prophet-forecast

June 5, 2025

[124]:
```
import pandas as pd
from prophet import Prophet
from sklearn.metrics import mean_absolute_error
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
import time
import os

warnings.filterwarnings("ignore")
```

[125]:
```
# 1. Cargar datos
df_2022 = pd.read_csv('2022_limpio.csv', sep=';',␣
 ↪parse_dates=['fecha_de_factura'], dayfirst=True)
df_2023 = pd.read_csv('2023_limpio.csv', sep=';',␣
 ↪parse_dates=['fecha_de_factura'], dayfirst=True)
df = pd.concat([df_2022, df_2023])
```

[126]:
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# 2. Limpieza
df['cantidad_neta'] = pd.to_numeric(df['cantidad_neta'], errors='coerce')
#df = df[df['cl_factura'] == 'VENTA']
df = df.dropna(subset=['cantidad_neta'])
```

[127]:
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# 3. Agrupar ventas diarias por cliente y ciudad
ventas_diarias = df.groupby(['fecha_de_factura', 'solicitante',␣
 ↪'CIUDAD'])['cantidad_neta'].sum().reset_index()
ventas_diarias.columns = ['ds', 'solicitante', 'CIUDAD', 'y']
```

[128]:
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# 4. Generar lista de combinaciones cliente + ciudad con al menos 180 días
clientes_unicos = ventas_diarias.groupby(['solicitante', 'CIUDAD']).size().
 ↪reset_index(name='n_dias')
clientes_filtrables = clientes_unicos[clientes_unicos['n_dias'] >= 180]
```

[129]:
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# 5. Fecha de corte: 18 meses entrenamiento, 6 prueba
fecha_corte = pd.to_datetime("2023-07-01")
```

