

FX HEDGING PLAN

Financial Risk Management

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PREPARED FOR:

ASSAD



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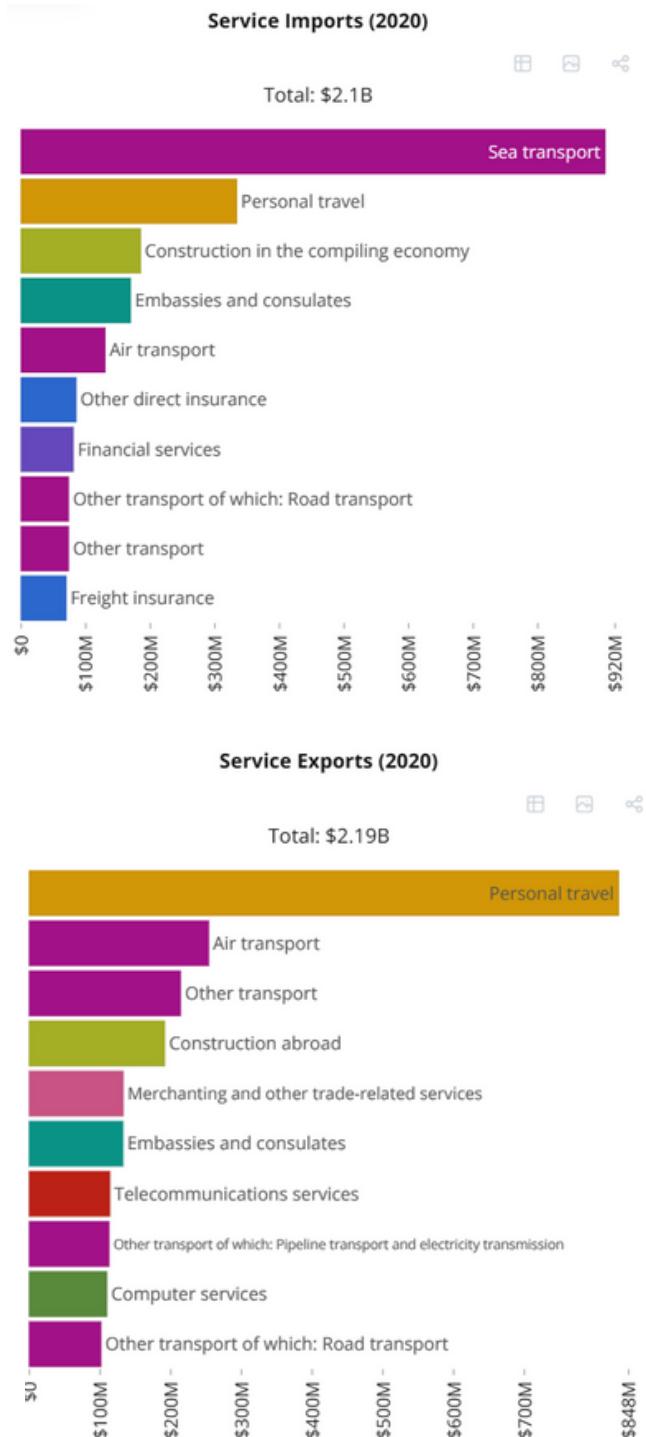
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INTRODUCTION

Choice of Industries

Before selecting Assad, we extensively explored options within the automotive, pharmaceutical, and energy industries. These industries were prioritized due to their heightened susceptibility to foreign exchange (FX) risks in contemporary markets. The automotive sector, reliant on global supply chains for components and raw materials, faces significant FX exposure due to fluctuating exchange rates impacting import costs. Similarly, the pharmaceutical industry, heavily dependent on imported raw materials and international markets for drug distribution, is vulnerable to currency fluctuations affecting production costs and pricing. Additionally, the energy industry, dealing with international trade of oil, gas, and other resources, is highly sensitive to FX risks given that commodity prices are influenced by currency fluctuations, impacting revenue and operational costs.



Company Overview



The Tunisian Accumulator ASSAD is a Tunisian company specializing in the production, repair, and sale of accumulators, the management and valorization of used and waste lead-acid batteries, and all commercial, financial, industrial, real estate, or other operations related to the aforementioned objects or any other similar or connected object.

The company produces automotive and industrial accumulators, as well as plates (semi-finished products made from lead entering the production of batteries). The automotive starter batteries will be destined for land, sea, and heavy equipment vehicles, while the industrial traction batteries will be used for electric carts and stationary applications.

The ASSAD group through its subsidiaries and companies is the industrial leader specializing in batteries in Tunisia and remains an essential reference on the African continent. As part of the development of its industrial batteries activity, the ASSAD group has established a partnership with the EnerSys group, a world leader in the manufacture and marketing of industrial batteries.



First contact :



After email exchanges, we scheduled a first meeting in the headquarters of ASSAD with the Head of Exports and Cash Manager of the group.

- The topics discussed included a brief presentation of TBS and its curriculum, an overview of the Context of the project, and our needs in terms of data.
- We had a brief discussion on the traditional Tunisian accounting standards. We focused especially on the fact that these standards don't take into account losses in market movements, and how strict foreign exchange controls, can limit the import of foreign vehicles and other goods, which made our participants intrigued by the new vision we introduced and our approach.

The Head of Exports added that the company is currently confronting an additional risk that it wishes to mitigate, which involves hedging both the lead market risk and the dollar exchange rate risk. This challenge has emerged in recent years due to new regulations restricting the import of used lead-acid batteries.

During discussions, they expressed a keen interest in hedging the commodity risk associated with this situation. We committed to exploring potential solutions, but upon consulting Mr. Mezri, it was communicated that there are limited options for hedging in Tunisia. Even if there were possibilities, the associated premiums would be substantial. Therefore, the most suitable approach in this scenario is to focus on hedging the USD exposure instead.

CURRENT FINANCIAL POSITION OF ASSAD

ASSAD is facing very distinct conditions

- Three consecutive years of net losses.
- Significant export revenues coupled with unforeseen substantial expenses in these years due to Tunisian regulations restricting the import of used lead-acid batteries. Consequently, the company found itself compelled to procure large quantities of lead, a highly volatile commodity, in dollars, exposing them to a dual risk, resulting in considerable challenges and hardships over the past years.

