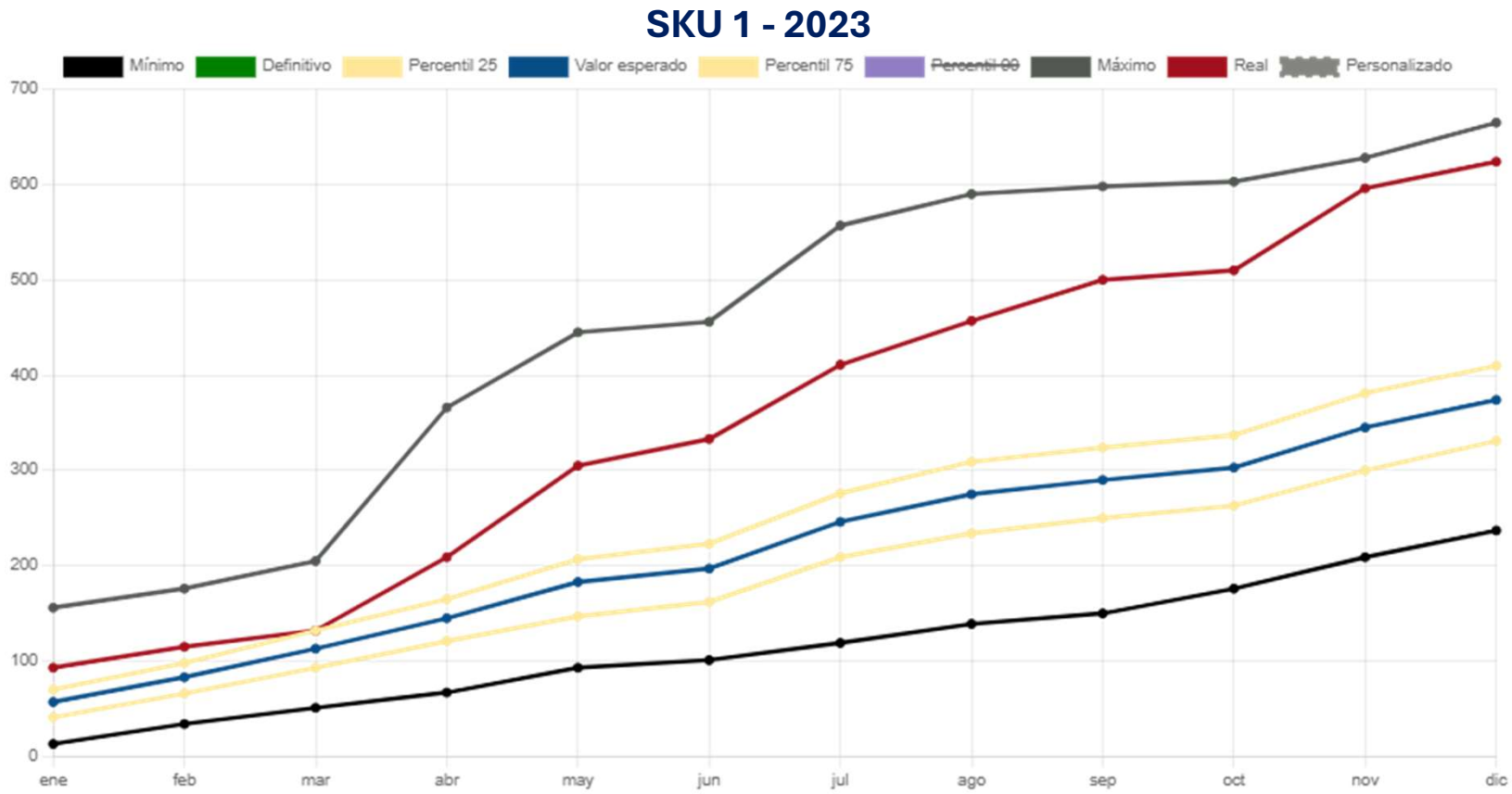
Probabilistic Forecast – The structure of the system



