Modelo_Clasificación_MCG

November 22, 2025

1 1. Modelo de Clasificación - Entrega Final Machine Learning

- Buscar un conjunto de datos (>2000 registros) al cuál se le pueda aplicar algoritmos de clasificación. Es decir, que busque predecir una variable con dos o más categorias.
- Explorar los datos
- Aplicar modelos: regresión logística, árboles de decisión y Random Forest
- Evaluar los modelos y seleccionar el mejor con la curva ROC.
- Hacer algunas predicciones.

2 1. Carga de los datos desde kaggle - Loan_approval_data_2025

Para este caso, vamos a usar los datos que se encuentrn en kaggle, en donde hay una serie de datos economicos donde se aprueban o no se aprueban creditos para compra de vivienda, el link se encuentra en el siguiente enlace

[1]:
```
import kagglehub
import os
import pandas as pd
```

[2]:
```
path = kagglehub.dataset_download("parthpatel2130/
  ↪realistic-loan-approval-dataset-us-and-canada")
print(path)
```

```
Using Colab cache for faster access to the 'realistic-loan-approval-dataset-us-
and-canada' dataset.
/kaggle/input/realistic-loan-approval-dataset-us-and-canada
```

[3]:
```
for f in os.listdir(path):
  print(f)
```

```
Loan_approval_data_2025.csv
```

[4]:
```
df_loan = pd.read_csv(path + "/Loan_approval_data_2025.csv")
df_loan.head()
```

[4]:

	customer_id	age	occupation_status	years_employed	annual_income	credit_score	credit_history_years	savings_assets	current_debt	defaults_on_file	delinquencies_last_2yrs	derogatory_marks	product_type	loan_intent	loan_amount	interest_rate	debt_to_income_ratio	loan_to_income_ratio	payment_to_income_ratio	loan_status
0	CUST100000	40	Employed	17.2	25579	692	5.3	895	10820	0	0	0	Credit Card	Business	600	17.02	0.423	0.023	0.008	1
1	CUST100001	33	Employed	7.3	43087	627	3.5	169	16550	0	1	0	Personal Loan	Home Improvement	53300	14.10	0.384	1.237	0.412	0
2	CUST100002	42	Student	1.1	20840	689	8.4	17	7852	0	0	0	Credit Card	Debt Consolidation	2100	18.33	0.377	0.101	0.034	1
3	CUST100003	53	Student	0.5	29147	692	9.8	1480	11603	0	1	0	Credit Card	Business	2900	18.74	0.398	0.099	0.033	1
4	CUST100004	32	Employed	12.5	63657	630	7.2	209	12424	0	0	0	Personal Loan	Education	99600	13.92	0.195	1.565	0.522	1

Para que la base de datos sea 100% funcional, vamos a eliminar de una vez la columna costumer id

[5]:
```
df_loan_final = df_loan.drop(columns=['customer_id'])
df_loan_final.head()
```

[5]:

	age	occupation_status	years_employed	annual_income	credit_score	credit_history_years	savings_assets	current_debt	defaults_on_file	delinquencies_last_2yrs	derogatory_marks	product_type	loan_intent	loan_amount	interest_rate	debt_to_income_ratio	loan_to_income_ratio	payment_to_income_ratio	loan_status
0	40	Employed	17.2	25579	692	5.3	895	10820	0	0	0	Credit Card	Business	600	17.02	0.423	0.023	0.008	1
1	33	Employed	7.3	43087	627	3.5	169	16550	0	1	0	Personal Loan	Home Improvement	53300	14.10	0.384	1.237	0.412	0
2	42	Student	1.1	20840	689	8.4	17	7852	0	0	0	Credit Card	Debt Consolidation	2100	18.33	0.377	0.101	0.034	1
3	53	Student	0.5	29147	692	9.8	1480	11603	0	1	0	Credit Card	Business	2900	18.74	0.398	0.099	0.033	1
4	32	Employed	12.5	63657	630	7.2	209	12424	0	0	0	Personal Loan	Education	99600	13.92	0.195	1.565	0.522	1

```
   credit_history_years  savings_assets  current_debt  defaults_on_file  \
0                   5.3             895         10820                 0
1                   3.5             169         16550                 0
2                   8.4              17          7852                 0
3                   9.8            1480         11603                 0
4                   7.2             209         12424                 0

   delinquencies_last_2yrs  derogatory_marks   product_type  \
0                        0                 0    Credit Card
1                        1                 0  Personal Loan
2                        0                 0    Credit Card
3                        1                 0    Credit Card
4                        0                 0  Personal Loan

          loan_intent  loan_amount  interest_rate  debt_to_income_ratio  \
0            Business          600          17.02                 0.423
1    Home Improvement        53300          14.10                 0.384
2  Debt Consolidation         2100          18.33                 0.377
3            Business         2900          18.74                 0.398
4           Education        99600          13.92                 0.195

   loan_to_income_ratio  payment_to_income_ratio  loan_status
0                 0.023                    0.008            1
1                 1.237                    0.412            0
2                 0.101                    0.034            1
3                 0.099                    0.033            1
4                 1.565                    0.522            1
```

3 CArga de las librerias necesariar

[6]:
```python
# --- Librerías Principales (Datos y Gráficos) ---
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
import statsmodels.api as sm
import warnings
from itertools import cycle # Útil para gráficos ROC

# --- Gráficos Específicos (Árboles y Colores) ---
from graphviz import Source
from sklearn.tree import export_graphviz
from matplotlib import cm
from matplotlib.colors import ListedColormap, LinearSegmentedColormap
from matplotlib.patches import Patch
```

```python
# --- Preprocesamiento y Herramientas de Datos ---
from sklearn.preprocessing import (StandardScaler, MinMaxScaler, LabelEncoder,
                                   OneHotEncoder, label_binarize)
from sklearn.compose import ColumnTransformer
from sklearn.pipeline import Pipeline
from sklearn.feature_selection import RFE
from sklearn.datasets import load_iris

# --- Selección y Optimización de Modelos ---
from sklearn.model_selection import (train_test_split, GridSearchCV,
                                     RandomizedSearchCV)

# --- Modelos de Clasificación ---
from sklearn.linear_model import LogisticRegression
from sklearn.naive_bayes import GaussianNB, MultinomialNB
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier

# --- Modelos de Regresión ---
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor, ExtraTreesRegressor
from xgboost import XGBRegressor
from lightgbm import LGBMRegressor

# --- Métricas de Evaluación ---
from sklearn import metrics
from sklearn.metrics import (
    # Métricas de Clasificación
    accuracy_score, precision_score, recall_score, f1_score,
    classification_report, confusion_matrix, ConfusionMatrixDisplay,
    roc_curve, auc, roc_auc_score,

    # Métricas de Regresión
    mean_squared_error, r2_score, mean_absolute_error
)
from imblearn.metrics import specificity_score

# --- Configuración (Opcional) ---
# Para omitir los warnings
warnings.filterwarnings("ignore")
```

4 Exploración de los datos

[7]:
```
print("Los datos tienen " + str(df_loan_final.shape[0]) + " ovservaciones y " +␣
 ↪str(df_loan_final.shape[1]) + " variables \n")

print(f"Los tipos de datos en las son las siguientes: \n{df_loan_final.dtypes}␣
 ↪\n")

print("Verificamos si hay datos faltantes:")
print(df_loan_final.isna().sum(), "\n")

print("Ahora analizaremos sus estadísticas descriptivas:")
round(df_loan_final.describe(), 3)
```

```
Los datos tienen 50000 ovservaciones y 19 variables

Los tipos de datos en las son las siguientes:
age                           int64
occupation_status            object
years_employed              float64
annual_income                 int64
credit_score                  int64
credit_history_years        float64
savings_assets                int64
current_debt                  int64
defaults_on_file              int64
delinquencies_last_2yrs       int64
derogatory_marks              int64
product_type                 object
loan_intent                  object
loan_amount                   int64
interest_rate               float64
debt_to_income_ratio        float64
loan_to_income_ratio        float64
payment_to_income_ratio     float64
loan_status                   int64
dtype: object

Verificamos si hay datos faltantes:
age                         0
occupation_status           0
years_employed              0
annual_income               0
credit_score                0
credit_history_years        0
savings_assets              0
current_debt                0
```

```
defaults_on_file           0
delinquencies_last_2yrs    0
derogatory_marks           0
product_type               0
loan_intent                0
loan_amount                0
interest_rate              0
debt_to_income_ratio       0
loan_to_income_ratio       0
payment_to_income_ratio    0
loan_status                0
dtype: int64
```

Ahora analizaremos sus estadísticas descriptivas:

[7]:

	age	years_employed	annual_income	credit_score	\
count	50000.000	50000.000	50000.000	50000.000	
mean	34.957	7.455	50062.892	643.615	
std	11.119	7.612	32630.501	64.732	
min	18.000	0.000	15000.000	348.000	
25%	26.000	1.300	27280.500	600.000	
50%	35.000	4.900	41607.500	643.000	
75%	43.000	11.400	62723.250	687.000	
max	70.000	39.900	250000.000	850.000	

	credit_history_years	savings_assets	current_debt	defaults_on_file	\
count	50000.000	50000.000	50000.000	50000.000	
mean	8.168	3595.619	14290.442	0.053	
std	7.208	13232.399	13243.757	0.225	
min	0.000	0.000	60.000	0.000	
25%	2.000	130.000	5581.000	0.000	
50%	6.100	568.000	10385.000	0.000	
75%	12.600	2271.000	18449.250	0.000	
max	30.000	300000.000	163344.000	1.000	

	delinquencies_last_2yrs	derogatory_marks	loan_amount	interest_rate	\
count	50000.000	50000.000	50000.000	50000.000	
mean	0.555	0.148	33041.874	15.499	
std	0.845	0.413	26116.185	4.068	
min	0.000	0.000	500.000	6.000	
25%	0.000	0.000	12300.000	12.180	
50%	0.000	0.000	26100.000	15.440	
75%	1.000	0.000	48500.000	18.870	
max	9.000	4.000	100000.000	23.000	

	debt_to_income_ratio	loan_to_income_ratio	payment_to_income_ratio	\
count	50000.000	50000.000	50000.000	

mean	0.286	0.702	0.234
std	0.160	0.466	0.155
min	0.002	0.008	0.003
25%	0.161	0.333	0.111
50%	0.265	0.622	0.207
75%	0.389	1.010	0.337
max	0.800	2.001	0.667

	loan_status
count	50000.000
mean	0.550
std	0.497
min	0.000
25%	0.000
50%	1.000
75%	1.000
max	1.000