| Libelle | Performances du 2ème Trimestre | | Cumul Période du 01/01 au 30/06 | | Variation | | 2022 | |
|--|--------------------------------|-----------------------|---------------------------------|-----------------------------|-----------------------------|----------------|----------------|----------------|
| | ('000 dinars) | 2023 | 2022 | 2023 | 2022 | En valeur | En % | |
| 1 Chiffre d'affaires | | 23 367 | 17 960 | 37 041 | 42 822⁽³⁾ | -5 781 | -13,5% | 102 178 |
| Chiffre d'affaires Local | 11 899 | 7 868 | 16 527 | 19 097 | -2 569 | -13,5% | 50 024 | |
| Chiffre d'affaires Export | 11 468 | 10 092 | 20 514 | 23 726 | -3 212 | -13,5% | 52 154 | |
| 2 Volume de Production (Equivalent Batterie standard) | 199 827 | 175 229 | 362 496 | 289 812 | 72 684 | 25,1% | 733 432 | |
| 3 Investissements | 6 002 | 120 | 7 344 | 561⁽³⁾ | 6 783 | 1209,0% | 1 297 | |
| Investissements corporels et incorporels | 6 002 | 120 | 7 344 | 561 | 6 783 | 1209,0% | 1 297 | |
| Investissements financiers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 4 Structure d'endettement | 4 149 | 761 | 99 009 | 89 354⁽³⁾ | 9 655 | 10,8% | 91 232 | |
| Endettement à long et moyen terme | -1 080 ⁽²⁾ | -1 738 ⁽²⁾ | 31 032 | 31 199 | -166 | -0,5% | 27 770 | |
| Crédits de gestion | 5 229 ⁽²⁾ | 2 500 ⁽²⁾ | 67 977 | 58 156 | 9 822 | 16,9% | 63 462 | |

- During the first semester of 2023, the turnover decreased by 13.5% compared to the same period in 2022, dropping from 42.8 to 37.0 million Tunisian dinars (MDT).
- In the second quarter of 2023, the turnover reached 23.4 million Tunisian dinars (MDT), marking an increase of 30.1% compared to the same period in 2022.
- In the local market, the turnover for the second quarter of 2023 increased by 51.2%, rising from 7.9 to 11.9 million Tunisian dinars (MDT).
- In the export market, the turnover for the second quarter of 2023 stood at 11.5 million Tunisian dinars (MDT), recording a 13.6% increase compared to the same period in 2022.
- Production for the first semester of 2023 increased by 25.1% compared to the first semester of 2022.
- Investments made during this period amounted to around 7.3 million Tunisian dinars (MDT).
- The total indebtedness of the company increased by 8.5% compared to December 31, 2022, and now stands at 99.009 million Tunisian dinars (MDT).

Data Received

We were only provided data from the past three years because of a system switch during that period, making retrieval of older data currently unattainable. However, this aligned with our needs, as the past three years provide the most accurate reflection of the company's current financial position.

We received a statement of operations in foreign currency settlements, specifying accounting date , document date, reconciliation document, and document type (BQ or KZ or RE).

L'état comprend :

- Date comptable : date de saisie de l'opération
- Date document : date de facture ou date de l'opération de négociation des devises.
- Pièce rapprochement : indique la référence de rapprochement de la facture avec l'opération de règlement.
- Type de pièce : RE = Facture.
KZ, BQ = L'opération de règlement de la facture.

Exemple :

| Date comptable | Date document | Pièce rapprochement | Type de pièce | Montant grand livre | Devise grand livre | Tx de change effect. |
|----------------|---------------|---------------------|---------------|---------------------|--------------------|----------------------|
| 30/12/2021 | 03/11/2021 | 100000895 | RE | -8 306,60 | EUR | 3,25230 |
| 16/12/2021 | 16/12/2021 | 100000896 | KZ | 8 306,60 | EUR | 3,28500 |

La facture de date 03/11/2021 avec référence pièce rapprochement 100000895 et cours de comptabilisation 3,2523 est réglée le 16/12/2023 (KZ 100000896) avec cours de 3,2850.

Meilleures Salutations.

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Batteries طاریفه
ASSAD اسد

Data Received

Later on , we received the company's Estimated monthly payment settlement for lead purchases in thousands of dollars along side forecasted volume of imports and exports

Bonjour,

Tout à bord, je m'excuse pour la réponse tardive.

Pour l'année 2024, nous prévoyons une augmentation significative dans le volume d'exportation. Nous tablons sur des revenus en devises de l'ordre de 20 millions d'EURO. Toutes nos exportations sont facturées en EURO.

Concernant les importations, nos estimations s'élèvent à :

- 8 millions d'euros pour les matières premières autre que plomb et pièces de rechange.
- 8,5 millions de dollars pour l'achat de plomb réparti mensuellement comme suite :

Répartition de règlement des achats de plomb par mois en milliers de dollars

| Janv-24 | Fevr-24 | Mars-24 | Avr-24 | Mai-24 | Juin-24 | Juill-24 | Aout-24 | Sept-24 | Oct-24 | Nov-24 | Déc-24 | TOTAL |
|---------|---------|---------|--------|--------|---------|----------|---------|---------|--------|--------|--------|-------|
| 580 | 120 | 310 | 560 | | 555 | 805 | 1190 | 1380 | 1450 | 1480 | 8450 | |

Merci de nous proposer :

- Une stratégie de couverture contre le risque de fluctuation du dollar.
- Une stratégie de couverture contre le risque de fluctuation de cours du plomb (le plomb est coté à la bourse des matières première de Londre : London Metal Exchange - LME).

J'espère que ces informations sont utiles pour développer une stratégie.

Salutations.



Wissem KALLEL

to me, Slim, financier

Bonjour,

Ci-après les montant de règlements mensuels des importations en milliers d'EURO :

| janv-24 | févr-24 | mars-24 | avr-24 | mai-24 | juin-24 | juill-24 | août-24 | sept-24 | oct-24 | nov-24 | déc-24 |
|---------|---------|---------|--------|--------|---------|----------|---------|---------|--------|--------|--------|
| 2 089 | 1 581 | 1 789 | 1 513 | 2 013 | 1 570 | 2 228 | 2 513 | 2 736 | 3 085 | 3 117 | 3 164 |

Supposons que ces montants ne sont pas couverts par les recettes des exportations.

Que serait votre stratégie de couverture ?

Sits.

Wissem KALLEL

ANALYSIS OF HISTORICAL DATA

Note: At the company's request, we ignore transactions in GBP as they are of negligible volume and to be soon eliminated entirely.

1) Estimating Voltailities using GARCH(1.1)

- 1.Extracting returns and computing variances from the provided dataset.
- 2.Log-Likelihood Calculation for Maximum Likelihood Estimation:

In preparation for the Maximum Likelihood Estimation method, we calculated the log-likelihood function with predetermined values for Alpha, Beta, and Omega using the following formula:

$$\sum_{i=1}^m \left[-\ln(\nu_i) - \frac{u_i^2}{\nu_i} \right]$$

- 3.Used Excel Solver to optimize model parameters:

The Solver tool was employed to maximize the log-likelihood function, allowing us to ascertain the best-fitted parameters.