MAPE VALUES

SKU 1

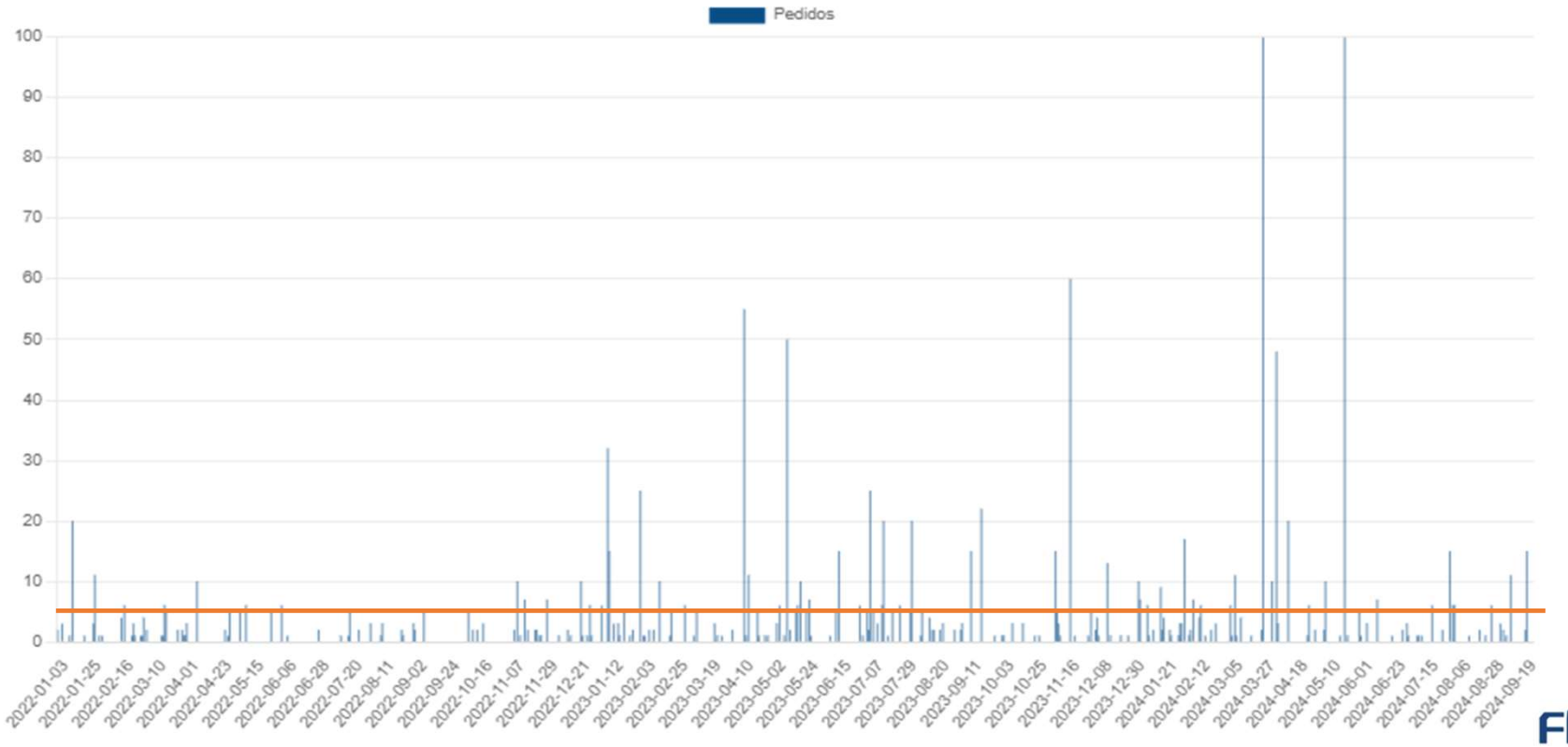
Cumulative forecast 2023:

Días histórico	Días con pedido	CV de pedidos (%)	CV de frecuencia (%)	MAPE mínimo	MAPE percentil 25	MAPE valor esperado	MAPE percentil 75	MAPE máximo	Menor MAPE	Percentil correspondiente	
995	232	199,63%	93,29%	62,02%	46,96%	40,06%	34,29%	6,57%	6,57%	MAPE maximo	W/outl
995	232	199,63%	93,29%	66,35%	49,04%	42,31%	37,02%	13,94%	**13,94%**	MAPE maximo	No outliers