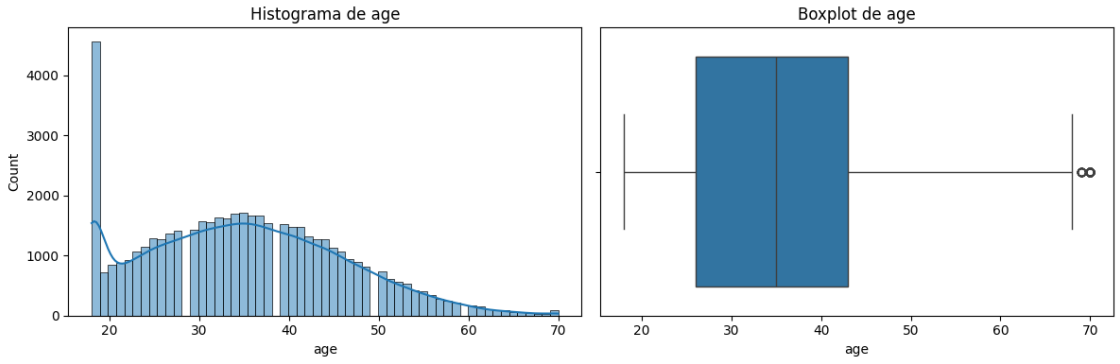
Diccionario de Variables

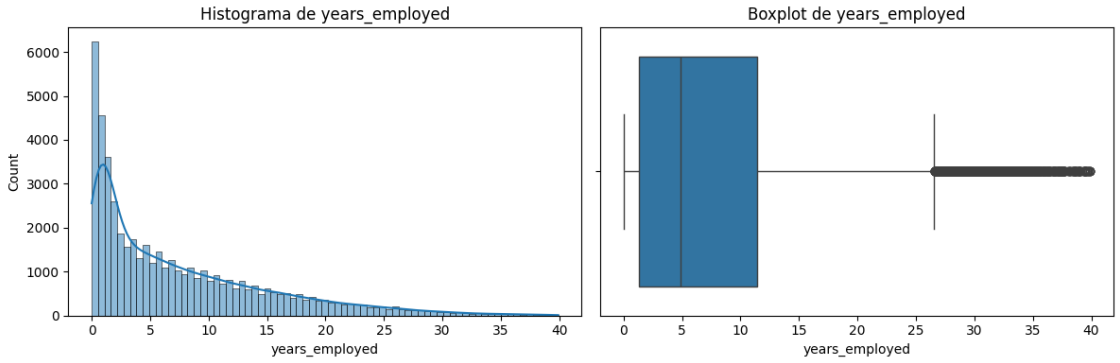
- age: Edad del solicitante en años.
- years_employed: Años que el solicitante ha estado empleado.
- annual_income: Ingreso anual del solicitante.
- credit_score: Puntaje crediticio del solicitante.
- credit_history_years: Años de historial crediticio del solicitante.
- savings_assets: Valor total de los ahorros o activos líquidos del solicitante. current_debt: Valor total de la deuda actual del solicitante.
- defaults_on_file: Número de incumplimientos o defaults registrados en el historial crediticio.
- delinquencies_last_2yrs: Número de moras o pagos atrasados en los últimos dos años.
- derogatory_marks: Número de marcas negativas severas en el historial crediticio (como cobranzas o quiebras).
- loan_amount: Monto solicitado del préstamo. interest_rate: Tasa de interés aplicada al préstamo.
- debt_to_income_ratio: Relación entre la deuda total del solicitante y su ingreso.
- loan_to_income_ratio: Relación entre el monto del préstamo solicitado y el ingreso anual del solicitante.
- payment_to_income_ratio: Proporción del pago del préstamo respecto al ingreso del solicitante.
- loan_status: Estado final del préstamo (por ejemplo, aprobado o rechazado).

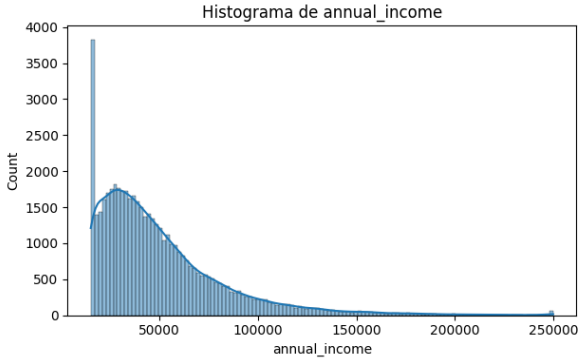
Gracias a la tabla anterior y el diccionario de variavles, aqui podemos ver que las solicitudes de creditos que solo se le hacen a personas que se encuentren entre los 18 y 70 años. Se tiene una media de 7 años empleado y un ingreso medio de 32000, con un historial crediticio de 8 añños con muchas variaciones y con un score promedio de 643 puntos.

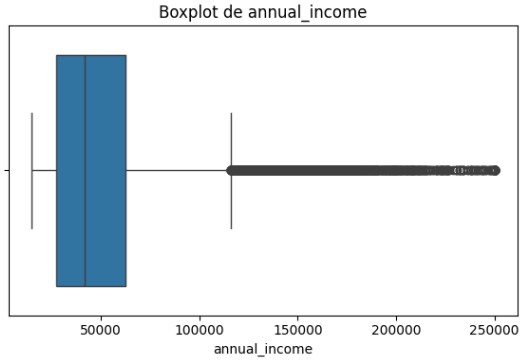
[8]:
```
datos_p1_graficas = df_loan_final.drop(["loan_status", "defaults_on_file",␣
↪"delinquencies_last_2yrs", "derogatory_marks"], axis = 1)
```

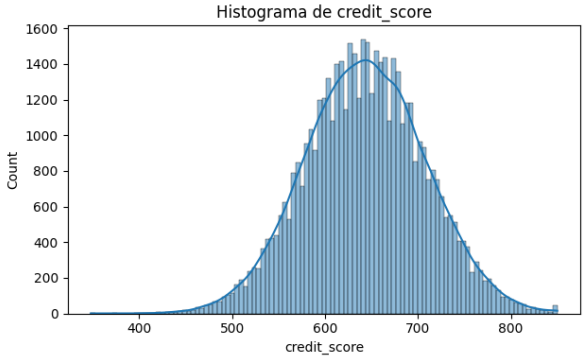
```python
for col in datos_p1_graficas.select_dtypes(include=np.number).columns:
    fig, axes = plt.subplots(1, 2, figsize=(12, 4))

    sns.histplot(datos_p1_graficas[col], kde=True, ax=axes[0])
    axes[0].set_title(f'Histograma de {col}')

    sns.boxplot(x=datos_p1_graficas[col], ax=axes[1])
    axes[1].set_title(f'Boxplot de {col}')

    plt.tight_layout()
    plt.show()
    print("\n")
```

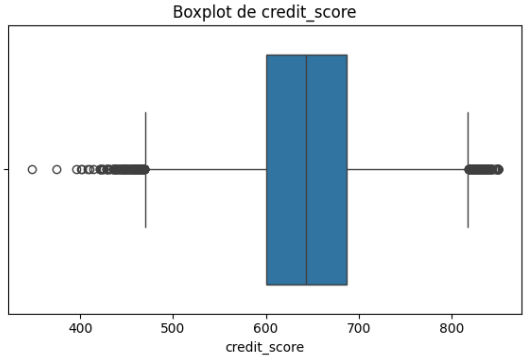


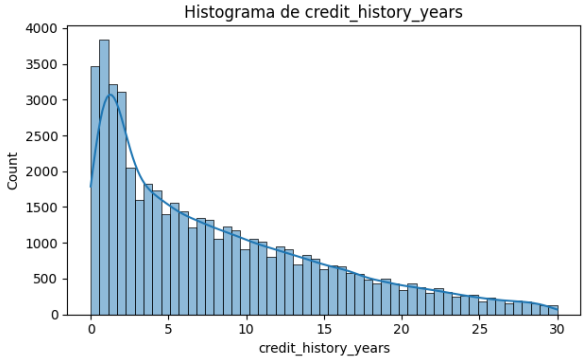


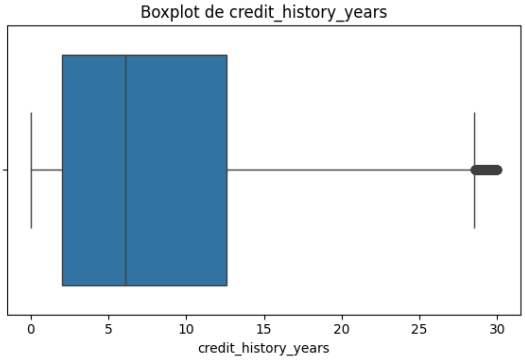

Histograma de annual_income
Count
annual_income
0
500
1000
1500
2000
2500
3000
3500
4000
50000
100000
150000
200000
250000

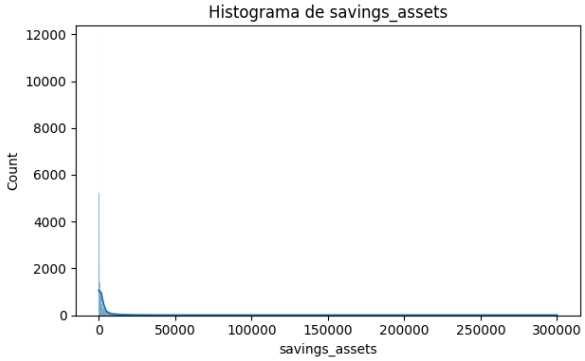

Boxplot de annual_income
annual_income
50000
100000
150000
200000
250000

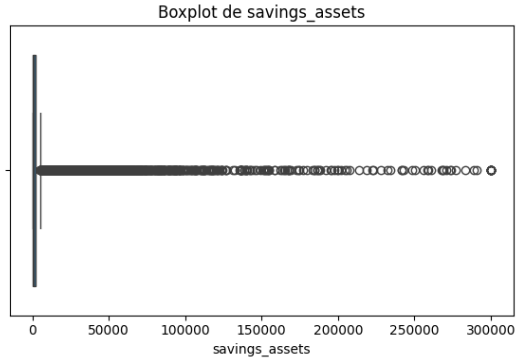

Histograma de credit_score
Count
credit_score
0
200
400
600
800
1000
1200
1400
1600
400
500
600
700
800

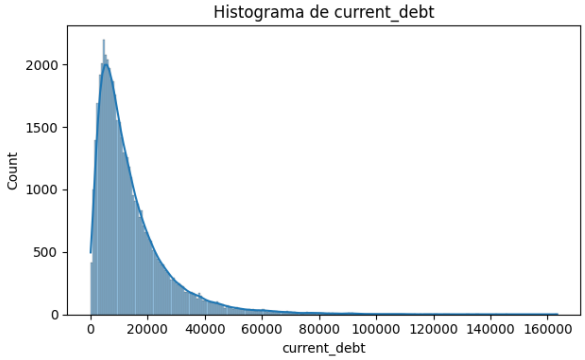

Boxplot de credit_score
credit_score
400
500
600
700
800

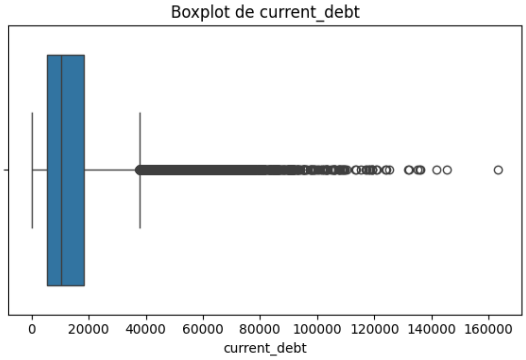

Histograma de credit_history_years
Count
credit_history_years
0
500
1000
1500
2000
2500
3000
3500
4000
0
5
10
15
20
25
30