- 4.Estimating Volatilities Using GARCH(1.1)

This step involved applying the identified alpha, beta, and omega values within the GARCH formula to derive volatility estimates.

$$\sigma_n^2 = \omega + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2$$

2) Calculation of Value at Risk (VAR) and Expected Shortfall (ES):

Leveraging the estimated volatilities obtained from the GARCH model, we computed both Value at Risk (VAR) and Expected Shortfall (ES). These risk measures provide insights into potential financial losses at specified confidence levels, derived from the volatility estimates.

$$VaR_t(\alpha) = -\phi(\alpha)\sqrt{h_t} - \mu$$

3) Transaction Cost Analysis:

Transaction Cost Analysis (TCA) is a method used to assess the costs associated with executing financial transactions, particularly in foreign exchange (FX) markets. It involves evaluating the expenses incurred when converting one currency to another, considering factors such as spreads, slippage, and other fees or charges.

In our case, we focused on comparing the mid-market rates (also known as the interbank rates or the theoretical "fair" rates) with the effective exchange rates used for actual transactions.

1

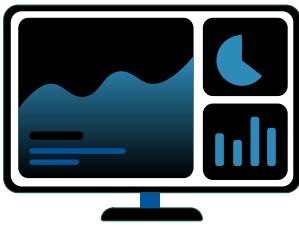
Calculation of the Difference between the mid market rate and the effective rate: this is the cost or benefit associated with the actual exchange rates used for converting currencies in your transactions.

2

Multiplying by the transaction amount.

3

Summation.



Dashboard

Utilizing Microsoft Excel, we have developed a comprehensive dashboard that serves as a centralized hub for critical insights and tools to facilitate effective risk management.:

01

TCA: Transaction Cost Analysis:



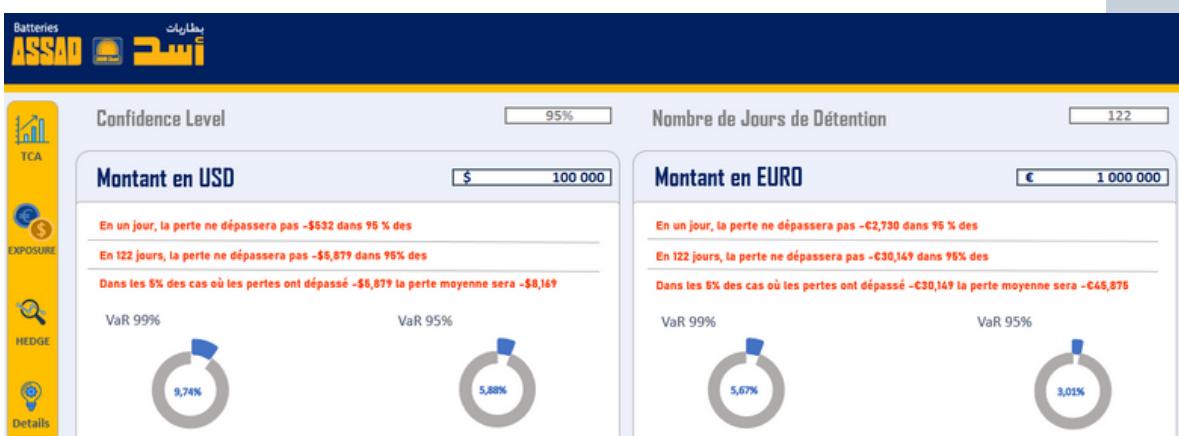
At first glance the user can check these following insights extracted from the provided data:

- Transaction volume per quarter (in foreign currency) (in bar chart and pie chart)
- Gain and loss (line chart)
- Gains and losses from usd and euro transactions in Dinars (cards)

The user can select different filters for different calculations (months and years, currencies..)

02

Exposure:



We've created a simulator for the user by customizing parameters to assess potential gains or losses by inputting based on different holding periods.

Users can customize parameters such as the currency, confidence level, and transaction amount for which he gets the corresponding exposure (the maximum potential losses as a percentage of the initial amount). Charts visualizing this data are also generated.

VaR and Expected Shortfall are calculated separately for USD and EUR in dedicated sheets.

03

Hedge

| Mois | Prévisions | Hedge Ratio | Montant à couvrir | Date de début du contrat | | | | | | | | | | | |
|-------------------|------------|-------------|-------------------|--------------------------|----------|----------|----------|----------|----------|----------|----------|---------|--------|--------|--------|
| | | | | janv-24 | févr-24 | mars-24 | avr-24 | mai-24 | juin-24 | juil-24 | août-24 | sept-24 | oct-24 | nov-24 | déc-24 |
| Besoins Jan 2024 | | | | | | | | | | | | | | | |
| Besoins Fév 2024 | | | | | | | | | | | | | | | |
| Besoins Mar 2024 | | | \$ 155,0 | | | | | | | | | | | | |
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| Besoins Mai 2024 | | | | \$ 140,0 | \$ 140,0 | | | | | | | | | | |
| Besoins Juin 2024 | | | | | | | | | | | | | | | |
| Besoins Juil 2024 | | | | | \$ 138,8 | \$ 138,8 | | | | | | | | | |
| Besoins Aout 2024 | | | | | | \$ 201,3 | \$ 201,3 | | | | | | | | |
| Besoins Sep 2024 | | | | | | | \$ 297,5 | \$ 297,5 | | | | | | | |
| Besoins Oct 2024 | | | | | | | | \$ 347,5 | \$ 347,5 | | | | | | |
| Besoins Nov 2024 | | | | | | | | | \$ 362,5 | \$ 362,5 | | | | | |
| Besoins Déc 2024 | | | | | | | | | | \$ 372,5 | \$ 372,5 | | | | |

This section shows in detail the import hedging program for each currency for the year 2024 further discussed in design of the forward contract

04

Details:

| Row Labels | Montant en USD | Montant en TND | Difference en TND | Years (Date com...) | | | |
|-------------|----------------|----------------|-------------------|---------------------|------|------|--|
| | | | | 2021 | 2022 | 2023 | |
| ■ 2021 | 5,280,615.83 | 14,749,206.27 | (64,841.93) | | | | |
| ■ Qtr1 | 1,058,407.00 | 2,898,245.33 | (22,007.65) | | | | |
| ■ Qtr2 | 588,719.14 | 1,626,497.00 | (3,220.14) | | | | |
| ■ Qtr3 | 2,995,756.36 | 8,395,138.60 | (33,637.08) | | | | |
| ■ Qtr4 | 637,733.33 | 1,829,325.34 | (5,977.05) | | | | |
| ■ 2022 | 4,430,735.73 | 13,830,768.31 | (92,695.16) | | | | |
| ■ Qtr1 | 456,667.82 | 1,337,470.08 | (12,582.21) | | | | |
| ■ Qtr2 | 1,611,641.08 | 4,921,570.10 | (23,937.71) | | | | |
| ■ Qtr3 | 1,740,052.60 | 5,545,519.13 | 27,377.29 | | | | |
| ■ Qtr4 | 622,374.23 | 2,026,209.00 | (83,552.53) | | | | |
| ■ 2023 | 6,085,475.76 | 18,903,143.45 | (136,134.51) | | | | |
| ■ Qtr1 | 3,215,045.46 | 9,981,552.15 | (120,374.60) | | | | |
| ■ Qtr2 | 985,197.89 | 3,037,518.68 | (20,085.90) | | | | |
| ■ Qtr3 | 779,832.31 | 2,418,532.64 | 5,011.94 | | | | |
| ■ Qtr4 | 1,105,400.10 | 3,465,539.97 | (685.95) | | | | |
| Grand Total | 15,796,827.32 | 47,483,118.03 | (293,671.59) | | | | |