	Actual demand	Actual orders	Demand frequency
Coeficiente de variación	450.74 %	199.63 %	93.29 %

Analysis of demand patterns: the structure of the system

SKU: 1



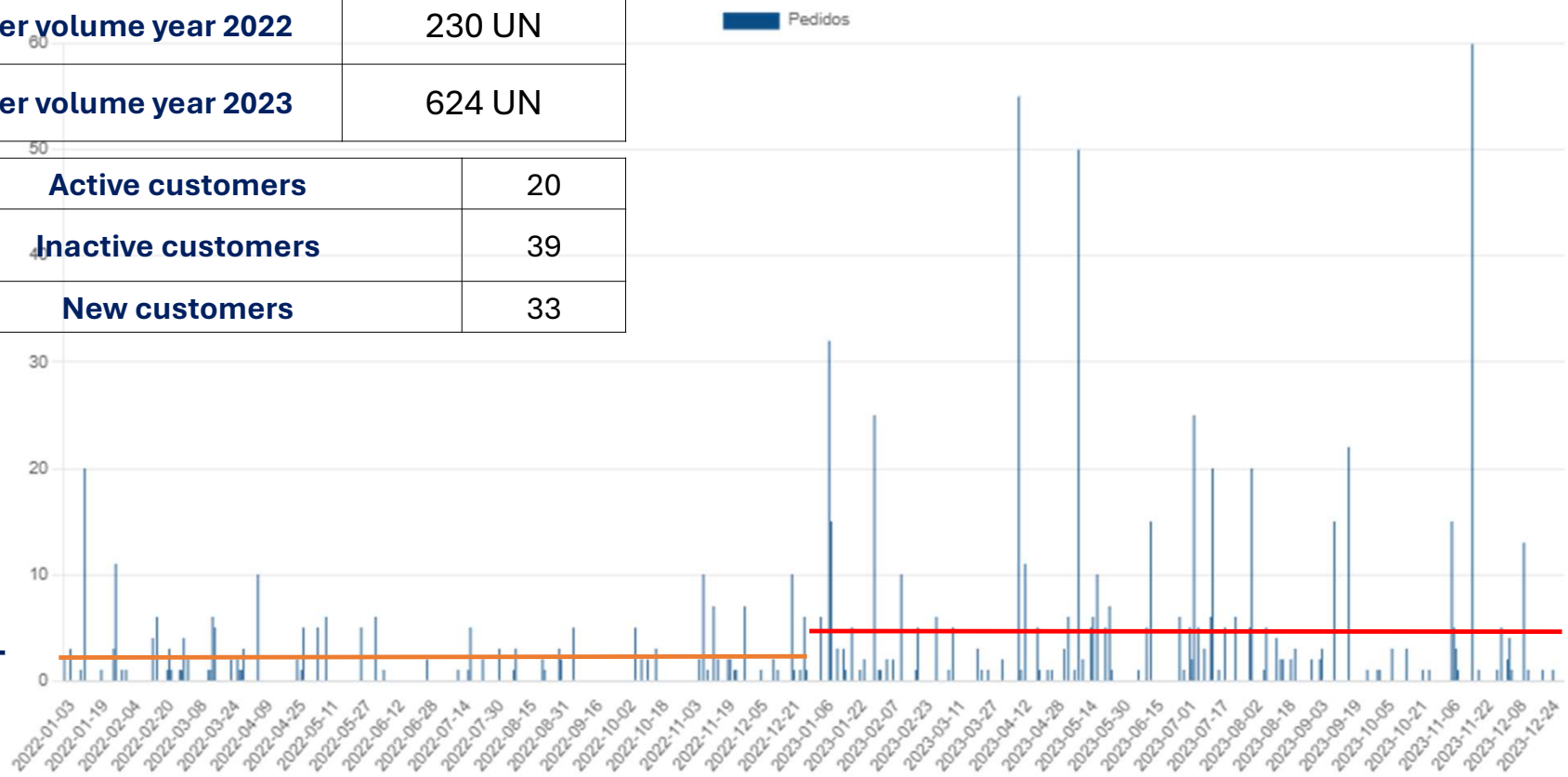
Average orders: 5.96 UND