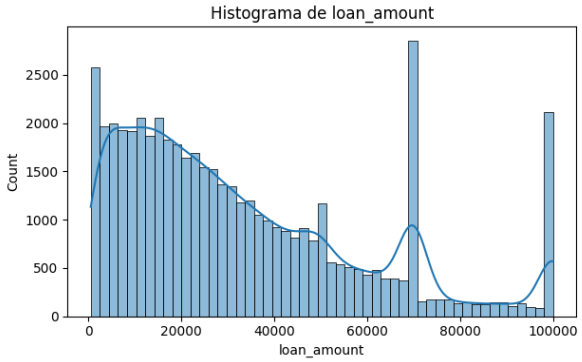

Boxplot de credit_history_years
credit_history_years
0
5
10
15
20
25
30

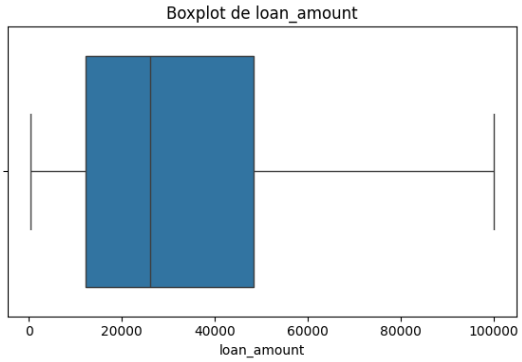

Histograma de savings_assets
Count
savings_assets

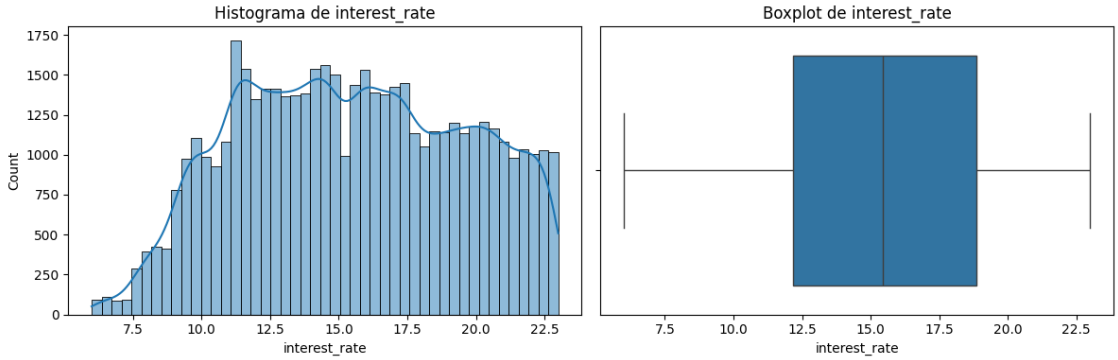

Boxplot de savings_assets
savings_assets

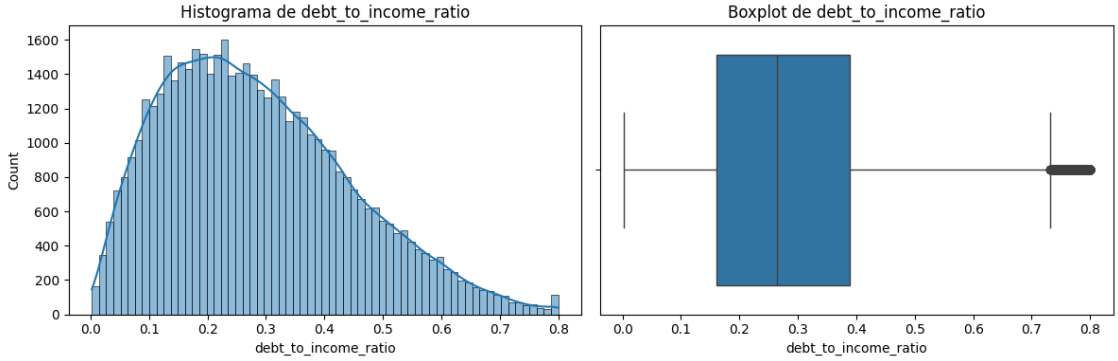

Histograma de current_debt
Count
current_debt

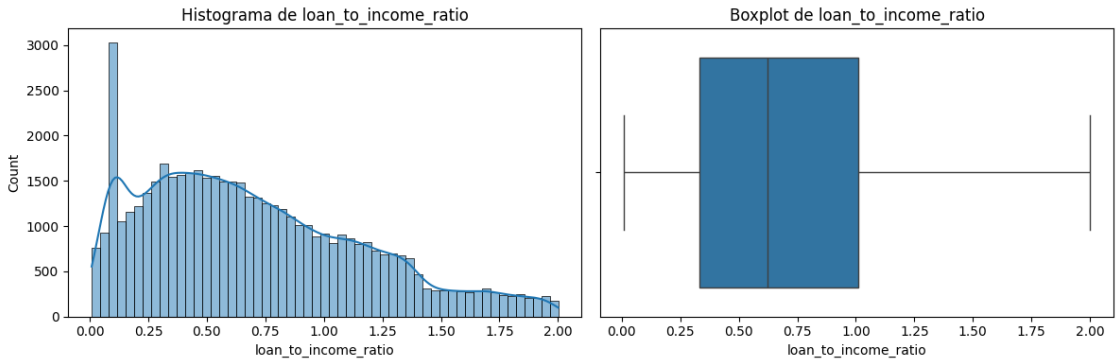

Boxplot de current_debt
current_debt

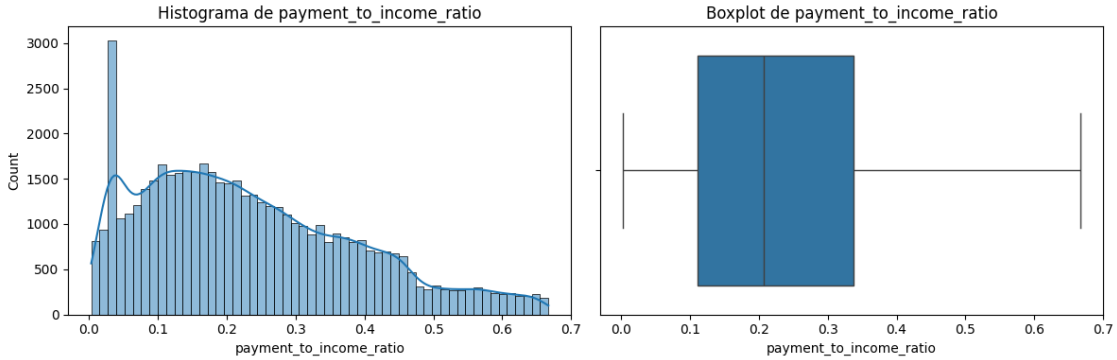

Histograma de loan_amount
Count
loan_amount


Boxplot de loan_amount
loan_amount


Histograma de interest_rate
Count
interest_rate
Boxplot de interest_rate
interest_rate


Histograma de debt_to_income_ratio
Count
debt_to_income_ratio
Boxplot de debt_to_income_ratio
debt_to_income_ratio


Histograma de loan_to_income_ratio
Count
loan_to_income_ratio
Boxplot de loan_to_income_ratio
loan_to_income_ratio



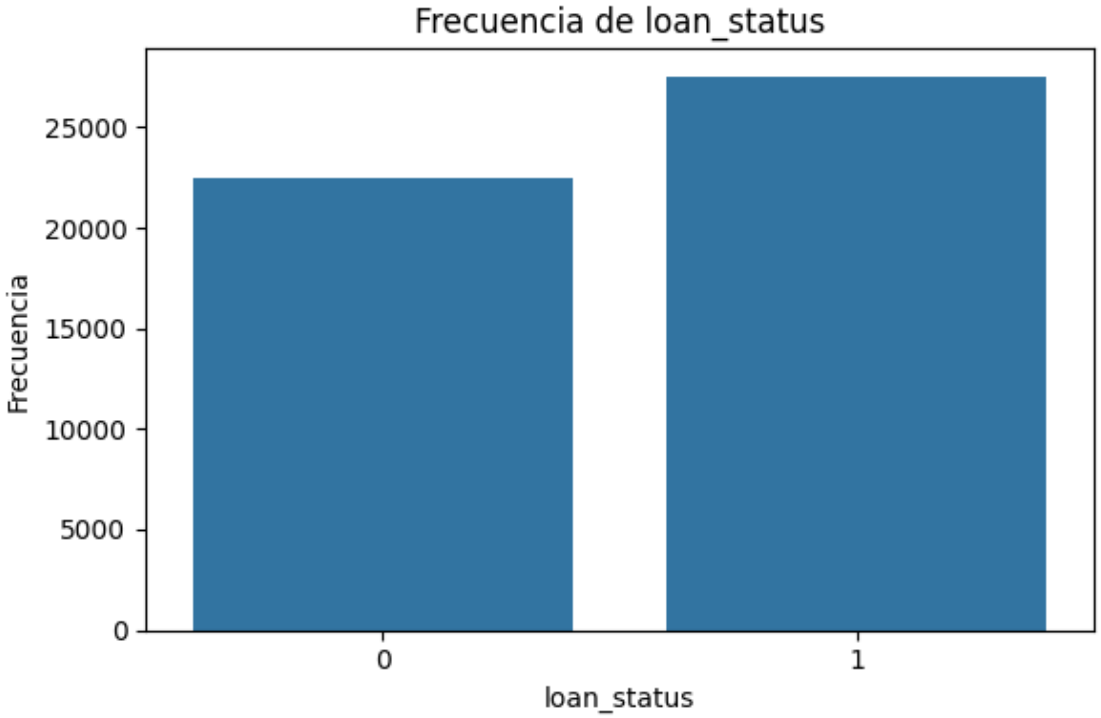
Aqui excuiimos la variable “loan_status”, “defaults_on_file”, “delinquencies_last_2yrs”y “derogatory_marks” ya que estas son variables categoricas, no vamos a poderla analizar como si fuera numerica, y su histograma solo se van a ver dos barras, una en 1 y la otra en 0 o sus categorias respectivas que se ven como numeros

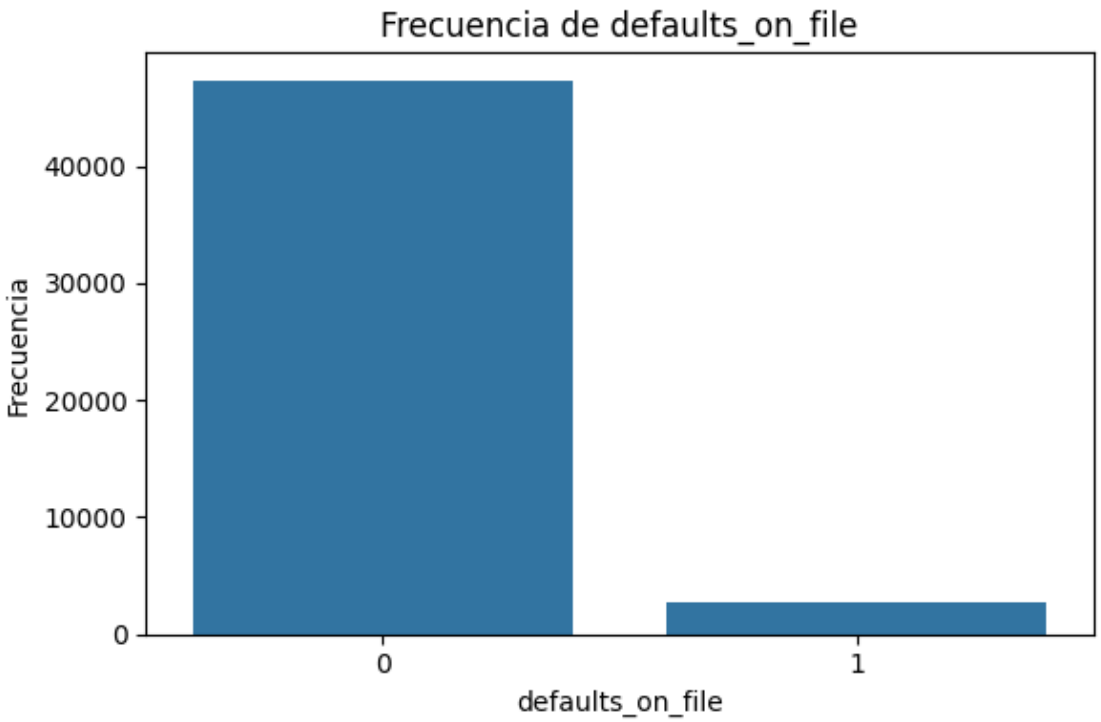
Podemos ver que la variable edad tiene una forma muy similar a la normal, pero esta tienen un pico de solicitudes de créditos en una temprana edad, antes de los 20 años con mas de 4000 aplicaciones, además esta se encuenta un poco sesgada a la derecha, ya que tiene unos datos atípicos ahi. la empeabilidad en años tiene un sesgo a cola derecha, ya que se ve que la mayoría de observaciones se encuentran en los primeros 10 años. Lo cual puede sugerir que las personas son nuevas en el mundo laboral. Para el inngreso anual se puede ver un pico en el inicio del histograma, en donde puede ayudarnos a intuir que este es el salario de los jovenes que tienen mas solicitudes de crédito, esta Tambien cuenta con un sesgo a cola derecha, y cuenta con un ingreso maximo de 250000 usd al año.