[130]:
```python
# 6. Evaluar cada combinación con Prophet
resultados = []
```

[131]:
```python
# 7. Bucle por cada cliente + ciudad
predictions_agg = []

if not os.path.exists('plots'):
    os.makedirs('plots')

for _, row in clientes_filtrables.iterrows():
    cliente = row['solicitante']
    ciudad = row['CIUDAD']

    subset = ventas_diarias[
        (ventas_diarias['solicitante'] == cliente) &
        (ventas_diarias['CIUDAD'] == ciudad)
    ].sort_values('ds')

    train = subset[subset['ds'] < fecha_corte]
    test = subset[subset['ds'] >= fecha_corte]

    # Saltar si no hay suficiente información para prueba
    if len(train) < 100 or len(test) < 30:
        continue

    try:
        # Entrenar modelo
        start_train_time = time.time()
        modelo = Prophet(daily_seasonality=True)
        modelo.fit(train)
        end_train_time = time.time()
        train_time_seconds = end_train_time - start_train_time

        # Generar pronóstico
        start_inference_time = time.time()
        future = modelo.make_future_dataframe(periods=len(test), freq='D')
        forecast = modelo.predict(future)
        end_inference_time = time.time()
        inference_time_seconds = end_inference_time - start_inference_time

        # Comparar con test real
        comparacion = forecast[['ds', 'yhat']].merge(test[['ds', 'y']],␣
 ↪on='ds', how='inner')
        if len(comparacion) == 0:
            continue

        # Calcular métricas
        mae = mean_absolute_error(comparacion['y'], comparacion['yhat'])
        promedio_real = comparacion['y'].mean()
        mae_relativo = mae / promedio_real if promedio_real != 0 else None

        accuracy = 1 - mae / promedio_real if promedio_real != 0 else None
        precision = 1 - mae / test['y'].mean() if test['y'].mean() != 0 else␣
↪None
        recall = 1 - mae / test['y'].mean() if test['y'].mean() != 0 else None
        f1_score = 2 * (precision * recall) / (precision + recall) if␣
↪(precision is not None and recall is not None) else None

        comparacion_filtrada = comparacion[comparacion['y'] != 0]
        if len(comparacion_filtrada) == 0:
            mape = None
        else:
            mape = (abs((comparacion_filtrada['y'] -␣
↪comparacion_filtrada['yhat']) / comparacion_filtrada['y'])).mean() * 100

        resultados.append({
            'cliente': cliente,
            'ciudad': ciudad,
            'MAE': mae,
            'Promedio_ventas_test': promedio_real,