Comparison 2022-2023

Order volume year 2022	230 UN
Order volume year 2023	624 UN

Active customers	20
Inactive customers	39
New customers	33

Average orders 2022: 2.74 UND



Average orders 2023: 5.11 UND

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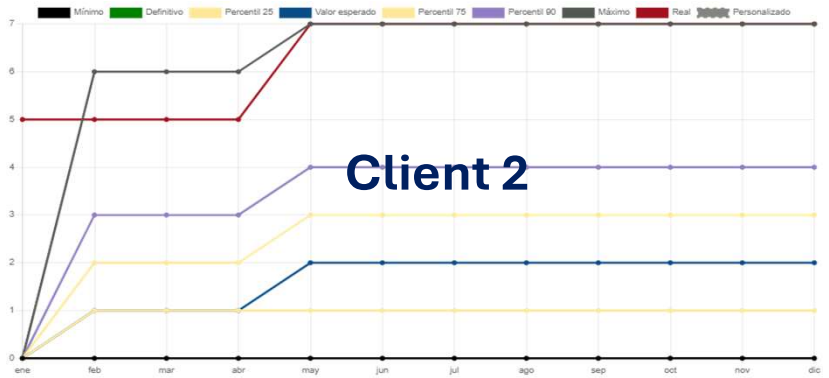
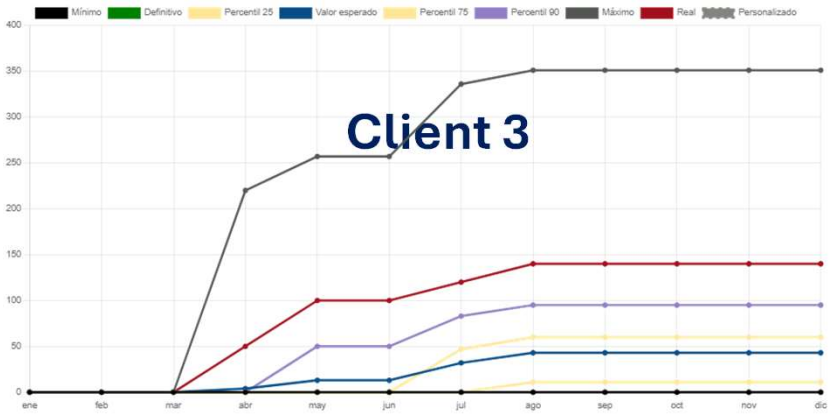
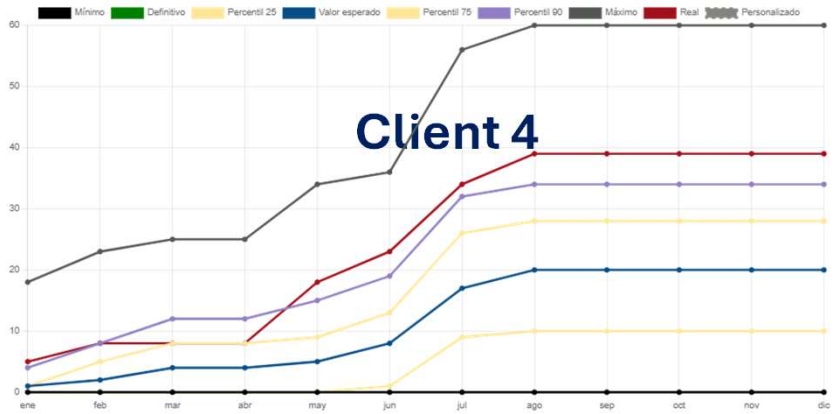
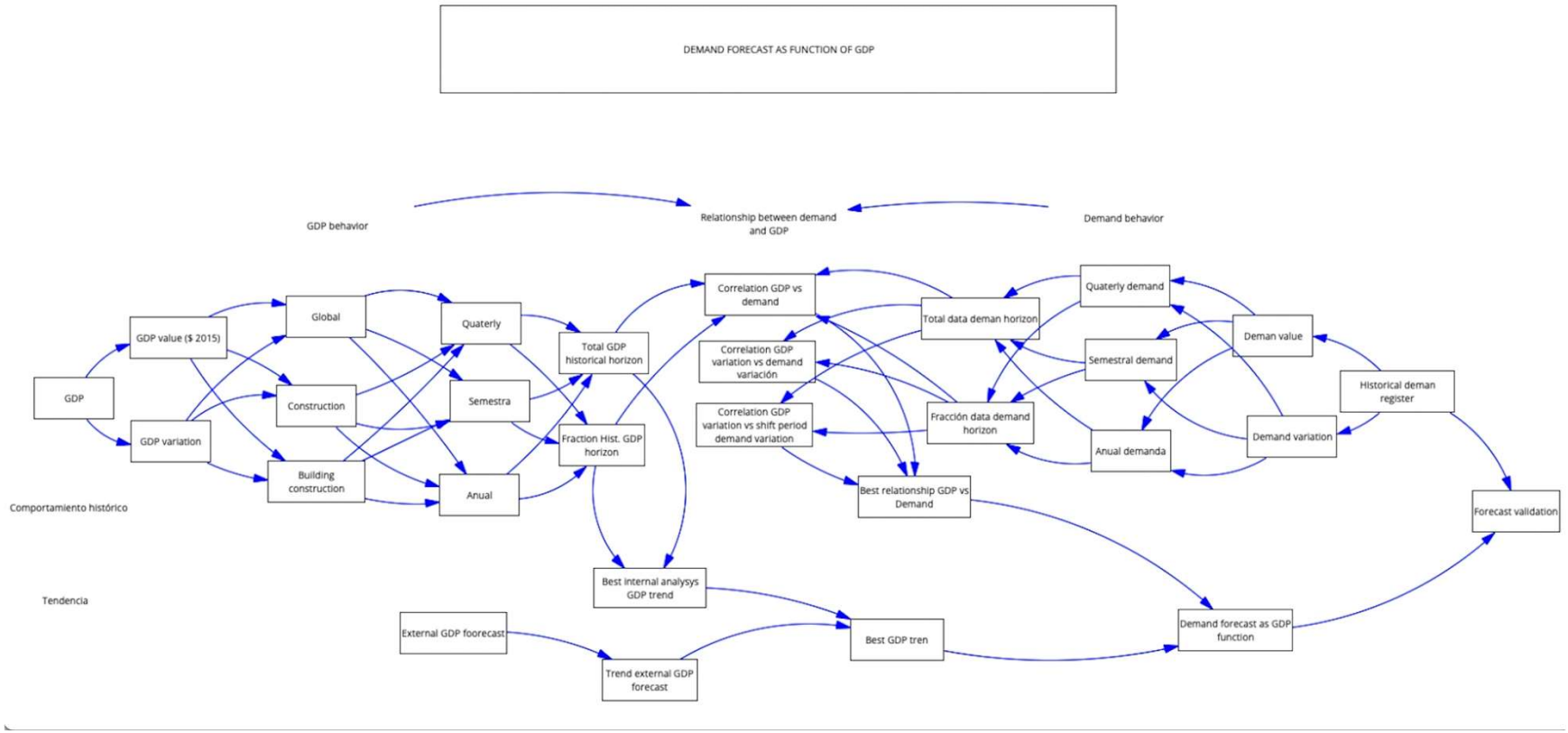
The structure of the system