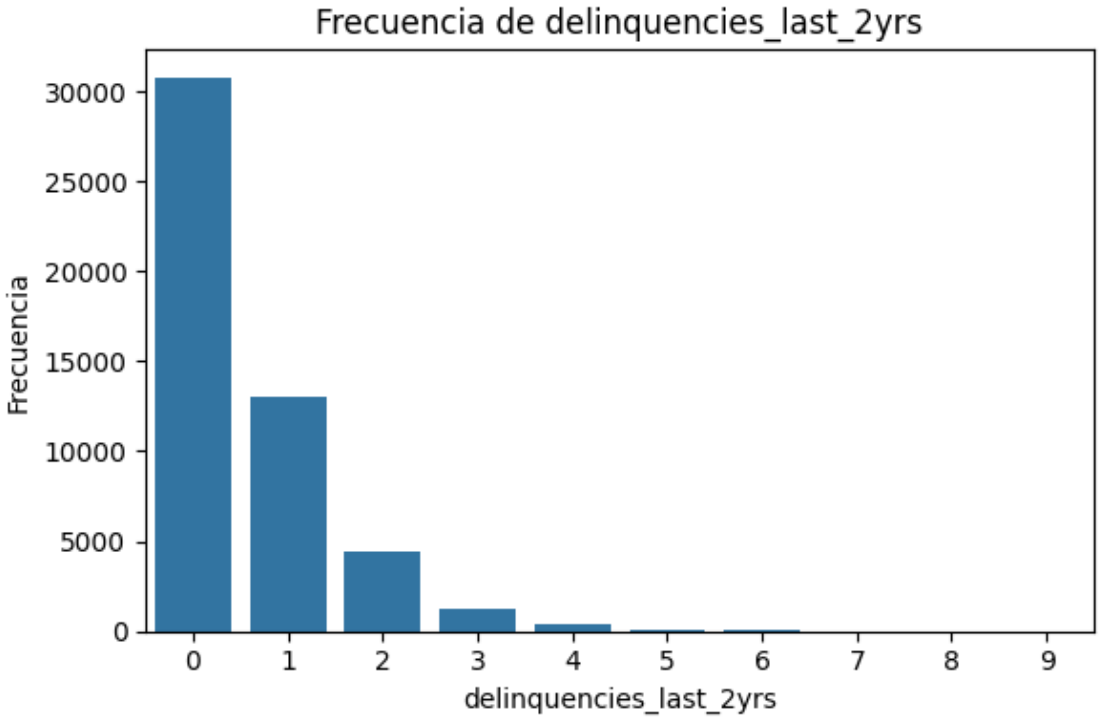
Para el historial crediticio, podemos ver que este es muy similar a la forma de una campana de gauss, por lo que podemos decir que es la que mas normalidad tiene de todas. Se puede ver que tanto para la dauda actual y para los ahorros hay valores muy bajos, por lo que se puede concluir que las personas no cuentan casi con ahorros o con una vida creditica con deudas en su mayoría. Por otro lado, podemos ver el índice de ingres vs deuda, que la media se encuentra por detrás del 30%, lo cual es bueno, pero por otro lado hay personas que destinan el 80% de sus ingresos en el pago de estas deudas.

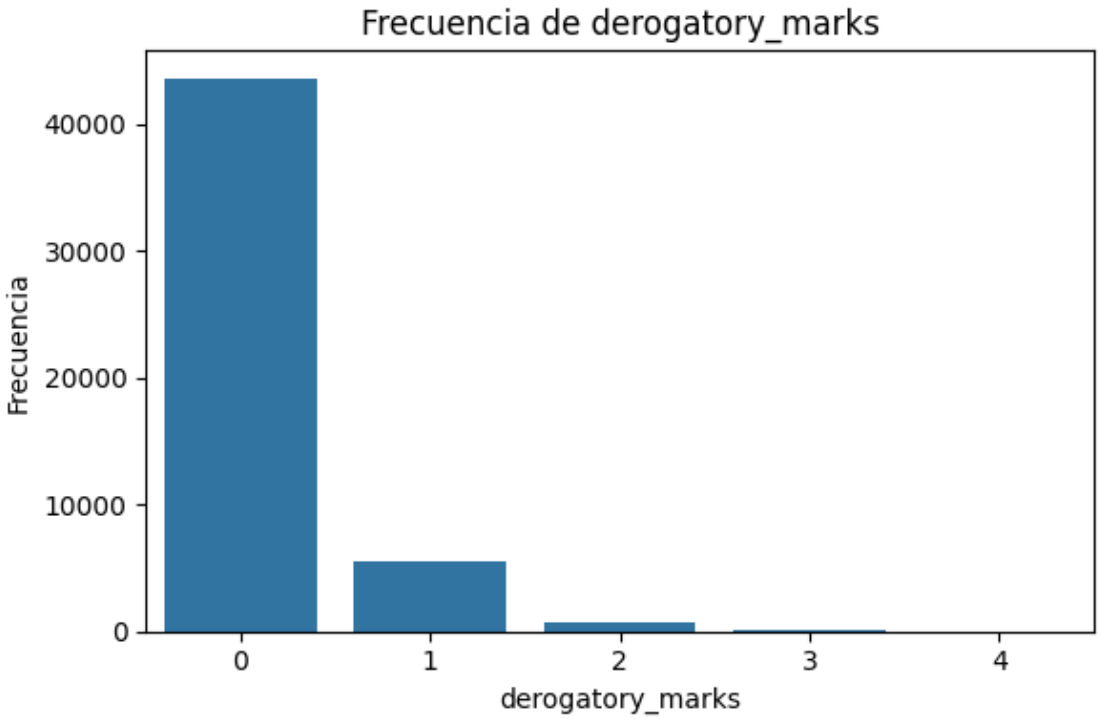
[9]:
```
vars_freq = ["loan_status", "defaults_on_file", "delinquencies_last_2yrs",␣
 ↪"derogatory_marks"]

for col in vars_freq:
    plt.figure(figsize=(6,4))
    sns.countplot(x=df_loan_final[col])
    plt.title(f'Frecuencia de {col}')
    plt.xlabel(col)
    plt.ylabel('Frecuencia')
```

```
    plt.tight_layout()
    plt.show()
    print("\n")
```




Frecuencia de defaults_on_file
Frecuencia
40000
30000
20000
10000
0
0
1
defaults_on_file

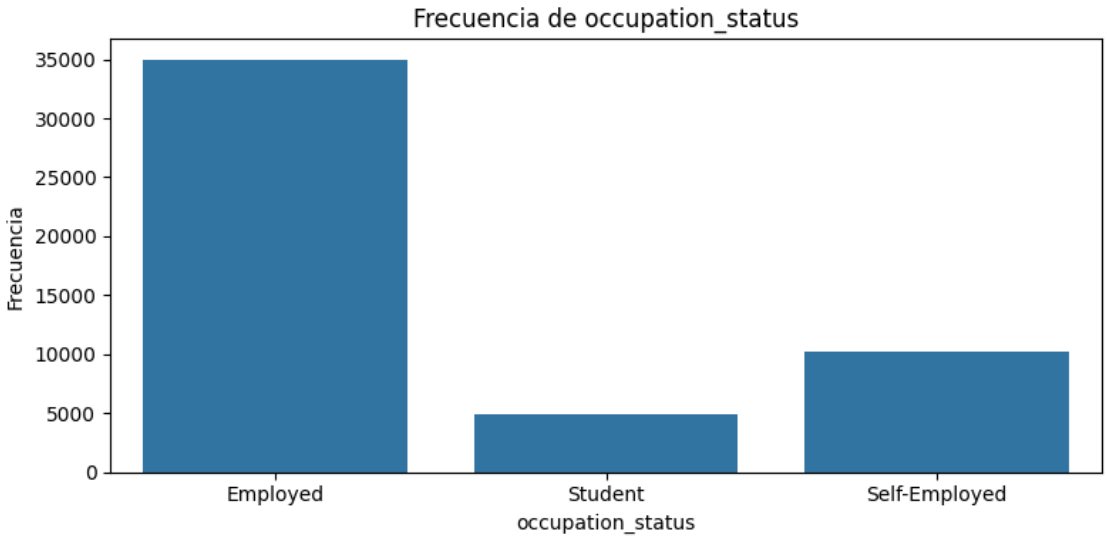

Frecuencia de delinquencies_last_2yrs
Frecuencia
30000
25000
20000
15000
10000
5000
0
0
1
2
3
4
5
6
7
8
9
delinquencies_last_2yrs

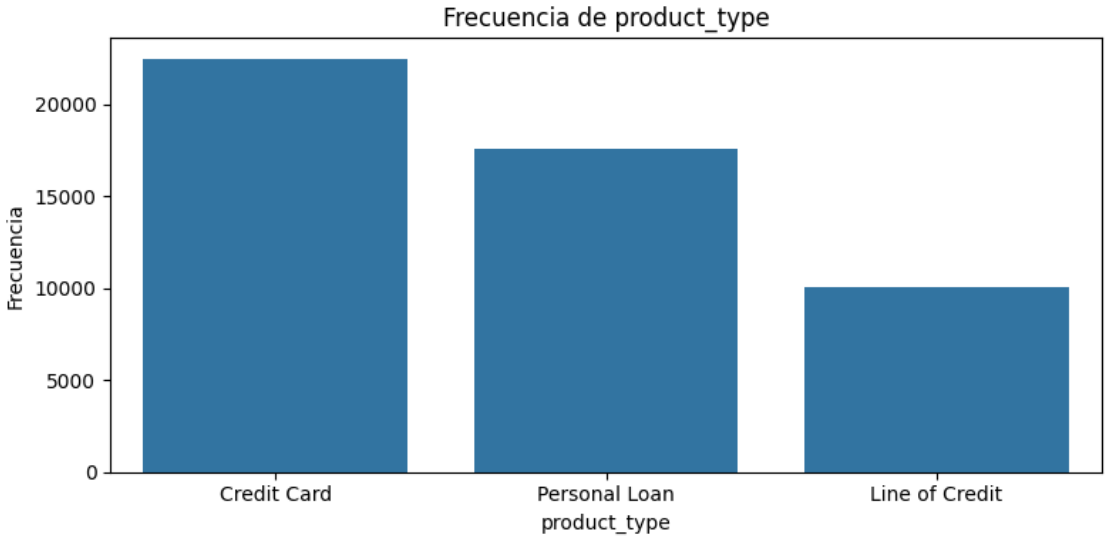


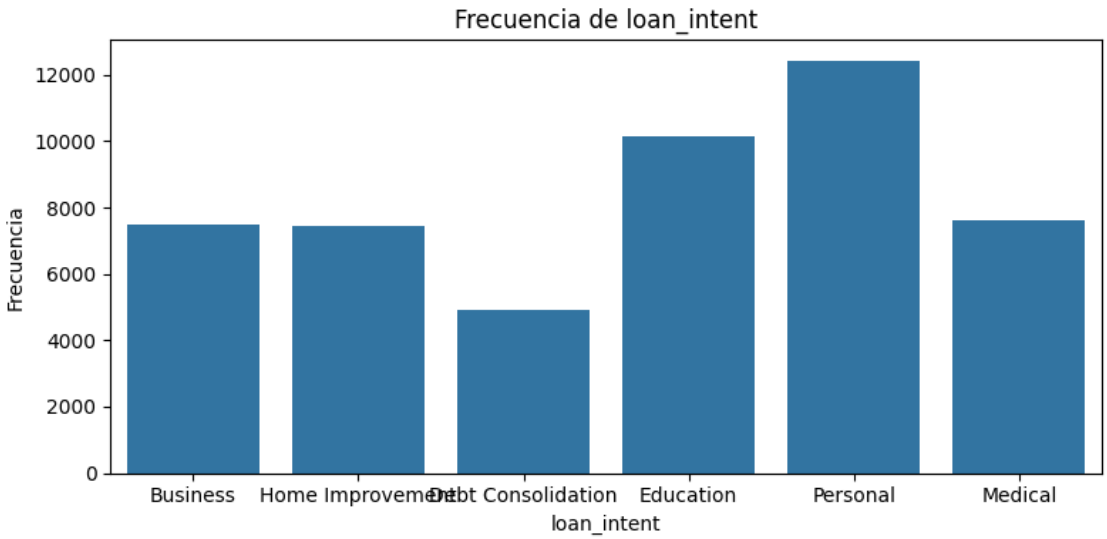
Analizando las figuras de frecuencias, se puede evidenciar que son mas los prestamos aprobados que los desaprobados, con una diferencia aproximada de 50000 observaciones. la Mayoria no cuenta con incumplimientos en el historial de crédito, no cuenta con moras o marcas negativas severas en el historial. No obstante, se ven ciertos comportamientos negativos en términos economicos en algunas observaciones.