            'MAE_relativo': mae_relativo,
            'MAPE (%)': mape,
            'accuracy': accuracy,
            'precision': precision,
            'recall': recall,
            'f1_score': f1_score,
            'observaciones': len(subset),
            'tiempo_entrenamiento_segundos': train_time_seconds,
            'tiempo_inferencia_segundos': inference_time_seconds
        })

        data_plot = pd.DataFrame({
            'fecha': comparacion_filtrada['ds'],
            'real': comparacion_filtrada['y'],
            'pred': comparacion_filtrada['yhat']
        })

        data_plot['ciudad'] = ciudad
        # data_plot['cliente'] = cliente # se omite cliente para no generar␣
↪tantas gráficas
        predictions_agg.append(data_plot)

        # Graficar Serie temporal: Ventas reales vs. Predicción (se guardan en␣
↪carpeta plots)
```

```
        plt.figure(figsize=(12, 6))
        plt.plot(comparacion_filtrada['ds'], comparacion_filtrada['y'],␣
↪label='Ventas Reales')
        plt.plot(comparacion_filtrada['ds'], comparacion_filtrada['yhat'],␣
↪label='Predicción', linestyle='--')
        plt.title(f'Ventas Reales vs. Predicción - Cliente: {cliente} | Ciudad:␣
↪{ciudad}')
        plt.xlabel('Fecha')
        plt.ylabel('Cantidad Neta')
        plt.legend()
        plt.savefig(f'plots/{ciudad}_cliente_{cliente}_real_vs_pred.png',␣
↪bbox_inches='tight')
        plt.close()

        # Graficar Scatter plot: Predicción vs. Ventas reales (se guardan en␣
↪carpeta plots)
        plt.figure(figsize=(8, 6))
        plt.scatter(comparacion_filtrada['y'], comparacion_filtrada['yhat'],␣
↪alpha=0.6)
        plt.plot([comparacion_filtrada['y'].min(), comparacion_filtrada['y'].
↪max()], [comparacion_filtrada['y'].min(), comparacion_filtrada['y'].max()],␣
↪'r--')
        plt.title(f'Scatter: Predicción vs. Ventas reales - Cliente: {cliente}␣
↪| Ciudad: {ciudad}')
        plt.xlabel('Ventas Reales')
        plt.ylabel('Predicción')
        plt.savefig(f'plots/{ciudad}_cliente_{cliente}_scatter.png',␣
↪bbox_inches='tight')
        plt.close()

    except Exception as e:
        print(f"Error en {cliente} - {ciudad}: {e}")
        continue
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```
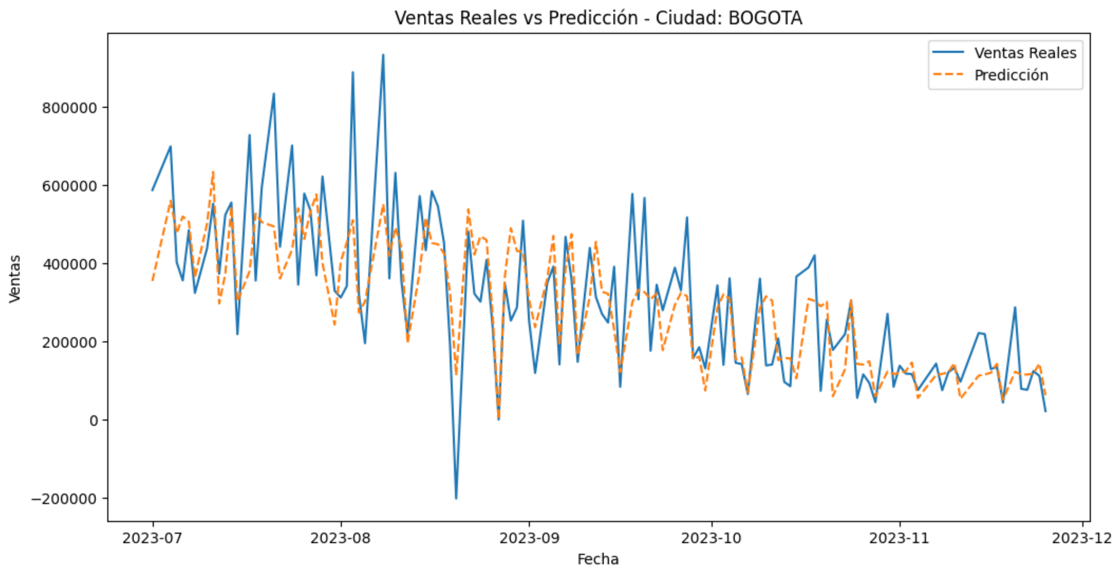
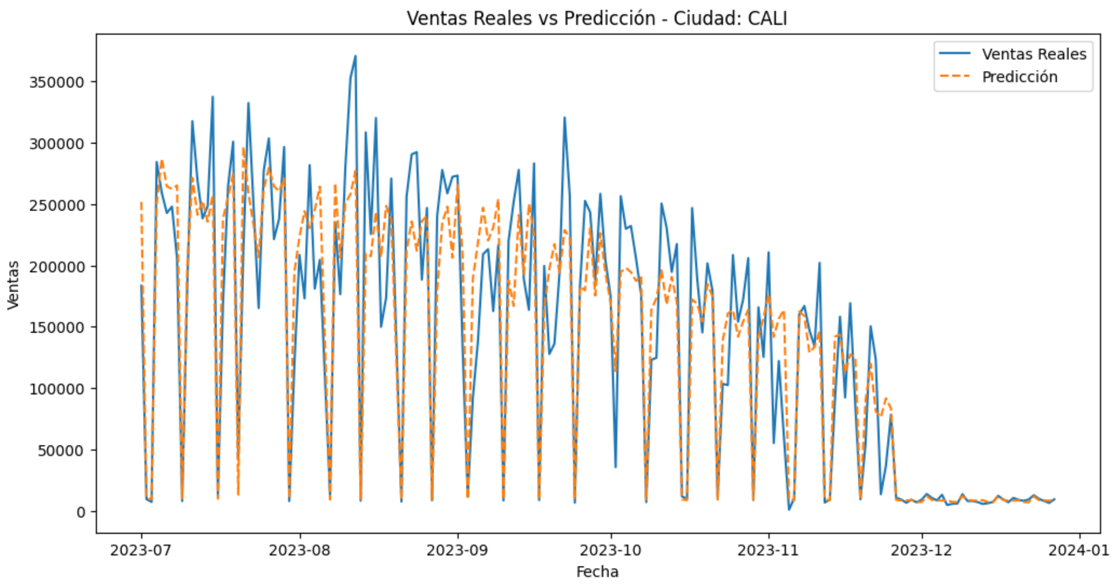
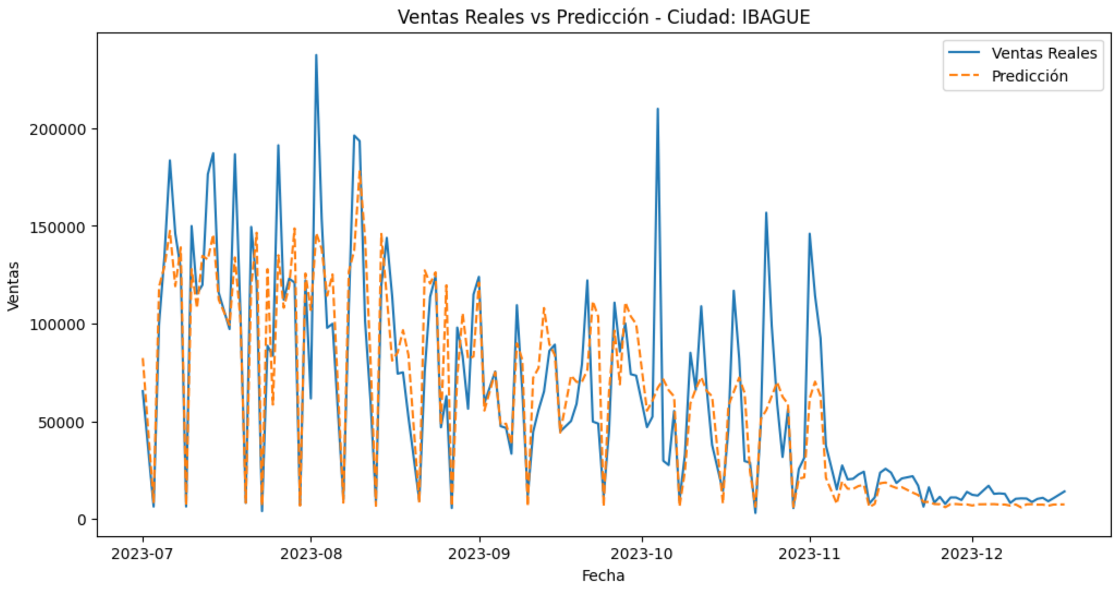
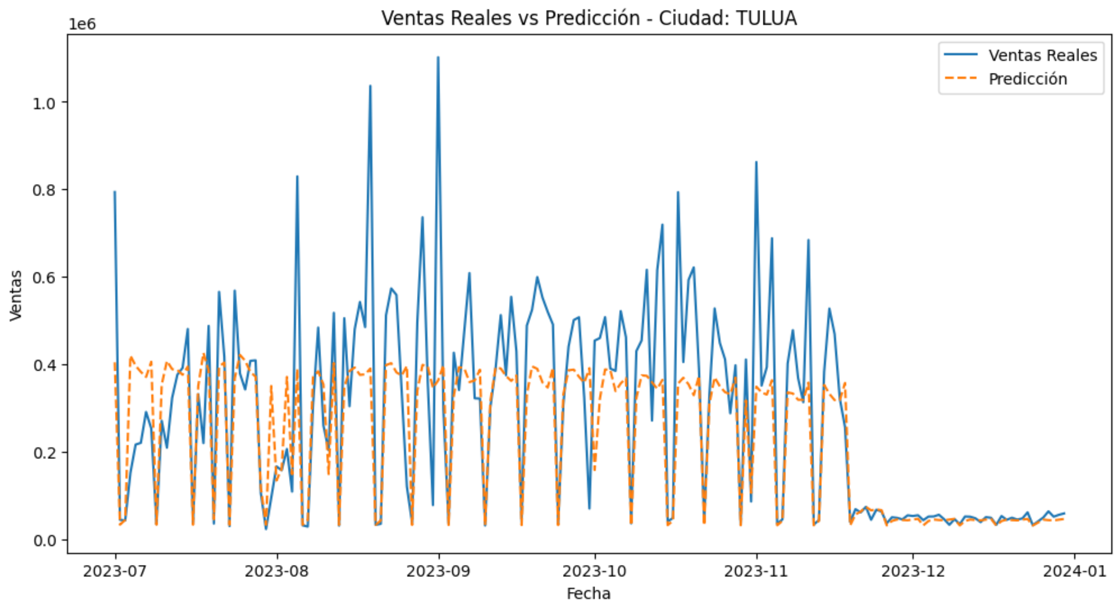
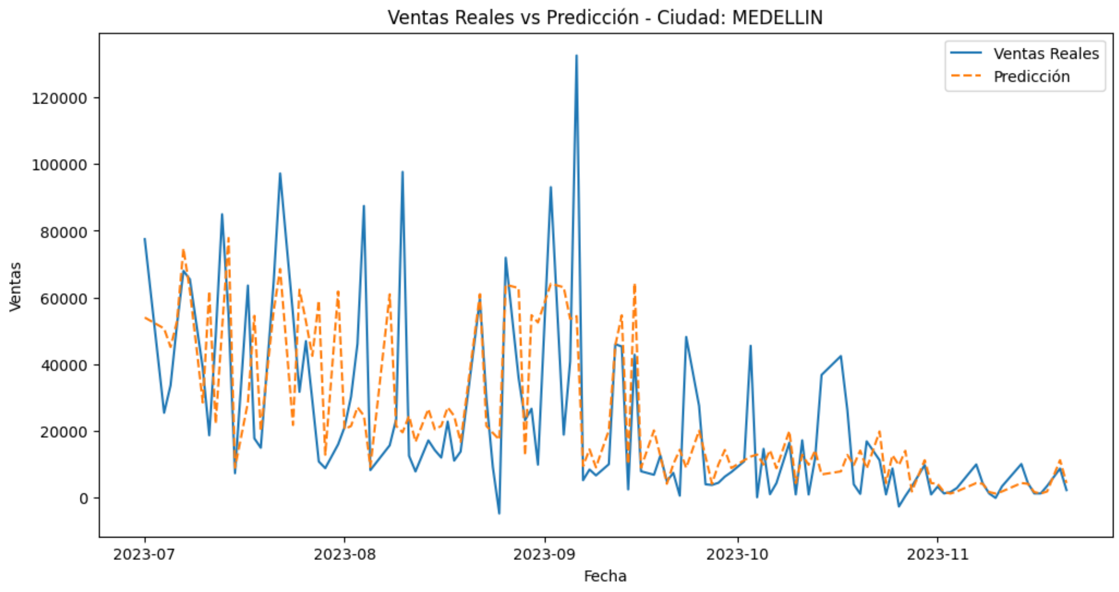

[132]:
```
df_predictions = pd.concat(predictions_agg, ignore_index=True)