| Row Labels | Montant en EUR | Montant en TND | Différence en TND | EURO | | | |
|-------------|----------------|----------------|-------------------|------|------|------|--|
| | | | | 2021 | 2022 | 2023 | |
| ■ 2021 | 5,673,324 | 18,706,153 | (87,348) | | | | |
| ■ Qtr1 | 1,802,018 | 5,878,196 | 26,159 | | | | |
| ■ Qtr2 | 1,251,457 | 4,145,896 | (10,598) | | | | |
| ■ Qtr3 | 1,355,457 | 4,497,189 | (36,001) | | | | |
| ■ Qtr4 | 1,264,393 | 4,184,872 | (66,909) | | | | |
| ■ 2022 | 3,897,832 | 12,737,144 | (126,502) | | | | |
| ■ Qtr1 | 966,026 | 3,171,276 | (23,747) | | | | |
| ■ Qtr2 | 1,425,173 | 4,661,284 | (63,834) | | | | |
| ■ Qtr3 | 510,957 | 1,674,290 | (43,595) | | | | |
| ■ Qtr4 | 995,676 | 3,230,294 | 4,675 | | | | |
| ■ 2023 | 3,858,188 | 12,829,716 | 27,527 | | | | |
| ■ Qtr1 | 1,347,122 | 4,443,800 | (25,984) | | | | |
| ■ Qtr2 | 982,423 | 3,271,304 | 14,156 | | | | |
| ■ Qtr3 | 855,617 | 2,849,157 | 39,250 | | | | |
| ■ Qtr4 | 673,026 | 2,265,455 | 104 | | | | |
| Grand Total | 13,429,345 | 44,273,013 | (186,323) | | | | |

The loss amount of each currency is represented in percentage. You can select a year and a month to reflect the correspondent percentage loss.

HEDGING THE COMPANY'S FX RISK

03



Current Strategy

To hedge their FX risks, ASSAD follows a Natural Hedging approach by using all revenues from its exports to cover import costs.

This revenue and cost matching effectively reduces its exposure to currency exchange rate fluctuations. As a result, if the value of the company's exports matches or exceeds the value of its imports in the respective currencies, it can act as a form of built-in protection against exchange rate movements, else the company buys currency using spot rates.

However, while this method can provide a degree of protection against currency risk, it might not offer complete insulation, especially if there are mismatches in timing or amounts between export revenues and import expenses. Significant fluctuations in exchange rates or sudden changes in the volumes of exports and imports can still affect the company's financial position.

This requires the use of a more comprehensive risk management approach.



Types of hedging:

Two types of hedging are available:

Dynamic hedging: involves the regular and active adjustment of hedge positions based on unfavorable fluctuations in exchange rates, utilizing various financial instruments including forward contracts, options, swaps, and others.

Passive hedging: aims to maintain constant hedge positions over an extended period, thereby offering a certain level of stability. However, it may potentially expose the company to losses if exchange rates move unfavorably without adequate adjustment of hedge positions.





STRATEGY CHOICE

The dynamic nature of the manufacturing industry, the company's projections regarding its imports in US dollars, and the significant fluctuations observed in its imports over the last three years have motivated the adoption of a dynamic hedging strategy based on the use of futures contracts. Within this strategy, monthly requirements will be allocated across two types of futures contracts: a 3-month contract and a 2-month contract. These contracts will be entered into respectively 3 and 2 months prior to the start of each month in which imports are planned.

To maximize the benefits of this strategy, the amounts and coverage ratios will be flexible, determined based on the strength of the dollar during each period and the company's holdings in foreign currencies.

HEDGING INSTRUMENT

Choosing forward contracts as a hedging instrument for our currency transactions is preferable to other instruments because:

- They provide a direct and specific fixing of exchange rates for future transactions, ensuring certainty regarding costs.
- Unlike options or currency swaps, forwards are simpler and more flexible.
- They do not involve initial costs (premiums).

To maximize the benefits of this strategy, the amounts and coverage ratios will be flexible, determined based on the strength of the dollar during each period and the company's holdings in foreign currencies.

DESIGN OF THE FORWARD CONTRACT

Forecasting FX rates:

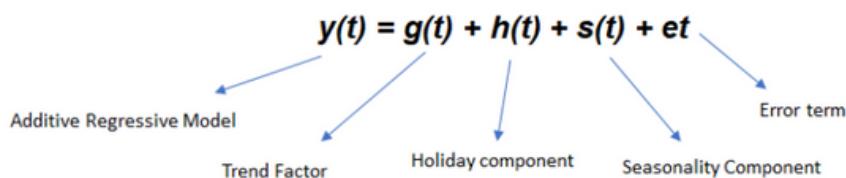
After analyzing the different methods we can use to forecast the forward rates, we ended up with two techniques: ARIMA and Prophet.

We eventually opted for Prophet, due to its better accuracy and flexibility, it might provide more precise forecasts compared to ARIMA, which assumes stationarity and might require extensive preprocessing for non-linear patterns.

Prophet

A time series forecasting tool that uses an additive model to forecast future values based on historical data. It is designed to be easy to use and requires minimal feature engineering. To use Prophet, we need to provide it with a historical time series dataset, which in our case is the EURTND and USDTND exchange rates. Prophet then uses this data to fit a model that captures the underlying trends, seasonality, and other patterns in the data. Once the model is trained, we can use it to make predictions for future time periods. Prophet also provides uncertainty intervals that indicate the range of possible values for each forecasted point

***You can find the Python code for detailed examination and analysis at the end of this document.**



DESIGN OF THE FORWARD CONTRACT

The company initially chooses a coverage ratio of 25%, 50%, 75%, 100%, which can be adjusted to 0% if necessary to take advantage of market fluctuations.

To explain further, if we set a 75% coverage ratio for our August imports (\$805,000), we will cover 75% of our dollar needs, which is \$603,750. We will allocate this amount across two forward contracts (with maturities of 3 and 2 months) starting in May and June, and we will purchase the remaining 25% in the spot market in August.

"Why split our hedge into two forward contracts with different maturities?"

Commodity and currency markets are subject to significant fluctuations. Additionally, the dynamic nature of our industry can lead to changes in our forecasts.

By structuring our needs this way, we can absorb adverse exchange rate movements that might occur against us. We can also benefit from favorable movements by reallocating our forward contracts based on market conditions.