[10]:
```
vars_obj = df_loan_final.select_dtypes(include="object").columns

for col in vars_obj:
    plt.figure(figsize=(8,4))
    sns.countplot(x=df_loan_final[col])
    plt.title(f'Frecuencia de {col}')
    plt.xlabel(col)
    plt.ylabel('Frecuencia')
    plt.tight_layout()
    plt.show()
```

```
    print("\n")
```


Frecuencia de occupation_status
Frecuencia
35000
30000
25000
20000
15000
10000
5000
0
Employed
Student
Self-Employed
occupation_status


Frecuencia de product_type
Frecuencia
20000
15000
10000
5000
0
Credit Card
Personal Loan
Line of Credit
product_type



En las ultimas graficas de frecuencia, podermos ver que que la mayoría son empleados de alguna compañía o trabajo con un empleador, después hay auto empleados y por últimos y con menos frecuencia, hay estudiantes. La mayoría de créditos son para sacar una tarjeta de crédito. Y por ultimose ven que los créditos son usados para beneficio u ocio propio, ya que su intención de prestamos en su mayoría son uso personal, mejorar su casa. Y por otro lado hay créditos que se piden para usos medicos y educacionales.

5 Aplicación de Modelos

Vamos a predecir la variable "loan_status", la cual es si le aprobaron o no el credito a determinada persona, esto lo vamos a hacer gracias a la información económica que tenemos de cada ovservacion. Primero vamos a hacer la division de la base en entrenamiento y prueba

[11]:
```
objetivo = 'loan_status'
lista_resultados = []

try:
    X = df_loan_final.drop(objetivo, axis=1)
    y = df_loan_final[objetivo]
except KeyError:
    print(f"Error: No se encontró la columna '{objetivo}' en datos_p1.")

X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                    test_size=0.3,
                                                    random_state=42,
                                                    stratify=y)
```

[12]:
```
variables_num = X_train.select_dtypes(include=np.number).columns.tolist()
variables_cat = X_train.select_dtypes(include='object').columns.tolist()

preprocesador = ColumnTransformer(
    transformers=[
        ('num', StandardScaler(), variables_num),
        ('cat', OneHotEncoder(handle_unknown='ignore', sparse_output=False),␣
 ↪variables_cat)
    ],
    remainder='passthrough'
)

X_train_transformado = preprocesador.fit_transform(X_train)
X_test_transformado = preprocesador.transform(X_test)

nombres_transformados = (
    variables_num +
    list(preprocesador.named_transformers_['cat'].
 ↪get_feature_names_out(variables_cat))
)

df_transformado = pd.DataFrame(
    X_train_transformado,
    columns=nombres_transformados
)
```

[13]:
```
lista_resultados = []

modelos_con_escalado_seleccionados = [
    ('Regresión Logística', LogisticRegression(max_iter=1000, random_state=42)),
]

for nombre, modelo in modelos_con_escalado_seleccionados:
    pipeline = Pipeline([
        ('preprocessor', preprocesador),
        ('classifier', modelo)
    ])

    pipeline.fit(X_train, y_train)

    y_pred = pipeline.predict(X_test)
    y_proba = pipeline.predict_proba(X_test)

    reporte = classification_report(y_test, y_pred, output_dict=True)

    lista_resultados.append({
        'Modelo': nombre,
```

```
        'Objeto Modelo': pipeline,  # <-- ¡Guardamos el Pipeline/Modelo␣
 ↪entrenado!
        'y_proba': y_proba,         # <-- ¡Guardamos la probabilidad!
        'Accuracy': reporte['accuracy'],
        'Precision (Macro)': reporte['macro avg']['precision'],
        'Recall (Macro)': reporte['macro avg']['recall'],
        'F1-Score (Macro)': reporte['macro avg']['f1-score']
    })

modelos_sin_escalado_seleccionados = [
    ('Árbol de Decisión', DecisionTreeClassifier(random_state=42)),
    ('Random Forest', RandomForestClassifier(random_state=42))
]

for nombre, modelo in modelos_sin_escalado_seleccionados:
    modelo.fit(X_train_transformado, y_train)

    y_pred = modelo.predict(X_test_transformado)
    y_proba = modelo.predict_proba(X_test_transformado) # <-- Obtenemos la␣
 ↪probabilidad

    reporte = classification_report(y_test, y_pred, output_dict=True)

    lista_resultados.append({
        'Modelo': nombre,
        'Objeto Modelo': modelo,
        'y_proba': y_proba,
        'Accuracy': reporte['accuracy'],
        'Precision (Macro)': reporte['macro avg']['precision'],
        'Recall (Macro)': reporte['macro avg']['recall'],
        'F1-Score (Macro)': reporte['macro avg']['f1-score']
    })

tabla_comparativa = pd.DataFrame(lista_resultados)


tabla_metricas = tabla_comparativa.drop(columns=['Objeto Modelo', 'y_proba'])
tabla_metricas = tabla_metricas.sort_values(by='F1-Score (Macro)',␣
 ↪ascending=False)
tabla_metricas = tabla_metricas.reset_index(drop=True)

display(tabla_metricas)
```

```
                Modelo  Accuracy  Precision (Macro)  Recall (Macro)  \
0        Random Forest  0.913667           0.912993        0.912472
1    Árbol de Decisión  0.874733           0.873402        0.873532
2  Regresión Logística  0.868067           0.867010        0.866158
```

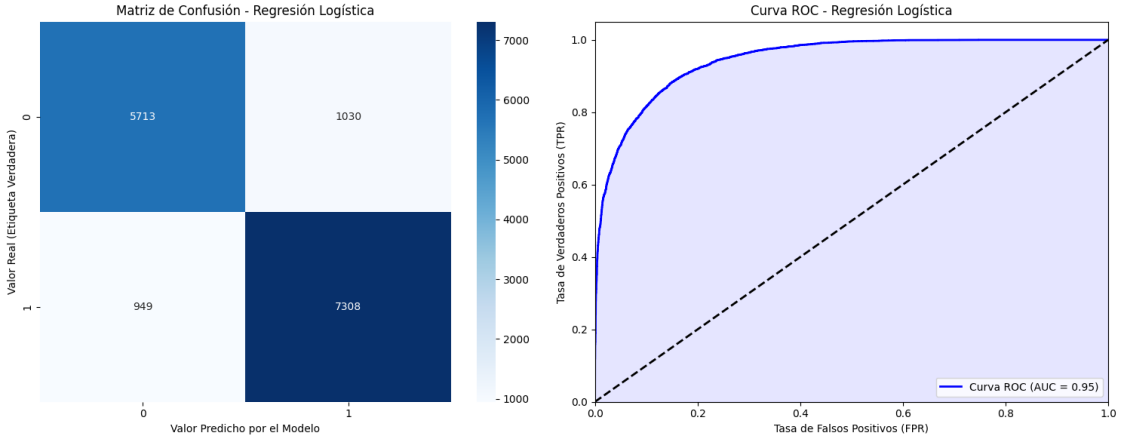
```
   F1-Score (Macro)
0          0.912724
1          0.873466
2          0.866558
```

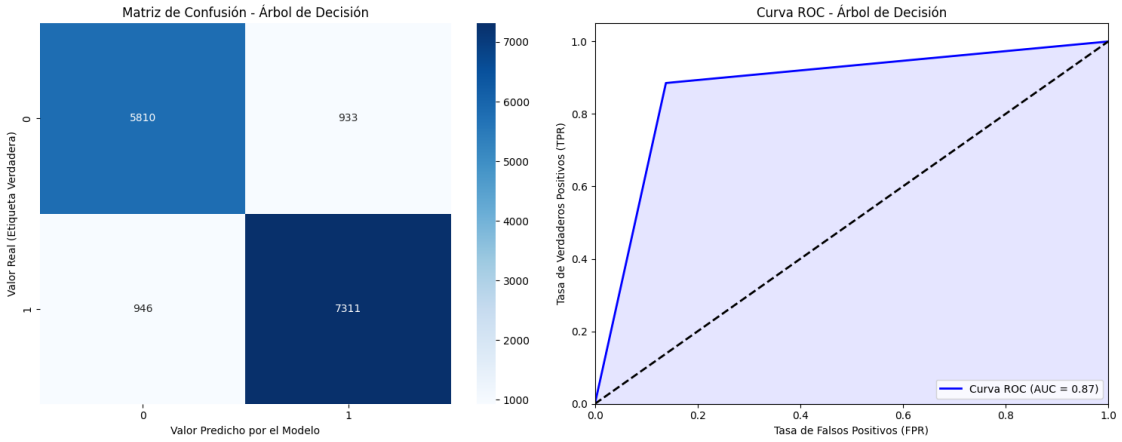
Tenemos que el mejor modelo es randim forest con un 0.91 de Acurrancy, Precision, Recall y F1-Score. No obstante, no se encuentra muy lejos el modelo de arbol de decisión

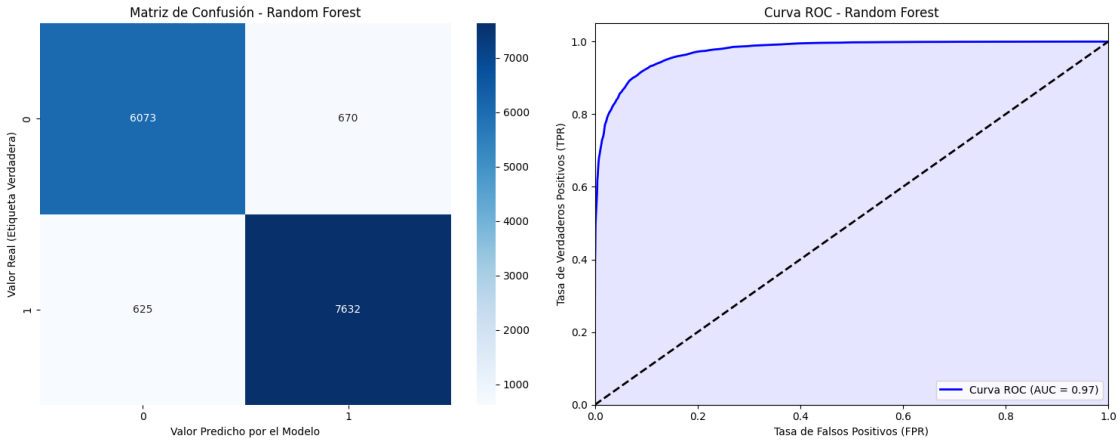
6 Selección y evaluación de los Modelos

[17]:
```
clases = np.unique(y_test)
n_clases = len(clases)

y_test_binarizado = label_binarize(y_test, classes=clases)

for index, fila in tabla_comparativa.iterrows():

    nombre = fila['Modelo']
    y_proba = fila['y_proba']

    y_pred = np.where(y_proba[:, 1] > 0.5, 1, 0)

    fig, axes = plt.subplots(1, 2, figsize=(15, 6))

    matriz = confusion_matrix(y_test, y_pred)
    sns.heatmap(matriz, annot=True, fmt='d', cmap='Blues',
                xticklabels=clases,
                yticklabels=clases,
                ax=axes[0])

    axes[0].set_title(f'Matriz de Confusión - {nombre}')
    axes[0].set_ylabel('Valor Real (Etiqueta Verdadera)')
    axes[0].set_xlabel('Valor Predicho por el Modelo')

    if n_clases == 2:
        fpr, tpr, _ = roc_curve(y_test_binarizado, y_proba[:, 1])
        roc_auc = auc(fpr, tpr)

        axes[1].plot(fpr, tpr, color='blue', lw=2,
                     label=f'Curva ROC (AUC = {roc_auc:.2f})')

        axes[1].fill_between(fpr, tpr, 0, alpha=0.1, color='blue')

    axes[1].plot([0, 1], [0, 1], 'k--', lw=2)

    axes[1].set_xlim([0.0, 1.0])
```

```
    axes[1].set_ylim([0.0, 1.05])
    axes[1].set_xlabel('Tasa de Falsos Positivos (FPR)')
    axes[1].set_ylabel('Tasa de Verdaderos Positivos (TPR)')
    axes[1].set_title(f'Curva ROC - {nombre}')
    axes[1].legend(loc="lower right")

    plt.tight_layout()
    plt.show()
    print("\n")
```