# 8. Gráfica por cada ciudad
ciudades = df_predictions['ciudad'].unique()
for city in ciudades:
    group = df_predictions[df_predictions['ciudad'] == city].groupby('fecha').
 ↪agg({'real': 'sum', 'pred': 'sum'}).reset_index()
    plt.figure(figsize=(12,6))
    plt.plot(group['fecha'], group['real'], label='Ventas Reales')
    plt.plot(group['fecha'], group['pred'], label='Predicción', linestyle='--')
    plt.title(f'Ventas Reales vs Predicción - Ciudad: {city}')
    plt.xlabel('Fecha')
    plt.ylabel('Ventas')
    plt.legend()
    plt.show()
```



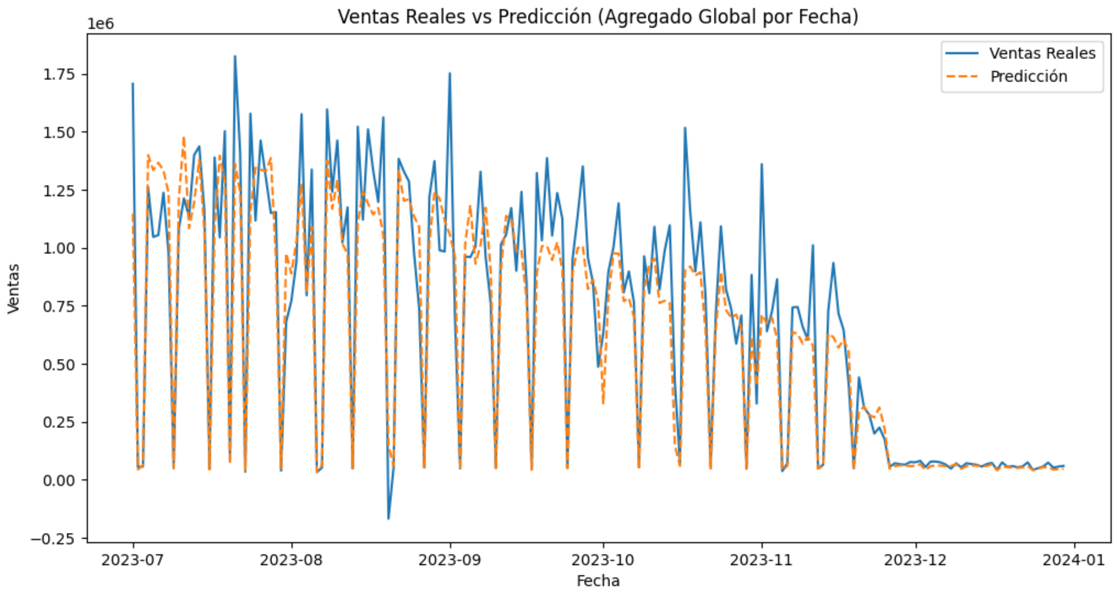

Ventas Reales vs Predicción - Ciudad: CALI
Ventas Reales
Predicción
Ventas
Fecha
0
50000
100000
150000
200000
250000
300000
350000
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
2024-01


Ventas Reales vs Predicción - Ciudad: IBAGUE
Ventas Reales
Predicción
Ventas
Fecha
0
50000
100000
150000
200000
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12

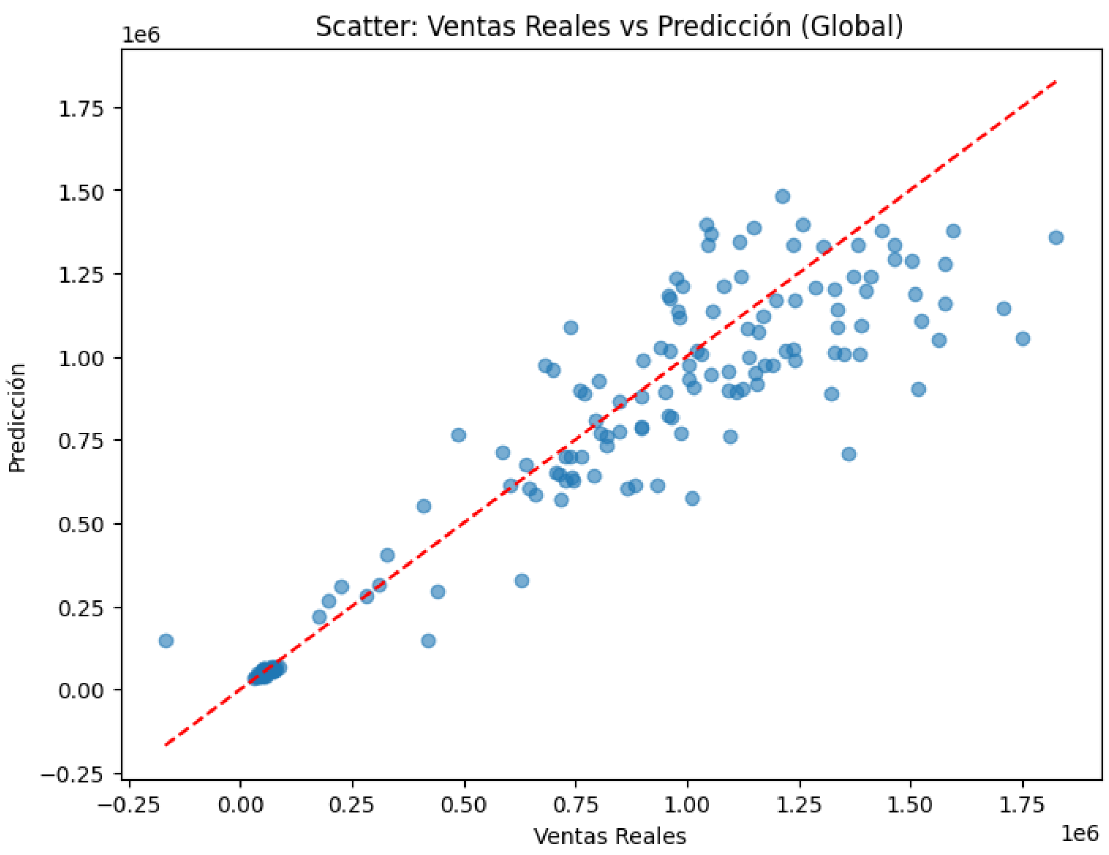