Batteries ASSAD

Programme USD

Programme EURO

TCA

EXPOSURE

HEDGE

Details

Programme de couverture des importations en USD 2024

| Mois | Prévisions | Hedge Ratio | Montant à couvrir |
|------|------------|-------------|-------------------|
| Jan | \$ 580 | 50% | \$ 290,0 |
| Fév | \$ 120 | 50% | \$ 60,0 |
| Mar | \$ 310 | 50% | \$ 155,0 |
| Avr | \$ - | 50% | \$ - |
| Mai | \$ 560 | 50% | \$ 280,0 |
| Jun | \$ - | 50% | \$ - |
| Jul | \$ 555 | 50% | \$ 277,5 |
| Aout | \$ 805 | 50% | \$ 402,5 |
| Sep | \$ 1 190 | 50% | \$ 595,0 |
| Oct | \$ 1 390 | 50% | \$ 695,0 |
| Nov | \$ 1 450 | 50% | \$ 725,0 |
| Déc | \$ 1 490 | 50% | \$ 745,0 |

| Date de début du contrat | Achat à terme Maturité 2 mois | | | | | | | | | | | |
|--------------------------|-------------------------------|----------|----------|--------|--------|---------|---------|---------|---------|--------|--------|--------|
| | janv-24 | févr-24 | mars-24 | avr-24 | mai-24 | juin-24 | juil-24 | août-24 | sept-24 | oct-24 | nov-24 | déc-24 |
| Besoins Jan 2024 | | | | | | | | | | | | |
| Besoins Fév 2024 | | | | | | | | | | | | |
| Besoins Mar 2024 | | \$ 155,0 | | | | | | | | | | |
| Besoins Avr 2024 | | | | | | | | | | | | |
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Risk Management and Financial Institutions by John C Hull

EURTND

December 26, 2023

```
[1]: import pandas as pd
import plotly.express as px
import plotly.graph_objs as go

from prophet import Prophet
from prophet.plot import add_changepoints_to_plot

from prophet.plot import plot_plotly

import warnings

warnings.filterwarnings('ignore')
```

```
[2]: df = pd.read_csv("data/EURTND.csv")
df.head(10)
```

```
[2]:      Date        TND
0  02/01/2003  1.397095
1  03/01/2003  1.398103
2  06/01/2003  1.402329
3  07/01/2003  1.401230
4  08/01/2003  1.400749
5  09/01/2003  1.406150
6  10/01/2003  1.409588
7  13/01/2003  1.407427
8  14/01/2003  1.403930
9  15/01/2003  1.409210
```

```
[3]: df['Date'] = pd.to_datetime(df['Date'], format='%d/%m/%Y')

df.columns=['ds', 'y']

df.head(5)
```

```
[3]:      ds        y
0  2003-01-02  1.397095
1  2003-01-03  1.398103
```

```
2 2003-01-06 1.402329
3 2003-01-07 1.401230
4 2003-01-08 1.400749
```

```
[4]: model = Prophet()
```

```
[5]: model.fit(df)
```

```
18:10:28 - cmdstanpy - INFO - Chain [1] start processing
18:10:31 - cmdstanpy - INFO - Chain [1] done processing
```

```
[5]: <prophet.forecaster.Prophet at 0x1d65d564f80>
```

```
[6]: model.component_modes
```

```
[6]: {'additive': ['yearly',
 'weekly',
 'additive_terms',
 'extra_regressors_additive',
 'holidays'],
 'multiplicative': ['multiplicative_terms', 'extra_regressors_multiplicative']}
```

```
[7]: df.tail()
```

```
[7]:      ds          y
5434 2023-12-11  3.364310
5435 2023-12-12  3.379195
5436 2023-12-13  3.378291
5437 2023-12-14  3.428257
5438 2023-12-15  3.368438
```

```
[8]: future_dates = model.make_future_dataframe(periods=365)
future_dates.tail()
```

```
[8]:      ds
5799 2024-12-10
5800 2024-12-11
5801 2024-12-12
5802 2024-12-13
5803 2024-12-14
```

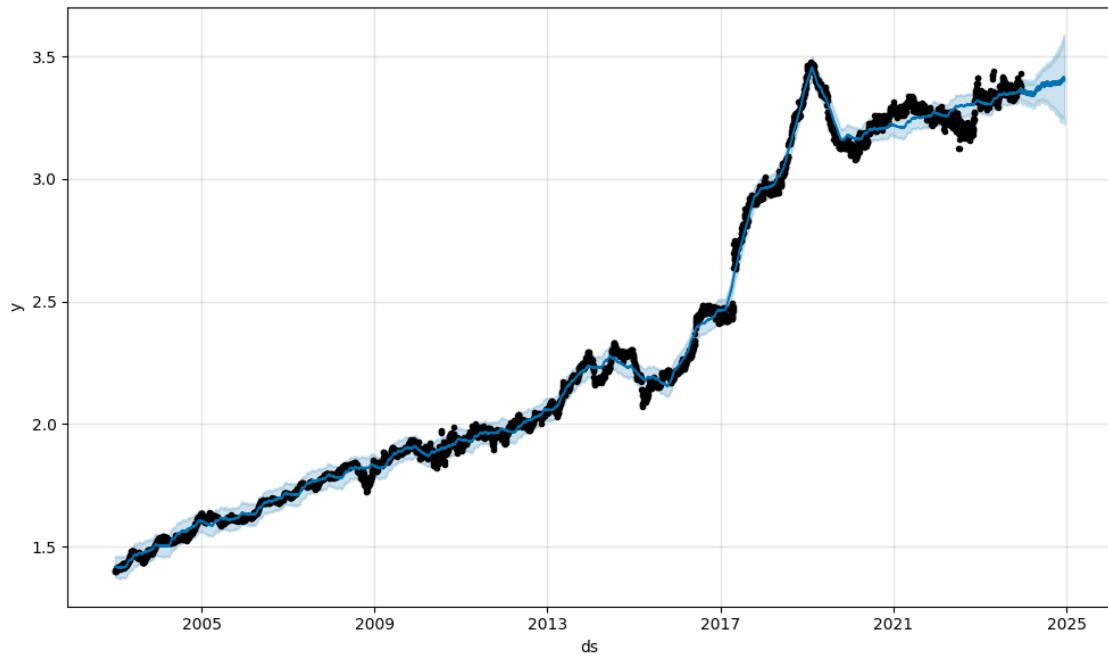
```
[9]: prediction = model.predict(future_dates)
```

```
[10]: prediction.tail()
```

```
[10]:      ds      trend  yhat_lower  yhat_upper  trend_lower  trend_upper \
5799 2024-12-10  3.399974    3.234331    3.572533    3.240711    3.556629
5800 2024-12-11  3.400104    3.254085    3.586687    3.239867    3.557292
```