Dado que el AUC del modelo de Random Forest es el mayor con un 0.97. Entonces tenemos que este es el mejor modelo que podemos usar para clasificar el problema antes presentado

7 Predicciones

[33]:
```
mejor_modelo_fila = tabla_comparativa.loc[tabla_comparativa['F1-Score (Macro)'].
  ↪idxmax()]

mejor_modelo = mejor_modelo_fila['Objeto Modelo']
nombre_mejor_modelo = mejor_modelo_fila['Modelo']



indices_muestra = X_test.sample(5, random_state=42).index
valores_reales = y_test.loc[indices_muestra]

muestras_prueba_original = X_test.loc[indices_muestra]
muestras_prueba = preprocesador.transform(muestras_prueba_original)


# Realizar la predicción
predicciones = mejor_modelo.predict(muestras_prueba)

comparativa = pd.DataFrame({
    'Valor Real (y_test)': valores_reales,
    'Valor Predicho': predicciones,
})

print("\n Predicciones ejemplo:")
```

```python
print(comparativa)

print("\n Observacion")
for indices in indices_muestra:
    print(f"sujeto {indices}")
    print(df_loan_final.iloc[indices], "\n")
```

```
 Predicciones ejemplo:
       Valor Real (y_test)  Valor Predicho
16485                    0               0
12172                    0               0
19206                    0               0
6729                     1               1
11611                    1               1

 Observacion
sujeto 16485
age                                    21
occupation_status                 Employed
years_employed                         0.7
annual_income                        22372
credit_score                           605
credit_history_years                   0.9
savings_assets                           9
current_debt                          5432
defaults_on_file                         0
delinquencies_last_2yrs                  4
derogatory_marks                         0
product_type                 Line of Credit
loan_intent                Debt Consolidation
loan_amount                          18100
interest_rate                         12.5
debt_to_income_ratio                 0.243
loan_to_income_ratio                 0.809
payment_to_income_ratio               0.27
loan_status                              0
Name: 16485, dtype: object

sujeto 12172
age                                    18
occupation_status                 Student
years_employed                         0.6
annual_income                        15000
credit_score                           647
credit_history_years                   1.0
savings_assets                           8
```

```
current_debt                             6885
defaults_on_file                            0
delinquencies_last_2yrs                     2
derogatory_marks                            0
product_type                      Credit Card
loan_intent               Debt Consolidation
loan_amount                              1500
interest_rate                           19.25
debt_to_income_ratio                    0.459
loan_to_income_ratio                      0.1
payment_to_income_ratio                 0.033
loan_status                                 0
Name: 12172, dtype: object

sujeto 19206
age                                        35
occupation_status                Self-Employed
years_employed                             3.0
annual_income                            60303
credit_score                               727
credit_history_years                       7.9
savings_assets                            4248
current_debt                             34477
defaults_on_file                             0
delinquencies_last_2yrs                      0
derogatory_marks                             0
product_type                      Personal Loan
loan_intent                           Education
loan_amount                               88000
interest_rate                             10.69
debt_to_income_ratio                      0.572
loan_to_income_ratio                      1.459
payment_to_income_ratio                   0.486
loan_status                                  0
Name: 19206, dtype: object

sujeto 6729
age                                        56
occupation_status                     Student
years_employed                             0.2
annual_income                            19670
credit_score                               711
credit_history_years                      27.8
savings_assets                            1572
current_debt                              5258
defaults_on_file                             0
delinquencies_last_2yrs                      1
derogatory_marks                             0
```

```
product_type                Personal Loan
loan_intent                      Personal
loan_amount                         16200
interest_rate                        9.68
debt_to_income_ratio                0.267
loan_to_income_ratio                0.824
payment_to_income_ratio             0.275
loan_status                             1
Name: 6729, dtype: object

sujeto 11611
age                                    66
occupation_status                Employed
years_employed                       38.2
annual_income                       53992
credit_score                          770
credit_history_years                 25.5
savings_assets                       5358
current_debt                         7478
defaults_on_file                        0
delinquencies_last_2yrs                 0
derogatory_marks                        0
product_type                   Credit Card
loan_intent                Home Improvement
loan_amount                         20800
interest_rate                       15.65
debt_to_income_ratio                0.139
loan_to_income_ratio                0.385
payment_to_income_ratio             0.128
loan_status                             1
Name: 11611, dtype: object
```

Vemos 5 tomas random y la prediccion que esta hace, y vemos que no hay errores en la clasificacion, por lo que si tiene sentido el 90% de efectividad y el valor de la curva roc tan alto. Ahora, vamos a hacer la prediccion de sujetos inventados a continuación.

[38]:
```python
import pandas as pd

datos_inventados_nuevos = {
    'age': [20, 45],
    'occupation_status': ['Unemployed', 'Employed'],
    'years_employed': [0.0, 20.0],
    'annual_income': [10000, 150000],
    'credit_score': [650, 800],
    'credit_history_years': [0.5, 25.0],
    'savings_assets': [500, 50000],
    'current_debt': [0, 10000],
```

```
    'defaults_on_file': [0, 0],
    'delinquencies_last_2yrs': [0, 0],
    'derogatory_marks': [0, 0],
    'product_type': ['Credit Card', 'Line of Credit'],
    'loan_intent': ['Personal', 'Business'],
    'loan_amount': [500, 100000],
    'interest_rate': [18.0, 6.5],
    'debt_to_income_ratio': [0.0, 0.067],
    'loan_to_income_ratio': [0.05, 0.67],
    'payment_to_income_ratio': [0.05, 0.04]
}

df_nuevos_casos = pd.DataFrame(datos_inventados_nuevos)

df_nuevos_casos.head(2)
```

[38]:

	age	occupation_status	years_employed	annual_income	credit_score	credit_history_years	savings_assets	current_debt	defaults_on_file	delinquencies_last_2yrs	derogatory_marks	product_type	loan_intent	loan_amount	interest_rate	debt_to_income_ratio	loan_to_income_ratio	payment_to_income_ratio
0	20	Unemployed	0.0	10000	650	0.5	500	0	0	0	0	Credit Card	Personal	500	18.0	0.000	0.05	0.05
1	45	Employed	20.0	150000	800	25.0	50000	10000	0	0	0	Line of Credit	Business	100000	6.5	0.067	0.67	0.04

- Estudiante: Se trata de un individuo de 20 años clasificado como Desempleado con solo 0.5 años de historial crediticio. Sus ingresos anuales son bajos ($10,000), y solicita una cantidad menor de crédito ($500) con la intención de obtener una Tarjeta de Crédito personal. Su puntaje crediticio de 650 es regular, y la alta tasa de interés asociada al perfil (18.0%) refleja el riesgo percibido por la falta de un historial laboral y de crédito significativo.
- Empresario: Este sujeto es un profesional de 45 años que está Empleado con 20 años de experiencia laboral y 25 años de historial crediticio. Muestra una excelente salud financiera, con un ingreso anual muy alto ($150,000) y un puntaje crediticio de 800. A pesar de solicitar una línea de crédito sustancial ($100,000) para fines comerciales, su baja relación deuda-ingreso y la tasa de interés muy favorable (6.5%) lo posicionan como un solicitante de muy bajo riesgo y alta capacidad de pago.

[39]:
```
mejor_modelo_fila = tabla_comparativa.loc[tabla_comparativa['F1-Score (Macro)'].
 ↪idxmax()]
mejor_modelo = mejor_modelo_fila['Objeto Modelo']
nombre_mejor_modelo = mejor_modelo_fila['Modelo']

df_nuevos_casos = pd.DataFrame(datos_inventados_nuevos)

X_nuevos_a_predecir = preprocesador.transform(df_nuevos_casos)

predicciones_inventadas = mejor_modelo.predict(X_nuevos_a_predecir)

print(f"--- Resultados de la Simulación (Modelo: {nombre_mejor_modelo}) ---")
resultados = {
    0: "0 (DESAPROBADO / RIESGO)",
    1: "1 (APROBADO / SEGURO)"
}

for i, prediccion in enumerate(predicciones_inventadas):
    caso = "Estudiante (Baja Capacidad)" if i == 0 else "Empresario (Alta␣
 ↪Capacidad)"
    resultado_texto = resultados.get(prediccion, "Clase Desconocida")

    print(f"Caso {i+1} [{caso}]: El modelo predice {resultado_texto}")
```

```
--- Resultados de la Simulación (Modelo: Random Forest) ---
Caso 1 [Estudiante (Baja Capacidad)]: El modelo predice 1 (APROBADO / SEGURO)
Caso 2 [Empresario (Alta Capacidad)]: El modelo predice 1 (APROBADO / SEGURO)
```