```
[133]: # 9. Grafica Ventas Reales vs Predicción (Agregado Global por Fecha)
df_total = df_predictions.groupby('fecha').agg({'real': 'sum', 'pred': 'sum'}).
 ↪reset_index()

plt.figure(figsize=(12,6))
plt.plot(df_total['fecha'], df_total['real'], label='Ventas Reales')
plt.plot(df_total['fecha'], df_total['pred'], label='Predicción',␣
 ↪linestyle='--')
plt.title('Ventas Reales vs Predicción (Agregado Global por Fecha)')
plt.xlabel('Fecha')
plt.ylabel('Ventas')
plt.legend()
plt.show()
```



[134]:
```
# 11. Grafica Scatter: Ventas Reales vs Predicción (Global)
plt.figure(figsize=(8,6))
plt.scatter(df_total['real'], df_total['pred'], alpha=0.6)
plt.plot([df_total['real'].min(), df_total['real'].max()],
         [df_total['real'].min(), df_total['real'].max()],
         'r--')
plt.title('Scatter: Ventas Reales vs Predicción (Global)')
plt.xlabel('Ventas Reales')
plt.ylabel('Predicción')
plt.show()
```



[135]:
```
# 12. Mostrar resultados
df_resultados = pd.DataFrame(resultados).sort_values('MAE')
df_resultados
```

[135]:
```
       cliente  ciudad            MAE  Promedio_ventas_test  MAE_relativo  \
484  1028796.0  IBAGUE       9.076410            115.555556      0.078546
86   1003113.0  IBAGUE      12.022324             51.428571      0.233767
227  1016370.0  IBAGUE      13.885713             75.584416      0.183711
434  1027079.0  BOGOTA      16.643813             57.743363      0.288238
392  1025888.0  IBAGUE      16.906349             46.000000      0.367529
..         …       …              …                   …             …
641  1032930.0  BOGOTA   35316.210731          35323.756098      0.999786
34   1000936.0  BOGOTA   46778.609780          86951.500000      0.537985
601  1031842.0  BOGOTA   59035.330618          91012.727273      0.648649
242  1018222.0  BOGOTA   91362.498792         144315.680000      0.633074
243  1018222.0   TULUA  133407.335724         292461.798165      0.456153

       MAPE (%)  accuracy  precision    recall  f1_score  observaciones  \
484   10.187581  0.921454   0.925358  0.925358  0.925358            311
86    28.536383  0.766233   0.810627  0.810627  0.810627            192
```