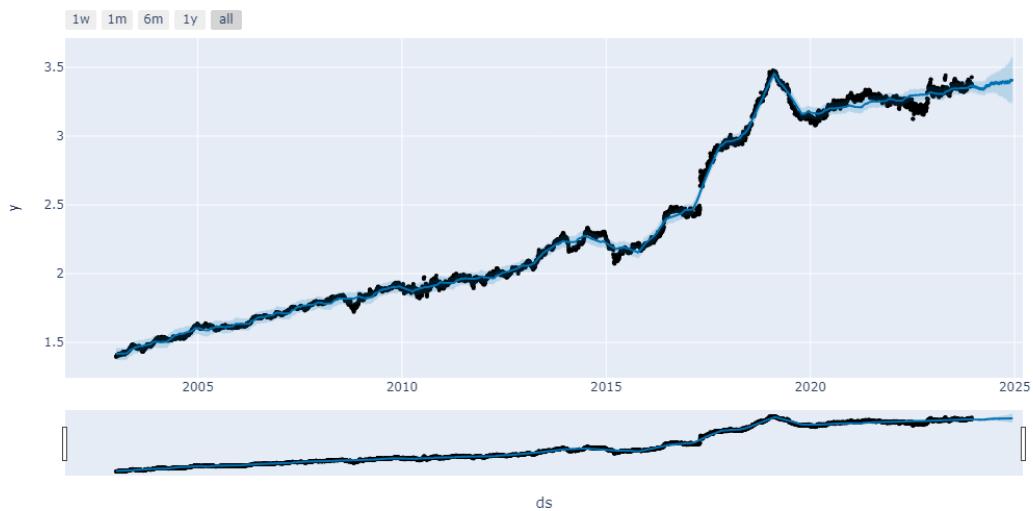
| | | | | | | |
|------|------------|-----------|-----------|----------|----------|-----------|
| 5801 | 2024-12-12 | 3.400234 | 3.254099 | 3.584796 | 3.239022 | 3.558262 |
| 5802 | 2024-12-13 | 3.400364 | 3.247610 | 3.584566 | 3.238195 | 3.559231 |
| 5803 | 2024-12-14 | 3.400494 | 3.222389 | 3.568637 | 3.237486 | 3.559635 |
| | | | | | | \ |
| 5799 | | 0.014830 | 0.014830 | | 0.014830 | 0.003582 |
| 5800 | | 0.014525 | 0.014525 | | 0.014525 | 0.003488 |
| 5801 | | 0.014928 | 0.014928 | | 0.014928 | 0.004164 |
| 5802 | | 0.013833 | 0.013833 | | 0.013833 | 0.003395 |
| 5803 | | 0.000641 | 0.000641 | | 0.000641 | -0.009422 |
| | | | | | | \ |
| 5799 | | 0.003582 | 0.003582 | 0.011248 | 0.011248 | 0.011248 |
| 5800 | | 0.003488 | 0.003488 | 0.011036 | 0.011036 | 0.011036 |
| 5801 | | 0.004164 | 0.004164 | 0.010765 | 0.010765 | 0.010765 |
| 5802 | | 0.003395 | 0.003395 | 0.010438 | 0.010438 | 0.010438 |
| 5803 | | -0.009422 | -0.009422 | 0.010064 | 0.010064 | 0.010064 |
| | | | | | | \ |
| 5799 | | 0.0 | | 0.0 | | |
| 5800 | | 0.0 | | 0.0 | | |
| 5801 | | 0.0 | | 0.0 | | |
| 5802 | | 0.0 | | 0.0 | | |
| 5803 | | 0.0 | | 0.0 | | |
| | | | | | | \ |
| 5799 | | | 0.0 | 3.414804 | | |
| 5800 | | | 0.0 | 3.414629 | | |
| 5801 | | | 0.0 | 3.415163 | | |
| 5802 | | | 0.0 | 3.414198 | | |
| 5803 | | | 0.0 | 3.401136 | | |

```
[11]: fig = model.plot(prediction)
```

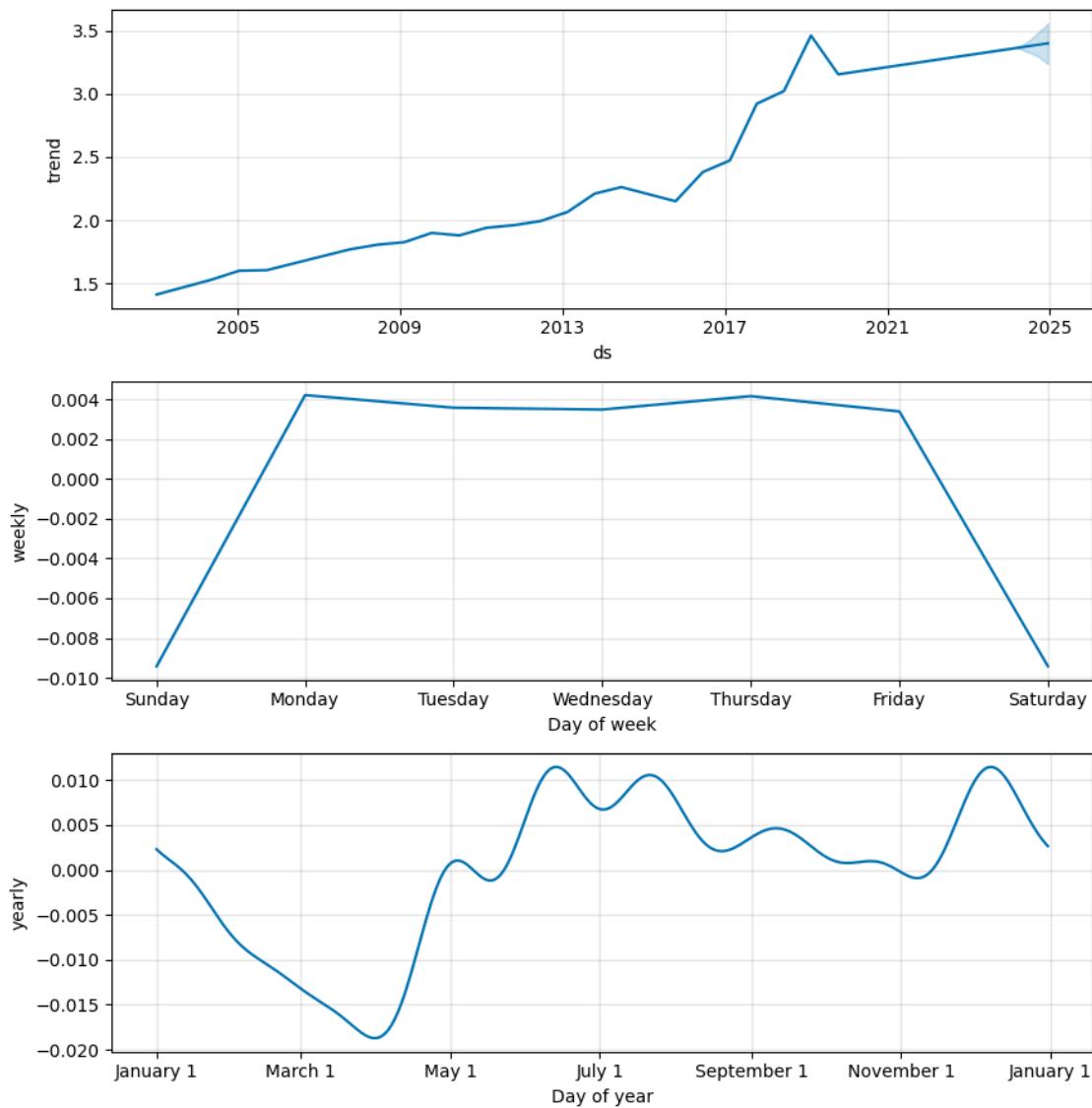


0.0.1 Our model's prediction (the blue line) vs actual historical values.

```
[12]: plotly(model, prediction)
```



```
[13]: fig2 = model.plot_components(prediction)
```



```
[16]: prediction.to_excel('output/EURTND-predictions.xlsx')
```