[40]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

[43]:
```
!apt-get install texlive-xetex texlive-latex-extra pandoc
```

```
Reading package lists… Done
Building dependency tree… Done
Reading state information… Done
pandoc is already the newest version (2.9.2.1-3ubuntu2).
pandoc set to manually installed.
The following additional packages will be installed:
  dvisvgm fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono
  fonts-texgyre fonts-urw-base35 libapache-pom-java libcommons-logging-java
  libcommons-parent-java libfontbox-java libgs9 libgs9-common libidn12
  libijs-0.35 libjbig2dec0 libkpathsea6 libpdfbox-java libptexenc1 libruby3.0
  libsynctex2 libteckit0 libtexlua53 libtexluajit2 libwoff1 libzzip-0-13
  lmodern poppler-data preview-latex-style rake ruby ruby-net-telnet
  ruby-rubygems ruby-webrick ruby-xmlrpc ruby3.0 rubygems-integration t1utils
```

```
  teckit tex-common tex-gyre texlive-base texlive-binaries
  texlive-fonts-recommended texlive-latex-base texlive-latex-recommended
  texlive-pictures texlive-plain-generic tipa xfonts-encodings xfonts-utils
Suggested packages:
  fonts-noto fonts-freefont-otf | fonts-freefont-ttf libavalon-framework-java
  libcommons-logging-java-doc libexcalibur-logkit-java liblog4j1.2-java
  poppler-utils ghostscript fonts-japanese-mincho | fonts-ipafont-mincho
  fonts-japanese-gothic | fonts-ipafont-gothic fonts-arphic-ukai
  fonts-arphic-uming fonts-nanum ri ruby-dev bundler debhelper gv
  | postscript-viewer perl-tk xpdf | pdf-viewer xzdec
  texlive-fonts-recommended-doc texlive-latex-base-doc python3-pygments
  icc-profiles libfile-which-perl libspreadsheet-parseexcel-perl
  texlive-latex-extra-doc texlive-latex-recommended-doc texlive-luatex
  texlive-pstricks dot2tex prerex texlive-pictures-doc vprerex
  default-jre-headless tipa-doc
The following NEW packages will be installed:
  dvisvgm fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono
  fonts-texgyre fonts-urw-base35 libapache-pom-java libcommons-logging-java
  libcommons-parent-java libfontbox-java libgs9 libgs9-common libidn12
  libijs-0.35 libjbig2dec0 libkpathsea6 libpdfbox-java libptexenc1 libruby3.0
  libsynctex2 libteckit0 libtexlua53 libtexluajit2 libwoff1 libzzip-0-13
  lmodern poppler-data preview-latex-style rake ruby ruby-net-telnet
  ruby-rubygems ruby-webrick ruby-xmlrpc ruby3.0 rubygems-integration t1utils
  teckit tex-common tex-gyre texlive-base texlive-binaries
  texlive-fonts-recommended texlive-latex-base texlive-latex-extra
  texlive-latex-recommended texlive-pictures texlive-plain-generic
  texlive-xetex tipa xfonts-encodings xfonts-utils
0 upgraded, 53 newly installed, 0 to remove and 41 not upgraded.
Need to get 182 MB of archives.
After this operation, 571 MB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-droid-fallback all
1:6.0.1r16-1.1build1 [1,805 kB]
Get:2 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-lato all 2.0-2.1
[2,696 kB]
Get:3 http://archive.ubuntu.com/ubuntu jammy/main amd64 poppler-data all
0.4.11-1 [2,171 kB]
Get:4 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tex-common all 6.17
[33.7 kB]
Get:5 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-urw-base35 all
20200910-1 [6,367 kB]
Get:6 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libgs9-common
all 9.55.0~dfsg1-0ubuntu5.13 [753 kB]
Get:7 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libidn12 amd64
1.38-4ubuntu1 [60.0 kB]
Get:8 http://archive.ubuntu.com/ubuntu jammy/main amd64 libijs-0.35 amd64
0.35-15build2 [16.5 kB]
Get:9 http://archive.ubuntu.com/ubuntu jammy/main amd64 libjbig2dec0 amd64
0.19-3build2 [64.7 kB]
```

```
Get:10 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libgs9 amd64
9.55.0~dfsg1-0ubuntu5.13 [5,032 kB]
Get:11 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libkpathsea6
amd64 2021.20210626.59705-1ubuntu0.2 [60.4 kB]
Get:12 http://archive.ubuntu.com/ubuntu jammy/main amd64 libwoff1 amd64
1.0.2-1build4 [45.2 kB]
Get:13 http://archive.ubuntu.com/ubuntu jammy/universe amd64 dvisvgm amd64
2.13.1-1 [1,221 kB]
Get:14 http://archive.ubuntu.com/ubuntu jammy/universe amd64 fonts-lmodern all
2.004.5-6.1 [4,532 kB]
Get:15 http://archive.ubuntu.com/ubuntu jammy/main amd64 fonts-noto-mono all
20201225-1build1 [397 kB]
Get:16 http://archive.ubuntu.com/ubuntu jammy/universe amd64 fonts-texgyre all
20180621-3.1 [10.2 MB]
Get:17 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libapache-pom-java
all 18-1 [4,720 B]
Get:18 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libcommons-parent-
java all 43-1 [10.8 kB]
Get:19 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libcommons-logging-
java all 1.2-2 [60.3 kB]
Get:20 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libptexenc1
amd64 2021.20210626.59705-1ubuntu0.2 [39.1 kB]
Get:21 http://archive.ubuntu.com/ubuntu jammy/main amd64 rubygems-integration
all 1.18 [5,336 B]
Get:22 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 ruby3.0 amd64
3.0.2-7ubuntu2.11 [50.1 kB]
Get:23 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 ruby-rubygems
all 3.3.5-2ubuntu1.2 [228 kB]
Get:24 http://archive.ubuntu.com/ubuntu jammy/main amd64 ruby amd64 1:3.0~exp1
[5,100 B]
Get:25 http://archive.ubuntu.com/ubuntu jammy/main amd64 rake all 13.0.6-2 [61.7
kB]
Get:26 http://archive.ubuntu.com/ubuntu jammy/main amd64 ruby-net-telnet all
0.1.1-2 [12.6 kB]
Get:27 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 ruby-webrick
all 1.7.0-3ubuntu0.2 [52.5 kB]
Get:28 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 ruby-xmlrpc all
0.3.2-1ubuntu0.1 [24.9 kB]
Get:29 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libruby3.0
amd64 3.0.2-7ubuntu2.11 [5,114 kB]
Get:30 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libsynctex2
amd64 2021.20210626.59705-1ubuntu0.2 [55.6 kB]
Get:31 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libteckit0 amd64
2.5.11+ds1-1 [421 kB]
Get:32 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libtexlua53
amd64 2021.20210626.59705-1ubuntu0.2 [120 kB]
Get:33 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 libtexluajit2
amd64 2021.20210626.59705-1ubuntu0.2 [267 kB]
```

```
Get:34 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libzzip-0-13 amd64
0.13.72+dfsg.1-1.1 [27.0 kB]
Get:35 http://archive.ubuntu.com/ubuntu jammy/main amd64 xfonts-encodings all
1:1.0.5-0ubuntu2 [578 kB]
Get:36 http://archive.ubuntu.com/ubuntu jammy/main amd64 xfonts-utils amd64
1:7.7+6build2 [94.6 kB]
Get:37 http://archive.ubuntu.com/ubuntu jammy/universe amd64 lmodern all
2.004.5-6.1 [9,471 kB]
Get:38 http://archive.ubuntu.com/ubuntu jammy/universe amd64 preview-latex-style
all 12.2-1ubuntu1 [185 kB]
Get:39 http://archive.ubuntu.com/ubuntu jammy/main amd64 t1utils amd64
1.41-4build2 [61.3 kB]
Get:40 http://archive.ubuntu.com/ubuntu jammy/universe amd64 teckit amd64
2.5.11+ds1-1 [699 kB]
Get:41 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tex-gyre all
20180621-3.1 [6,209 kB]
Get:42 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 texlive-
binaries amd64 2021.20210626.59705-1ubuntu0.2 [9,860 kB]
Get:43 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-base all
2021.20220204-1 [21.0 MB]
Get:44 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-fonts-
recommended all 2021.20220204-1 [4,972 kB]
Get:45 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-latex-base
all 2021.20220204-1 [1,128 kB]
Get:46 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libfontbox-java all
1:1.8.16-2 [207 kB]
Get:47 http://archive.ubuntu.com/ubuntu jammy/universe amd64 libpdfbox-java all
1:1.8.16-2 [5,199 kB]
Get:48 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-latex-
recommended all 2021.20220204-1 [14.4 MB]
Get:49 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-pictures
all 2021.20220204-1 [8,720 kB]
Get:50 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-latex-extra
all 2021.20220204-1 [13.9 MB]
Get:51 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-plain-
generic all 2021.20220204-1 [27.5 MB]
Get:52 http://archive.ubuntu.com/ubuntu jammy/universe amd64 tipa all 2:1.3-21
[2,967 kB]
Get:53 http://archive.ubuntu.com/ubuntu jammy/universe amd64 texlive-xetex all
2021.20220204-1 [12.4 MB]
Fetched 182 MB in 8s (22.6 MB/s)
Extracting templates from packages: 100%
Preconfiguring packages …
Selecting previously unselected package fonts-droid-fallback.
(Reading database … 121713 files and directories currently installed.)
Preparing to unpack …/00-fonts-droid-fallback_1%3a6.0.1r16-1.1build1_all.deb
…
Unpacking fonts-droid-fallback (1:6.0.1r16-1.1build1) …
```

```
Selecting previously unselected package fonts-lato.
Preparing to unpack …/01-fonts-lato_2.0-2.1_all.deb …
Unpacking fonts-lato (2.0-2.1) …
Selecting previously unselected package poppler-data.
Preparing to unpack …/02-poppler-data_0.4.11-1_all.deb …
Unpacking poppler-data (0.4.11-1) …
Selecting previously unselected package tex-common.
Preparing to unpack …/03-tex-common_6.17_all.deb …
Unpacking tex-common (6.17) …
Selecting previously unselected package fonts-urw-base35.
Preparing to unpack …/04-fonts-urw-base35_20200910-1_all.deb …
Unpacking fonts-urw-base35 (20200910-1) …
Selecting previously unselected package libgs9-common.
Preparing to unpack …/05-libgs9-common_9.55.0~dfsg1-0ubuntu5.13_all.deb …
Unpacking libgs9-common (9.55.0~dfsg1-0ubuntu5.13) …
Selecting previously unselected package libidn12:amd64.
Preparing to unpack …/06-libidn12_1.38-4ubuntu1_amd64.deb …
Unpacking libidn12:amd64 (1.38-4ubuntu1) …
Selecting previously unselected package libijs-0.35:amd64.
Preparing to unpack …/07-libijs-0.35_0.35-15build2_amd64.deb …
Unpacking libijs-0.35:amd64 (0.35-15build2) …
Selecting previously unselected package libjbig2dec0:amd64.
Preparing to unpack …/08-libjbig2dec0_0.19-3build2_amd64.deb …
Unpacking libjbig2dec0:amd64 (0.19-3build2) …
Selecting previously unselected package libgs9:amd64.
Preparing to unpack …/09-libgs9_9.55.0~dfsg1-0ubuntu5.13_amd64.deb …
Unpacking libgs9:amd64 (9.55.0~dfsg1-0ubuntu5.13) …
Selecting previously unselected package libkpathsea6:amd64.
Preparing to unpack …/10-libkpathsea6_2021.20210626.59705-1ubuntu0.2_amd64.deb
…
Unpacking libkpathsea6:amd64 (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package libwoff1:amd64.
Preparing to unpack …/11-libwoff1_1.0.2-1build4_amd64.deb …
Unpacking libwoff1:amd64 (1.0.2-1build4) …
Selecting previously unselected package dvisvgm.
Preparing to unpack …/12-dvisvgm_2.13.1-1_amd64.deb …
Unpacking dvisvgm (2.13.1-1) …
Selecting previously unselected package fonts-lmodern.
Preparing to unpack …/13-fonts-lmodern_2.004.5-6.1_all.deb …
Unpacking fonts-lmodern (2.004.5-6.1) …
Selecting previously unselected package fonts-noto-mono.
Preparing to unpack …/14-fonts-noto-mono_20201225-1build1_all.deb …
Unpacking fonts-noto-mono (20201225-1build1) …
Selecting previously unselected package fonts-texgyre.
Preparing to unpack …/15-fonts-texgyre_20180621-3.1_all.deb …
Unpacking fonts-texgyre (20180621-3.1) …
Selecting previously unselected package libapache-pom-java.
Preparing to unpack …/16-libapache-pom-java_18-1_all.deb …
```

```
Unpacking libapache-pom-java (18-1) …
Selecting previously unselected package libcommons-parent-java.
Preparing to unpack …/17-libcommons-parent-java_43-1_all.deb …
Unpacking libcommons-parent-java (43-1) …