```
227    16.553256  0.816289   0.815472  0.815472  0.815472            441
434    29.532314  0.711762   0.719166  0.719166  0.719166            559
392    38.672471  0.632471   0.687600  0.687600  0.687600            246
..           …         …         …        …         …         …
641  8496.907307  0.000214  -0.548299 -0.548299 -0.548299            192
34    353.640485  0.462015   0.472180  0.472180  0.472180            615
601  3464.074448  0.351351   0.330012  0.330012  0.330012            204
242  1669.589181  0.366926   0.315496  0.315496  0.315496            551
243  1293.624701  0.543847   0.538040  0.538040  0.538040            564

     tiempo_entrenamiento_segundos  tiempo_inferencia_segundos
484                       0.125335                    0.065465
86                        0.148657                    0.055318
227                       0.142255                    0.085117
434                       0.146549                    0.092258
392                       0.136587                    0.043970
..                             …                           …
641                       0.187947                    0.062973
34                        0.181039                    0.097406
601                       0.134142                    0.046472
242                       0.158500                    0.089518
243                       0.188486                    0.108221

[648 rows x 13 columns]
```

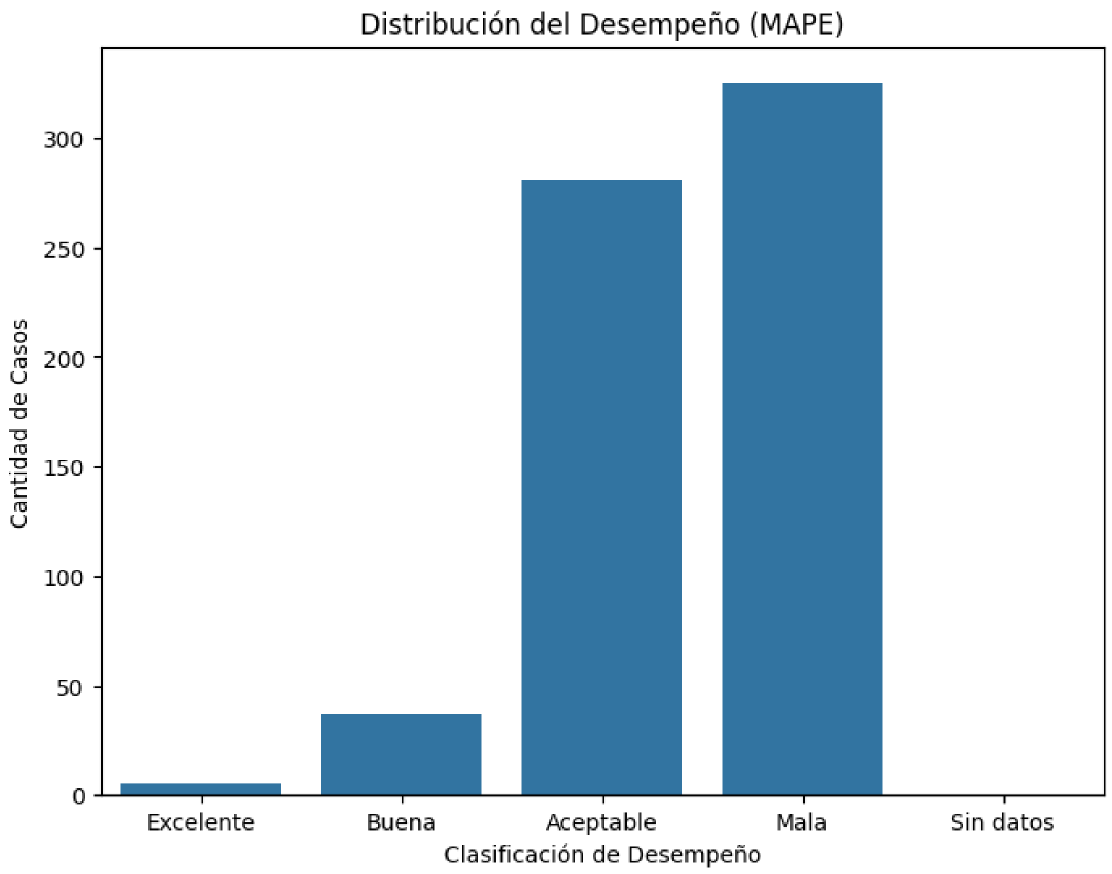
[136]:
```python
# 13. Clasificación por MAPE
def clasificar_mape(mape):
    if pd.isna(mape):
        return 'Sin datos'
    elif mape < 10:
        return 'Excelente'
    elif mape < 20:
        return 'Buena'
    elif mape < 50:
        return 'Aceptable'
    else:
        return 'Mala'

df_resultados['desempeño'] = df_resultados['MAPE (%)'].apply(clasificar_mape)
```

[137]:
```python
print("\nDistribución del desempeño (porcentaje):")
print(df_resultados['desempeño'].value_counts(normalize=True) * 100)
print(df_resultados['MAPE (%)'].mean())
```