USDTND

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```
[40]: import pandas as pd
import plotly.express as px
import plotly.graph_objs as go

from prophet import Prophet
from prophet.plot import add_changepoints_to_plot

from prophet.plot import plot_plotly

import warnings

warnings.filterwarnings('ignore')
```

```
[41]: df = pd.read_csv("data/USDTND.csv")
df.head(10)
```

```
[41]:      Date      TND
0  02/01/2003  1.3470
1  03/01/2003  1.3422
2  06/01/2003  1.3381
3  07/01/2003  1.3435
4  08/01/2003  1.3483
5  09/01/2003  1.3419
6  10/01/2003  1.3385
7  13/01/2003  1.3337
8  14/01/2003  1.3257
9  15/01/2003  1.3309
```

```
[42]: df['Date'] = pd.to_datetime(df['Date'], format='%d/%m/%Y')

df.columns=['ds', 'y']

df.head(5)
```

```
[42]:      ds      y
0 2003-01-02  1.3470
1 2003-01-03  1.3422
```

```
2 2003-01-06 1.3381
3 2003-01-07 1.3435
4 2003-01-08 1.3483
```

```
[43]: model = Prophet()
```

```
[44]: model.fit(df)
```

```
16:48:24 - cmdstanpy - INFO - Chain [1] start processing
16:48:26 - cmdstanpy - INFO - Chain [1] done processing
```

```
[44]: <prophet.forecaster.Prophet at 0x24f2ff5b7d0>
```

```
[45]: model.component_modes
```

```
[45]: {'additive': ['yearly',
 'weekly',
 'additive_terms',
 'extra_regressors_additive',
 'holidays'],
 'multiplicative': ['multiplicative_terms', 'extra_regressors_multiplicative']}
```

```
[46]: df.tail()
```

```
[46]:      ds      y
5434 2023-12-11  3.1315
5435 2023-12-12  3.1315
5436 2023-12-13  3.1310
5437 2023-12-14  3.1180
5438 2023-12-15  3.0865
```

```
[47]: future_dates = model.make_future_dataframe(periods=365)
future_dates.tail()
```

```
[47]:      ds
5799 2024-12-10
5800 2024-12-11
5801 2024-12-12
5802 2024-12-13
5803 2024-12-14
```

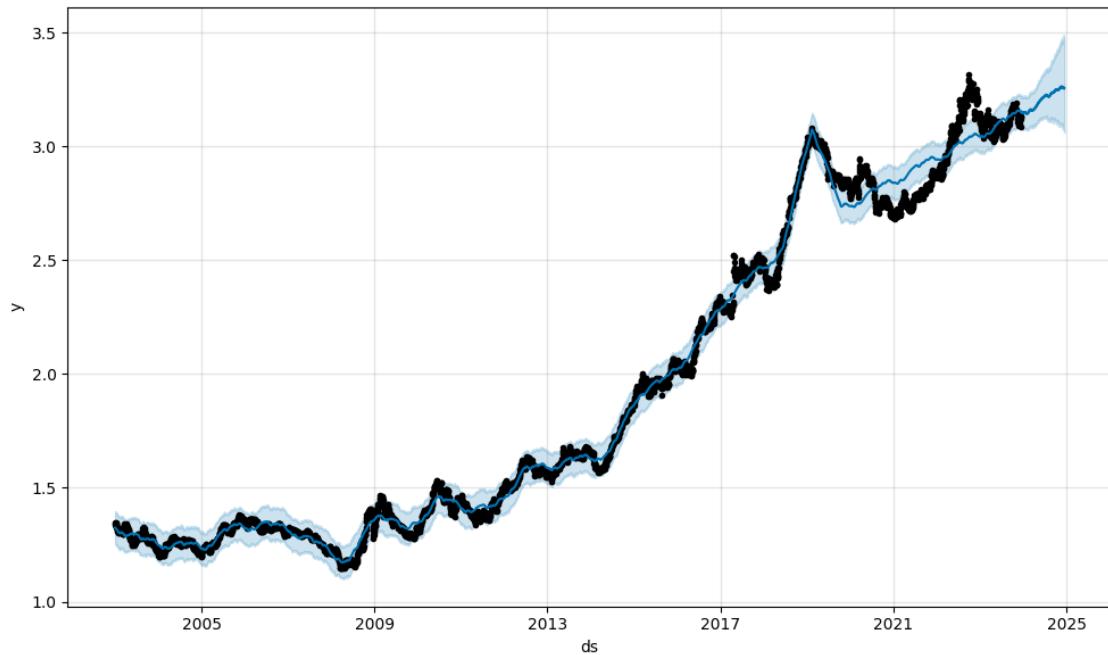
```
[48]: prediction = model.predict(future_dates)
```