Selecting previously unselected package libcommons-logging-java.
Preparing to unpack …/18-libcommons-logging-java_1.2-2_all.deb …
Unpacking libcommons-logging-java (1.2-2) …
Selecting previously unselected package libptexenc1:amd64.
Preparing to unpack …/19-libptexenc1_2021.20210626.59705-1ubuntu0.2_amd64.deb
…
Unpacking libptexenc1:amd64 (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package rubygems-integration.
Preparing to unpack …/20-rubygems-integration_1.18_all.deb …
Unpacking rubygems-integration (1.18) …
Selecting previously unselected package ruby3.0.
Preparing to unpack …/21-ruby3.0_3.0.2-7ubuntu2.11_amd64.deb …
Unpacking ruby3.0 (3.0.2-7ubuntu2.11) …
Selecting previously unselected package ruby-rubygems.
Preparing to unpack …/22-ruby-rubygems_3.3.5-2ubuntu1.2_all.deb …
Unpacking ruby-rubygems (3.3.5-2ubuntu1.2) …
Selecting previously unselected package ruby.
Preparing to unpack …/23-ruby_1%3a3.0~exp1_amd64.deb …
Unpacking ruby (1:3.0~exp1) …
Selecting previously unselected package rake.
Preparing to unpack …/24-rake_13.0.6-2_all.deb …
Unpacking rake (13.0.6-2) …
Selecting previously unselected package ruby-net-telnet.
Preparing to unpack …/25-ruby-net-telnet_0.1.1-2_all.deb …
Unpacking ruby-net-telnet (0.1.1-2) …
Selecting previously unselected package ruby-webrick.
Preparing to unpack …/26-ruby-webrick_1.7.0-3ubuntu0.2_all.deb …
Unpacking ruby-webrick (1.7.0-3ubuntu0.2) …
Selecting previously unselected package ruby-xmlrpc.
Preparing to unpack …/27-ruby-xmlrpc_0.3.2-1ubuntu0.1_all.deb …
Unpacking ruby-xmlrpc (0.3.2-1ubuntu0.1) …
Selecting previously unselected package libruby3.0:amd64.
Preparing to unpack …/28-libruby3.0_3.0.2-7ubuntu2.11_amd64.deb …
Unpacking libruby3.0:amd64 (3.0.2-7ubuntu2.11) …
Selecting previously unselected package libsynctex2:amd64.
Preparing to unpack …/29-libsynctex2_2021.20210626.59705-1ubuntu0.2_amd64.deb
…
Unpacking libsynctex2:amd64 (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package libteckit0:amd64.
Preparing to unpack …/30-libteckit0_2.5.11+ds1-1_amd64.deb …
Unpacking libteckit0:amd64 (2.5.11+ds1-1) …
Selecting previously unselected package libtexlua53:amd64.
Preparing to unpack …/31-libtexlua53_2021.20210626.59705-1ubuntu0.2_amd64.deb
…
```

```
Unpacking libtexlua53:amd64 (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package libtexluajit2:amd64.
Preparing to unpack
…/32-libtexluajit2_2021.20210626.59705-1ubuntu0.2_amd64.deb …
Unpacking libtexluajit2:amd64 (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package libzzip-0-13:amd64.
Preparing to unpack …/33-libzzip-0-13_0.13.72+dfsg.1-1.1_amd64.deb …
Unpacking libzzip-0-13:amd64 (0.13.72+dfsg.1-1.1) …
Selecting previously unselected package xfonts-encodings.
Preparing to unpack …/34-xfonts-encodings_1%3a1.0.5-0ubuntu2_all.deb …
Unpacking xfonts-encodings (1:1.0.5-0ubuntu2) …
Selecting previously unselected package xfonts-utils.
Preparing to unpack …/35-xfonts-utils_1%3a7.7+6build2_amd64.deb …
Unpacking xfonts-utils (1:7.7+6build2) …
Selecting previously unselected package lmodern.
Preparing to unpack …/36-lmodern_2.004.5-6.1_all.deb …
Unpacking lmodern (2.004.5-6.1) …
Selecting previously unselected package preview-latex-style.
Preparing to unpack …/37-preview-latex-style_12.2-1ubuntu1_all.deb …
Unpacking preview-latex-style (12.2-1ubuntu1) …
Selecting previously unselected package t1utils.
Preparing to unpack …/38-t1utils_1.41-4build2_amd64.deb …
Unpacking t1utils (1.41-4build2) …
Selecting previously unselected package teckit.
Preparing to unpack …/39-teckit_2.5.11+ds1-1_amd64.deb …
Unpacking teckit (2.5.11+ds1-1) …
Selecting previously unselected package tex-gyre.
Preparing to unpack …/40-tex-gyre_20180621-3.1_all.deb …
Unpacking tex-gyre (20180621-3.1) …
Selecting previously unselected package texlive-binaries.
Preparing to unpack …/41-texlive-
binaries_2021.20210626.59705-1ubuntu0.2_amd64.deb …
Unpacking texlive-binaries (2021.20210626.59705-1ubuntu0.2) …
Selecting previously unselected package texlive-base.
Preparing to unpack …/42-texlive-base_2021.20220204-1_all.deb …
Unpacking texlive-base (2021.20220204-1) …
Selecting previously unselected package texlive-fonts-recommended.
Preparing to unpack …/43-texlive-fonts-recommended_2021.20220204-1_all.deb …
Unpacking texlive-fonts-recommended (2021.20220204-1) …
Selecting previously unselected package texlive-latex-base.
Preparing to unpack …/44-texlive-latex-base_2021.20220204-1_all.deb …
Unpacking texlive-latex-base (2021.20220204-1) …
Selecting previously unselected package libfontbox-java.
Preparing to unpack …/45-libfontbox-java_1%3a1.8.16-2_all.deb …
Unpacking libfontbox-java (1:1.8.16-2) …
Selecting previously unselected package libpdfbox-java.
Preparing to unpack …/46-libpdfbox-java_1%3a1.8.16-2_all.deb …
Unpacking libpdfbox-java (1:1.8.16-2) …
```

```
Selecting previously unselected package texlive-latex-recommended.
Preparing to unpack …/47-texlive-latex-recommended_2021.20220204-1_all.deb …
Unpacking texlive-latex-recommended (2021.20220204-1) …
Selecting previously unselected package texlive-pictures.
Preparing to unpack …/48-texlive-pictures_2021.20220204-1_all.deb …
Unpacking texlive-pictures (2021.20220204-1) …
Selecting previously unselected package texlive-latex-extra.
Preparing to unpack …/49-texlive-latex-extra_2021.20220204-1_all.deb …
Unpacking texlive-latex-extra (2021.20220204-1) …
Selecting previously unselected package texlive-plain-generic.
Preparing to unpack …/50-texlive-plain-generic_2021.20220204-1_all.deb …
Unpacking texlive-plain-generic (2021.20220204-1) …
Selecting previously unselected package tipa.
Preparing to unpack …/51-tipa_2%3a1.3-21_all.deb …
Unpacking tipa (2:1.3-21) …
Selecting previously unselected package texlive-xetex.
Preparing to unpack …/52-texlive-xetex_2021.20220204-1_all.deb …
Unpacking texlive-xetex (2021.20220204-1) …
Setting up fonts-lato (2.0-2.1) …
Setting up fonts-noto-mono (20201225-1build1) …
Setting up libwoff1:amd64 (1.0.2-1build4) …
Setting up libtexlua53:amd64 (2021.20210626.59705-1ubuntu0.2) …
Setting up libijs-0.35:amd64 (0.35-15build2) …
Setting up libtexluajit2:amd64 (2021.20210626.59705-1ubuntu0.2) …
Setting up libfontbox-java (1:1.8.16-2) …
Setting up rubygems-integration (1.18) …
Setting up libzzip-0-13:amd64 (0.13.72+dfsg.1-1.1) …
Setting up fonts-urw-base35 (20200910-1) …
Setting up poppler-data (0.4.11-1) …
Setting up tex-common (6.17) …
update-language: texlive-base not installed and configured, doing nothing!
Setting up libjbig2dec0:amd64 (0.19-3build2) …
Setting up libteckit0:amd64 (2.5.11+ds1-1) …
Setting up libapache-pom-java (18-1) …
Setting up ruby-net-telnet (0.1.1-2) …
Setting up xfonts-encodings (1:1.0.5-0ubuntu2) …
Setting up t1utils (1.41-4build2) …
Setting up libidn12:amd64 (1.38-4ubuntu1) …
Setting up fonts-texgyre (20180621-3.1) …
Setting up libkpathsea6:amd64 (2021.20210626.59705-1ubuntu0.2) …
Setting up ruby-webrick (1.7.0-3ubuntu0.2) …
Setting up fonts-lmodern (2.004.5-6.1) …
Setting up fonts-droid-fallback (1:6.0.1r16-1.1build1) …
Setting up ruby-xmlrpc (0.3.2-1ubuntu0.1) …
Setting up libsynctex2:amd64 (2021.20210626.59705-1ubuntu0.2) …
Setting up libgs9-common (9.55.0~dfsg1-0ubuntu5.13) …
Setting up teckit (2.5.11+ds1-1) …
Setting up libpdfbox-java (1:1.8.16-2) …
```

```
Setting up libgs9:amd64 (9.55.0~dfsg1-0ubuntu5.13) …
Setting up preview-latex-style (12.2-1ubuntu1) …
Setting up libcommons-parent-java (43-1) …
Setting up dvisvgm (2.13.1-1) …
Setting up libcommons-logging-java (1.2-2) …
Setting up xfonts-utils (1:7.7+6build2) …
Setting up libptexenc1:amd64 (2021.20210626.59705-1ubuntu0.2) …
Setting up texlive-binaries (2021.20210626.59705-1ubuntu0.2) …
update-alternatives: using /usr/bin/xdvi-xaw to provide /usr/bin/xdvi.bin
(xdvi.bin) in auto mode
update-alternatives: using /usr/bin/bibtex.original to provide /usr/bin/bibtex
(bibtex) in auto mode
Setting up lmodern (2.004.5-6.1) …
Setting up texlive-base (2021.20220204-1) …
/usr/bin/ucfr
/usr/bin/ucfr
/usr/bin/ucfr
/usr/bin/ucfr
mktexlsr: Updating /var/lib/texmf/ls-R-TEXLIVEDIST…
mktexlsr: Updating /var/lib/texmf/ls-R-TEXMFMAIN…
mktexlsr: Updating /var/lib/texmf/ls-R…
mktexlsr: Done.
tl-paper: setting paper size for dvips to a4:
/var/lib/texmf/dvips/config/config-paper.ps
tl-paper: setting paper size for dvipdfmx to a4:
/var/lib/texmf/dvipdfmx/dvipdfmx-paper.cfg
tl-paper: setting paper size for xdvi to a4: /var/lib/texmf/xdvi/XDvi-paper
tl-paper: setting paper size for pdftex to a4: /var/lib/texmf/tex/generic/tex-
ini-files/pdftexconfig.tex
Setting up tex-gyre (20180621-3.1) …
Setting up texlive-plain-generic (2021.20220204-1) …
Setting up texlive-latex-base (2021.20220204-1) …
Setting up texlive-latex-recommended (2021.20220204-1) …
Setting up texlive-pictures (2021.20220204-1) …
Setting up texlive-fonts-recommended (2021.20220204-1) …
Setting up tipa (2:1.3-21) …
Setting up texlive-latex-extra (2021.20220204-1) …
Setting up texlive-xetex (2021.20220204-1) …
Setting up rake (13.0.6-2) …
Setting up libruby3.0:amd64 (3.0.2-7ubuntu2.11) …
Setting up ruby3.0 (3.0.2-7ubuntu2.11) …
Setting up ruby (1:3.0~exp1) …
Setting up ruby-rubygems (3.3.5-2ubuntu1.2) …
Processing triggers for man-db (2.10.2-1) …
Processing triggers for mailcap (3.70+nmu1ubuntu1) …
Processing triggers for fontconfig (2.13.1-4.2ubuntu5) …
Processing triggers for libc-bin (2.35-0ubuntu3.8) …
/sbin/ldconfig.real: /usr/local/lib/libumf.so.1 is not a symbolic link
```

```
/sbin/ldconfig.real: /usr/local/lib/libtbbbind_2_5.so.3 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtcm_debug.so.1 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbbind_2_0.so.3 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libhwloc.so.15 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libur_adapter_level_zero_v2.so.0 is not a
symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbmalloc.so.2 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbb.so.12 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libur_loader.so.0 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbmalloc_proxy.so.2 is not a symbolic
link

/sbin/ldconfig.real: /usr/local/lib/libtbbbind.so.3 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtcm.so.1 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libur_adapter_level_zero.so.0 is not a
symbolic link

/sbin/ldconfig.real: /usr/local/lib/libur_adapter_opencl.so.0 is not a symbolic
link

Processing triggers for tex-common (6.17) …
Running updmap-sys. This may take some time… done.
Running mktexlsr /var/lib/texmf … done.
Building format(s) --all.
        This may take some time… done.
```

[44]:
```
!jupyter nbconvert --to PDF /content/drive/MyDrive/Modelo_Clasificación_MCG.
↪ipynb
```

```
[NbConvertApp] Converting notebook
/content/drive/MyDrive/Modelo_Clasificación_MCG.ipynb to PDF
[NbConvertApp] Support files will be in Modelo_Clasificación_MCG_files/
[NbConvertApp] Making directory ./Modelo_Clasificación_MCG_files
[NbConvertApp] Writing 122097 bytes to notebook.tex
[NbConvertApp] Building PDF
[NbConvertApp] Running xelatex 3 times: ['xelatex', 'notebook.tex', '-quiet']
[NbConvertApp] Running bibtex 1 time: ['bibtex', 'notebook']
```

```
[NbConvertApp] WARNING | bibtex had problems, most likely because there were no
citations
[NbConvertApp] PDF successfully created
[NbConvertApp] Writing 764668 bytes to
/content/drive/MyDrive/Modelo_Clasificación_MCG.pdf
```