```
Distribución del desempeño (porcentaje):
desempeño
```

```
Mala         50.154321
Aceptable    43.364198
Buena         5.709877
Excelente     0.771605
Name: proportion, dtype: float64
221.8541681106798
```

[138]:
```
# 14. Distribución del desempeño (por MAPE)
plt.figure(figsize=(8, 6))
sns.countplot(x='desempeño', data=df_resultados, order=['Excelente', 'Buena',␣
 ↪'Aceptable', 'Mala', 'Sin datos'])
plt.title('Distribución del Desempeño (MAPE)')
plt.xlabel('Clasificación de Desempeño')
plt.ylabel('Cantidad de Casos')
plt.show()
```

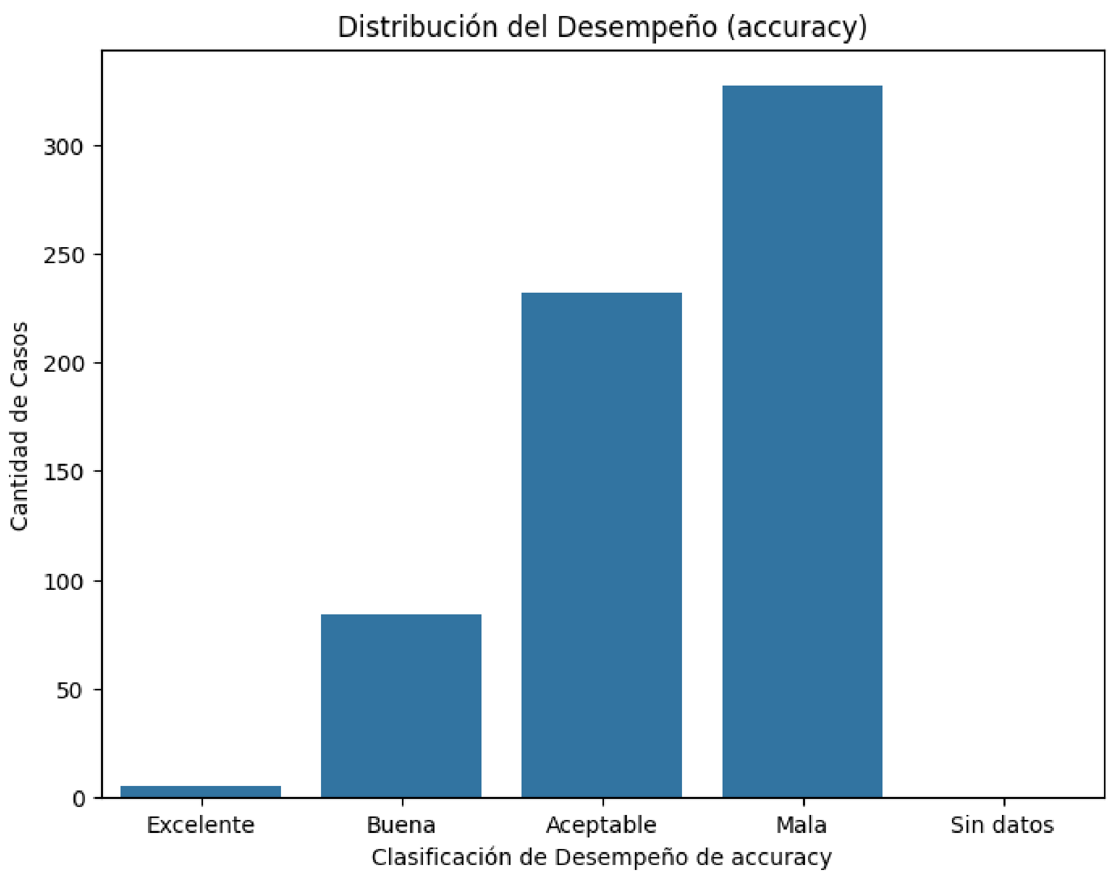


[139]:
```
# 15. Clasificación por accuracy
def clasificar_accuracy(accuracy):
    if pd.isna(accuracy):
        return 'Sin datos'
    elif accuracy > 0.9:
        return 'Excelente'
    elif accuracy > 0.75:
        return 'Buena'
    elif accuracy > 0.6:
        return 'Aceptable'
    else:
        return 'Mala'

df_resultados['desempeño_accuracy'] = df_resultados['accuracy'].
 ↪apply(clasificar_accuracy)
```

[140]:
```
print("\nDistribución del desempeño de accuracy (porcentaje):")
print(df_resultados['desempeño_accuracy'].value_counts(normalize=True) * 100)
print(df_resultados['accuracy'].mean())
```

```

Distribución del desempeño de accuracy (porcentaje):
desempeño_accuracy
Mala          50.462963
Aceptable     35.802469
Buena         12.962963
Excelente      0.771605
Name: proportion, dtype: float64
0.4565436796250229
```

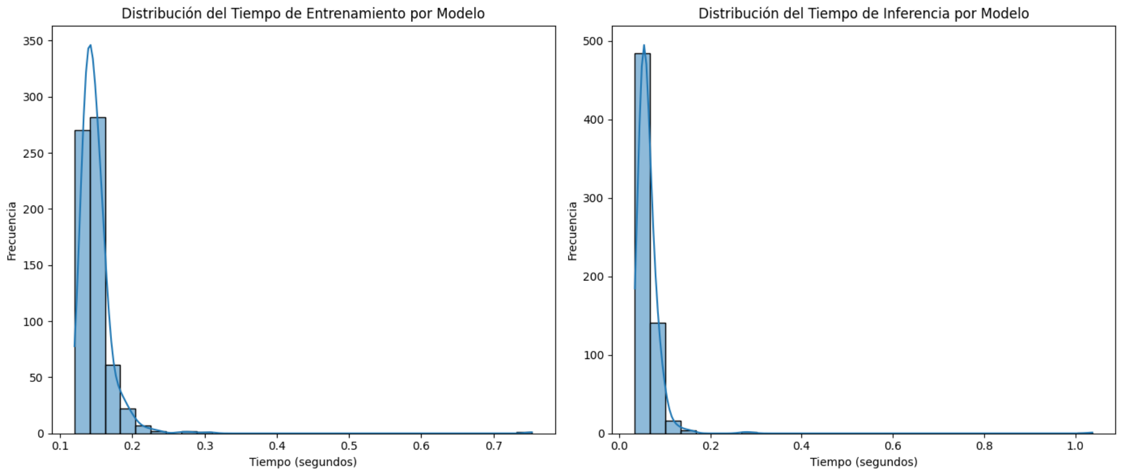
[141]:
```
# 16. Distribución del desempeño (por accuracy)
plt.figure(figsize=(8, 6))
sns.countplot(x='desempeño_accuracy', data=df_resultados, order=['Excelente',␣
 ↪'Buena', 'Aceptable', 'Mala', 'Sin datos'])
plt.title('Distribución del Desempeño (accuracy)')
plt.xlabel('Clasificación de Desempeño de accuracy')
plt.ylabel('Cantidad de Casos')
plt.show()
```



[142]:
```
# Análisis de Complejidad (Tiempos de Entrenamiento e Inferencia)