```
[49]: prediction.tail()
```

```
[49]:      ds      trend  yhat_lower  yhat_upper  trend_lower  trend_upper \
5799 2024-12-10  3.251800    3.066418    3.490349    3.076149    3.465924
5800 2024-12-11  3.252080    3.074399    3.482132    3.075141    3.467829
```

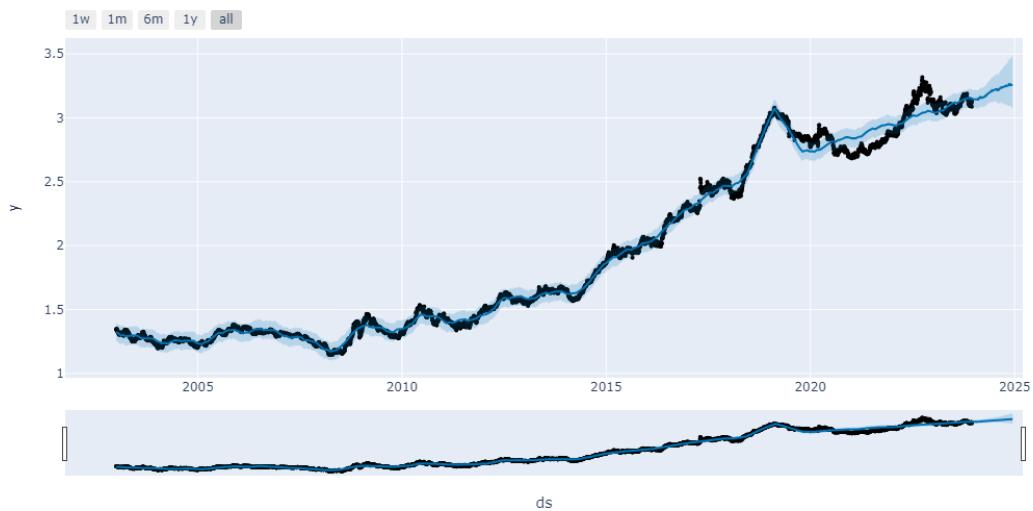
| | | | | | | |
|------|------------|-----------|-----------|----------|----------|--------------------|
| 5801 | 2024-12-12 | 3.252360 | 3.071993 | 3.483227 | 3.074421 | 3.469735 |
| 5802 | 2024-12-13 | 3.252639 | 3.067435 | 3.478872 | 3.073700 | 3.471615 |
| 5803 | 2024-12-14 | 3.252919 | 3.061616 | 3.476539 | 3.072980 | 3.473493 |
| | | | | | | \ |
| 5799 | | 0.002272 | | 0.002272 | | 0.002272 -0.001130 |
| 5800 | | 0.001573 | | 0.001573 | | 0.001573 -0.001119 |
| 5801 | | 0.001398 | | 0.001398 | | 0.001398 -0.000577 |
| 5802 | | 0.000105 | | 0.000105 | | 0.000105 -0.001148 |
| 5803 | | 0.002956 | | 0.002956 | | 0.002956 0.002428 |
| | | | | | | \ |
| 5799 | | -0.001130 | -0.001130 | 0.003402 | 0.003402 | 0.003402 |
| 5800 | | -0.001119 | -0.001119 | 0.002692 | 0.002692 | 0.002692 |
| 5801 | | -0.000577 | -0.000577 | 0.001975 | 0.001975 | 0.001975 |
| 5802 | | -0.001148 | -0.001148 | 0.001253 | 0.001253 | 0.001253 |
| 5803 | | 0.002428 | 0.002428 | 0.000528 | 0.000528 | 0.000528 |
| | | | | | | \ |
| 5799 | | 0.0 | | 0.0 | | 0.0 |
| 5800 | | 0.0 | | 0.0 | | 0.0 |
| 5801 | | 0.0 | | 0.0 | | 0.0 |
| 5802 | | 0.0 | | 0.0 | | 0.0 |
| 5803 | | 0.0 | | 0.0 | | 0.0 |
| | | | | | | \ |
| 5799 | | 0.0 | 3.254072 | | | |
| 5800 | | 0.0 | 3.253653 | | | |
| 5801 | | 0.0 | 3.253758 | | | |
| 5802 | | 0.0 | 3.252745 | | | |
| 5803 | | 0.0 | 3.255875 | | | |

```
[50]: fig = model.plot(prediction)
```

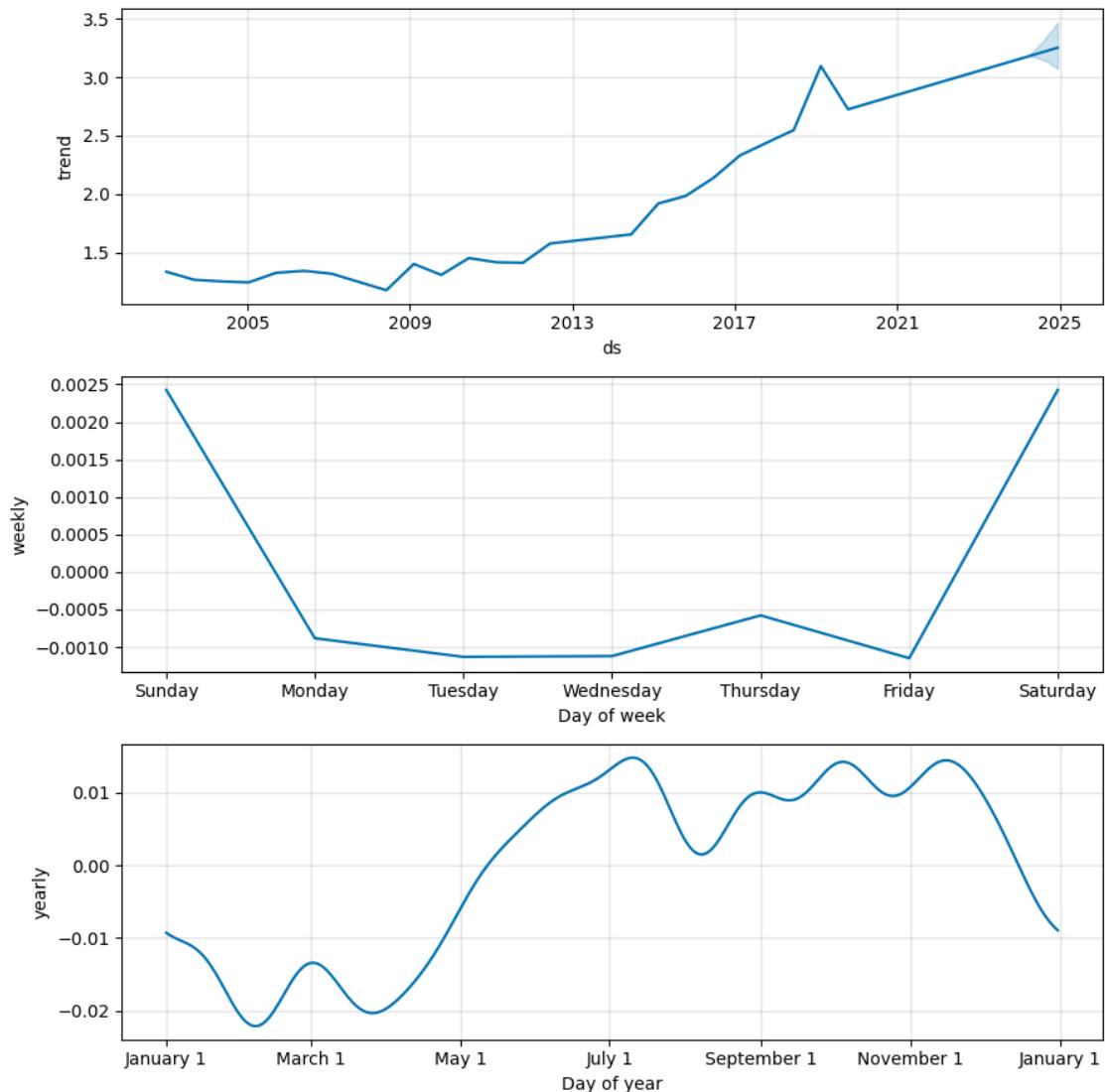


0.0.1 Our model's prediction (the blue line) vs actual historical values.

```
[51]: plotly(model, prediction)
```



```
[52]: fig2 = model.plot_components(prediction)
```



```
[53]: prediction.to_excel('data/USDTND-predictions.xlsx')
```