BANK LOAN DEFAULT RISK ANALYSIS

SQL Server Express → Python

```
In [1]: import pandas as pd
        import numpy as np
        import matplotlib.pyplot as plt
        import seaborn as sns
        import plotly.express as px
        import plotly.graph_objects as go
        from plotly.subplots import make_subplots
```

SQL Server connection

```
In [2]: from sqlalchemy import create_engine
```

```
In [3]: engine = create_engine('mssql+pyodbc://ROHIT\SQLEXPRESS/BankLoanRisk?driver=ODBC

        print("✅ Connected to SQL Server Express - BankLoanRisk database")
        print("="*80)
```

```
✅ Connected to SQL Server Express - BankLoanRisk database
================================================================================
```

1. LOAD DATA FROM YOUR CLEANED TABLES & VIEWS

```
In [4]: # Main analysis dataset
        df = pd.read_sql("""
            SELECT *
            FROM dw.vw_loan_performance_detail
            WHERE loan_amount IS NOT NULL
        """, engine)
```

```
In [5]: print(f"📊 Loaded {len(df):,} loan records")
        print(f"   Default rate: {df['default_flag'].mean():.1%}")
        print(df['loan_status'].value_counts())
        print("\nDataset shape:", df.shape)
        print("\nKey columns:")
        print(df.select_dtypes(include=['int64','float64']).columns.tolist())
```

```
📊 Loaded 97,940 loan records
   Default rate: 10.0%
loan_status
Current    88135
Default     9805
Name: count, dtype: int64

Dataset shape: (97940, 32)

Key columns:
['loan_id', 'borrower_id', 'origination_year', 'origination_quarter', 'loan_amoun
t', 'interest_rate', 'monthly_payment', 'is_joint_application', 'default_flag',
'annual_income', 'dti_ratio', 'length_credit_history', 'num_total_credit_lines',
'num_open_credit_lines', 'num_open_credit_lines_1_year', 'revolving_balance', 're
volving_utilization_rate', 'num_derogatory_rec', 'num_delinquency_2_years', 'num_
chargeoff_1_year', 'num_inquiries_6_mon', 'risk_history_flag']
```

In [6]:

```python
# Quick data quality check
print("🔍 DATA QUALITY SUMMARY")
print("="*50)
print(f"Null loan_amount: {df['loan_amount'].isna().sum()}")
print(f"Null interest_rate: {df['interest_rate'].isna().sum()}")
print(f"Date range: {df['origination_date'].min()} to {df['origination_date'].ma

# Portfolio overview
portfolio_stats = df.agg({
    'loan_amount': ['count', 'sum', 'mean', 'median'],
    'interest_rate': ['mean', 'std']
}).round(2)
print("\n📈 PORTFOLIO STATS")
print(portfolio_stats)
```