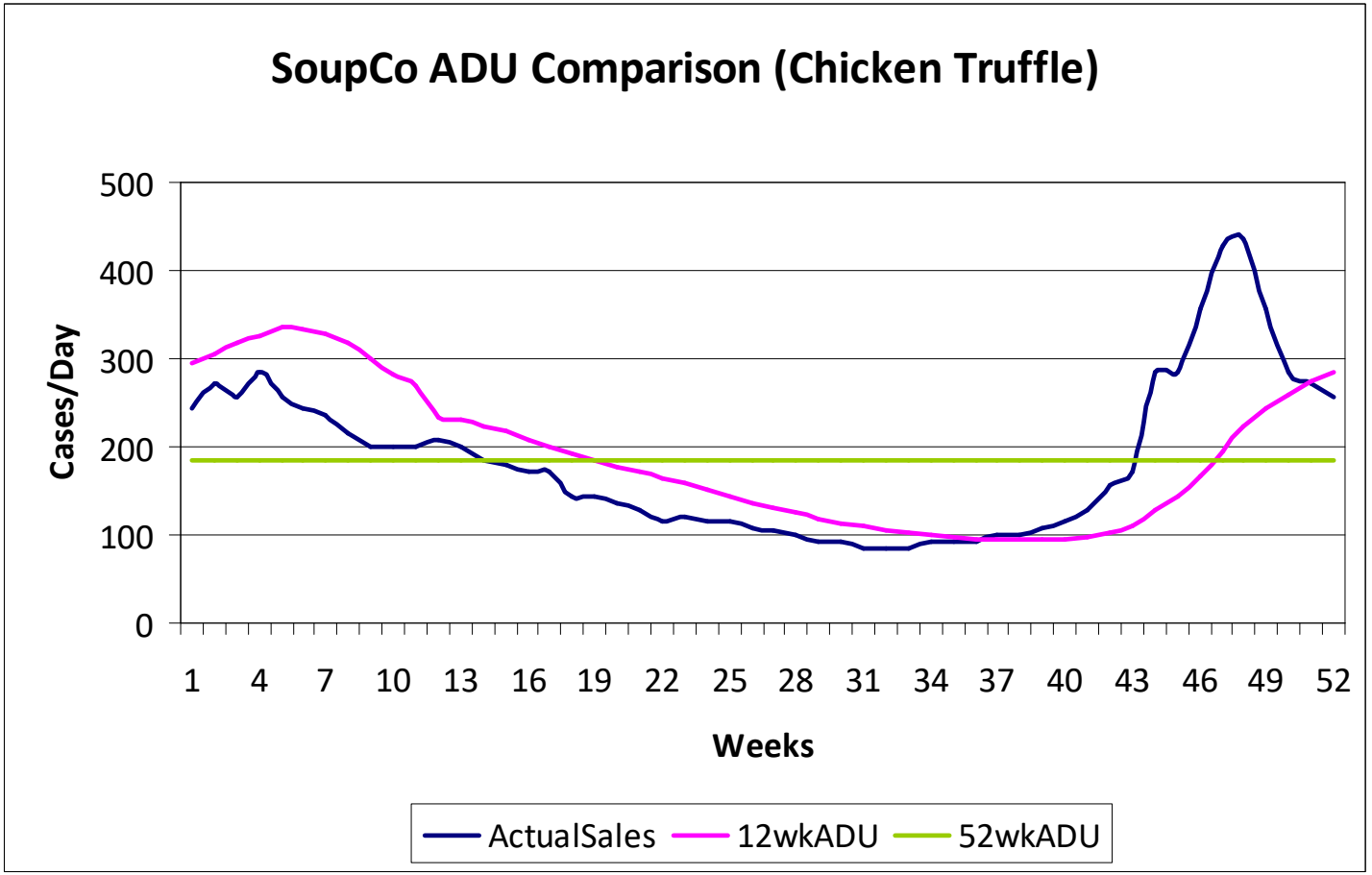




Impact of GDP growth in the forecast



ADU or FDU? When to change?



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ADU or FDU?

- Tactical horizon deals with ”Push” events that must be forecasted: seasonality, promotions, long lead time parts, Chinese New Year, etc.
- What should be considered a Push event?
- Again, it is defined by the demand patterns
- The difference between current ADU and FDU one lead time ahead must be constantly monitored.
- What if:
  - ADU/FDU = 0.6, or 0.8 or 0.3
  - ADU/FDU = 1.4, or 1.15 or 1.76

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ADU or FDU?

- There should be a defined threshold for moving from ADU to FDU.
- What is the right value?
- As usual, it depends:
  - Red zone design policy
  - Reliability of suppliers
  - Type of product: should we push B and C products?
- There should be a set of rules and a functionality in the software for choosing either one and apply it one lead time ahead.

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Further research

- Impact of the order frequency variability in the forecast
- What is really forecastable: Forecastability
- Impact of the lead time variability in the ADU to FDU date of change.

Thanks!

Questions?

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¡Muchas gracias!

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