print("\n--- Resumen de Tiempos de Complejidad ---")

# Filtrar solo casos donde se pudo calcular el tiempo (evitar errores None o␣
↪NaN)
df_tiempos = df_resultados.dropna(subset=['tiempo_entrenamiento_segundos',␣
↪'tiempo_inferencia_segundos'])

if not df_tiempos.empty:
    # Estadísticas para el tiempo de entrenamiento
    total_train_time = df_tiempos['tiempo_entrenamiento_segundos'].sum()
    avg_train_time = df_tiempos['tiempo_entrenamiento_segundos'].mean()
    median_train_time = df_tiempos['tiempo_entrenamiento_segundos'].median()
    max_train_time = df_tiempos['tiempo_entrenamiento_segundos'].max()
    min_train_time = df_tiempos['tiempo_entrenamiento_segundos'].min()

    print(f"\n**Tiempos de Entrenamiento (en segundos) para {len(df_tiempos)}␣
↪modelos:**")
```

```python
    print(f"  Tiempo Total: {total_train_time:.2f} segundos ({total_train_time /
↪ 60:.2f} minutos)")
    print(f"  Promedio por modelo: {avg_train_time:.4f} segundos")
    print(f"  Mediana por modelo: {median_train_time:.4f} segundos")
    print(f"  Máximo por modelo: {max_train_time:.4f} segundos")
    print(f"  Mínimo por modelo: {min_train_time:.4f} segundos")

    # Estadísticas para el tiempo de inferencia
    total_inference_time = df_tiempos['tiempo_inferencia_segundos'].sum()
    avg_inference_time = df_tiempos['tiempo_inferencia_segundos'].mean()
    median_inference_time = df_tiempos['tiempo_inferencia_segundos'].median()
    max_inference_time = df_tiempos['tiempo_inferencia_segundos'].max()
    min_inference_time = df_tiempos['tiempo_inferencia_segundos'].min()

    print(f"\n**Tiempos de Inferencia (en segundos) para {len(df_tiempos)}␣
↪modelos:**")
    print(f"  Tiempo Total: {total_inference_time:.2f} segundos␣
↪({total_inference_time / 60:.2f} minutos)")
    print(f"  Promedio por modelo: {avg_inference_time:.4f} segundos")
    print(f"  Mediana por modelo: {median_inference_time:.4f} segundos")
    print(f"  Máximo por modelo: {max_inference_time:.4f} segundos")
    print(f"  Mínimo por modelo: {min_inference_time:.4f} segundos")

    # Visualización de la distribución de tiempos
    plt.figure(figsize=(14, 6))
    plt.subplot(1, 2, 1)
    sns.histplot(df_tiempos['tiempo_entrenamiento_segundos'], bins=30, kde=True)
    plt.title('Distribución del Tiempo de Entrenamiento por Modelo')
    plt.xlabel('Tiempo (segundos)')
    plt.ylabel('Frecuencia')

    plt.subplot(1, 2, 2)
    sns.histplot(df_tiempos['tiempo_inferencia_segundos'], bins=30, kde=True)
    plt.title('Distribución del Tiempo de Inferencia por Modelo')
    plt.xlabel('Tiempo (segundos)')
    plt.ylabel('Frecuencia')
    plt.tight_layout()
    plt.show()

else:
    print("No hay datos de tiempo disponibles para analizar.")
```

```
--- Resumen de Tiempos de Complejidad ---

**Tiempos de Entrenamiento (en segundos) para 648 modelos:**
  Tiempo Total: 96.92 segundos (1.62 minutos)
  Promedio por modelo: 0.1496 segundos
  Mediana por modelo: 0.1444 segundos
  Máximo por modelo: 0.7532 segundos
  Mínimo por modelo: 0.1199 segundos

**Tiempos de Inferencia (en segundos) para 648 modelos:**
  Tiempo Total: 41.31 segundos (0.69 minutos)
  Promedio por modelo: 0.0637 segundos
  Mediana por modelo: 0.0564 segundos
  Máximo por modelo: 1.0370 segundos
  Mínimo por modelo: 0.0347 segundos
```



[143]:
```python
# Guardar resultados en Excel
df_resultados.to_excel('resultados_modelo_prophet.xlsx', index=False)
```