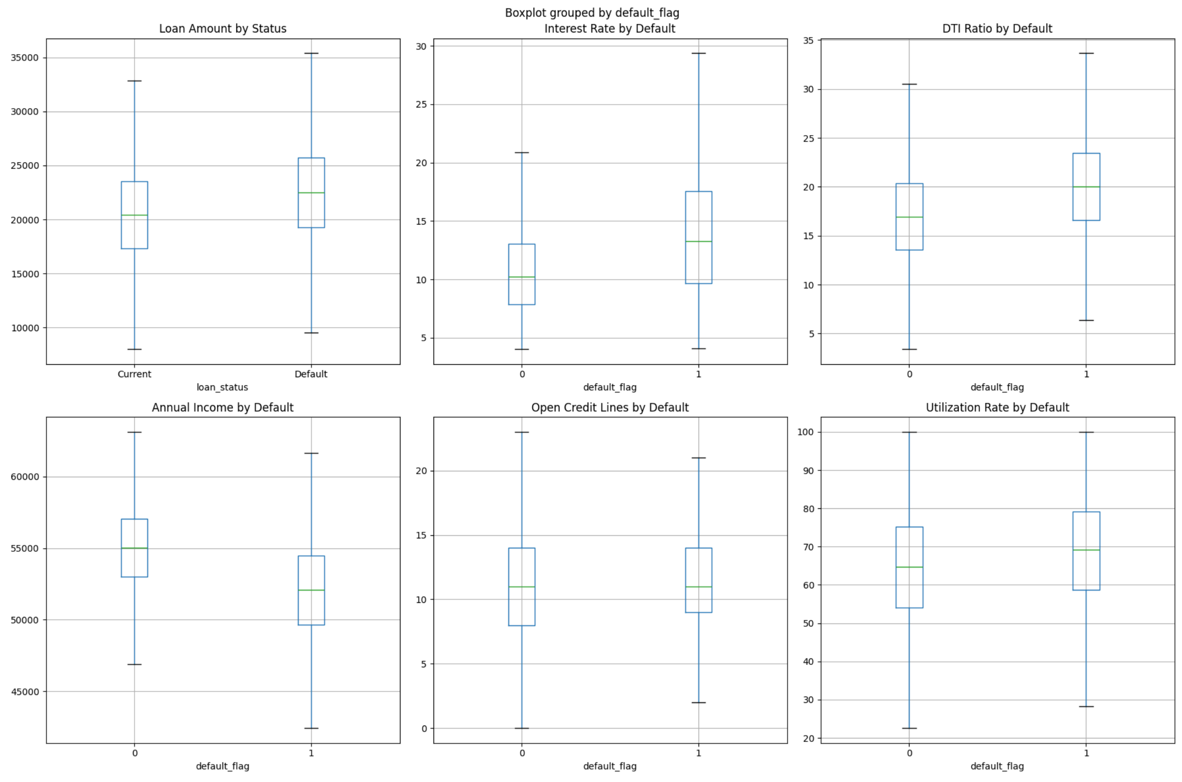
```
🔍 DATA QUALITY SUMMARY
==================================================
Null loan_amount: 0
Null interest_rate: 0
Date range: 2014-05-13 to 2016-06-30

📈 PORTFOLIO STATS
         loan_amount  interest_rate
count   9.794000e+04            NaN
sum     2.023022e+09            NaN
mean    2.065573e+04          10.98
median  2.059700e+04            NaN
std              NaN           3.90
```

2. EXPLORATORY DATA ANALYSIS (EDA)

In [7]:

```python
fig, axes = plt.subplots(2, 3, figsize=(18, 12))
fig.suptitle('Loan Portfolio EDA', fontsize=16, fontweight='bold')

# 1. Loan amount distribution by status
df.boxplot(column='loan_amount', by='loan_status', ax=axes[0,0], showfliers=Fals
axes[0,0].set_title('Loan Amount by Status')

# 2. Interest rate distribution
df.boxplot(column='interest_rate', by='default_flag', ax=axes[0,1], showfliers=F
axes[0,1].set_title('Interest Rate by Default')
```

```
# 3. DTI ratio
df.boxplot(column='dti_ratio', by='default_flag', ax=axes[0,2], showfliers=False
axes[0,2].set_title('DTI Ratio by Default')

# 4. Income distribution
df.boxplot(column='annual_income', by='default_flag', ax=axes[1,0], showfliers=F
axes[1,0].set_title('Annual Income by Default')

# 5. Credit lines
df.boxplot(column='num_open_credit_lines', by='default_flag', ax=axes[1,1], show
axes[1,1].set_title('Open Credit Lines by Default')

# 6. Utilization
df.boxplot(column='revolving_utilization_rate', by='default_flag', ax=axes[1,2],
axes[1,2].set_title('Utilization Rate by Default')

plt.tight_layout()
plt.show()
```

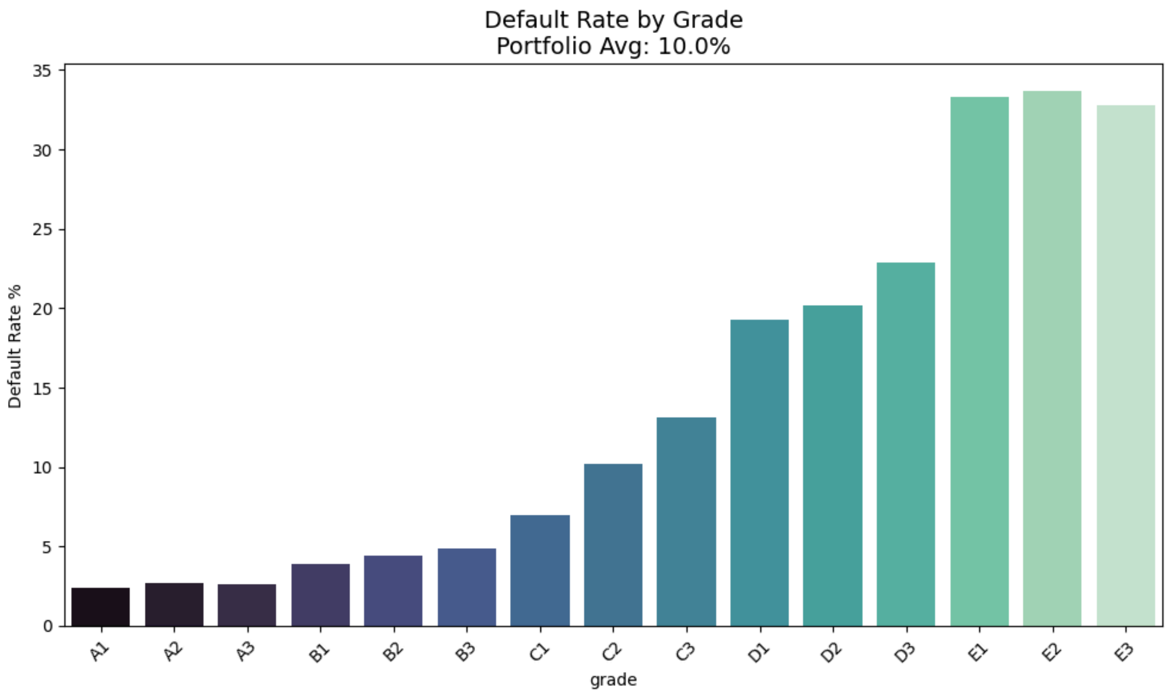


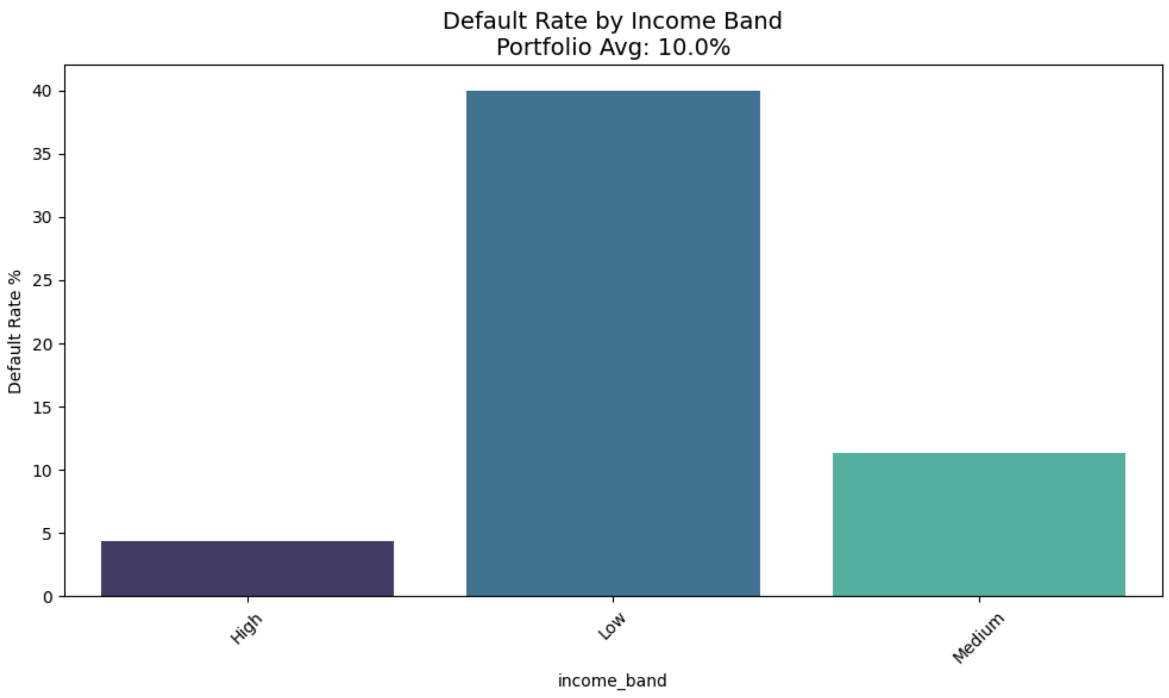
3. DEFAULT RATE ANALYSIS (Key Business Insights)

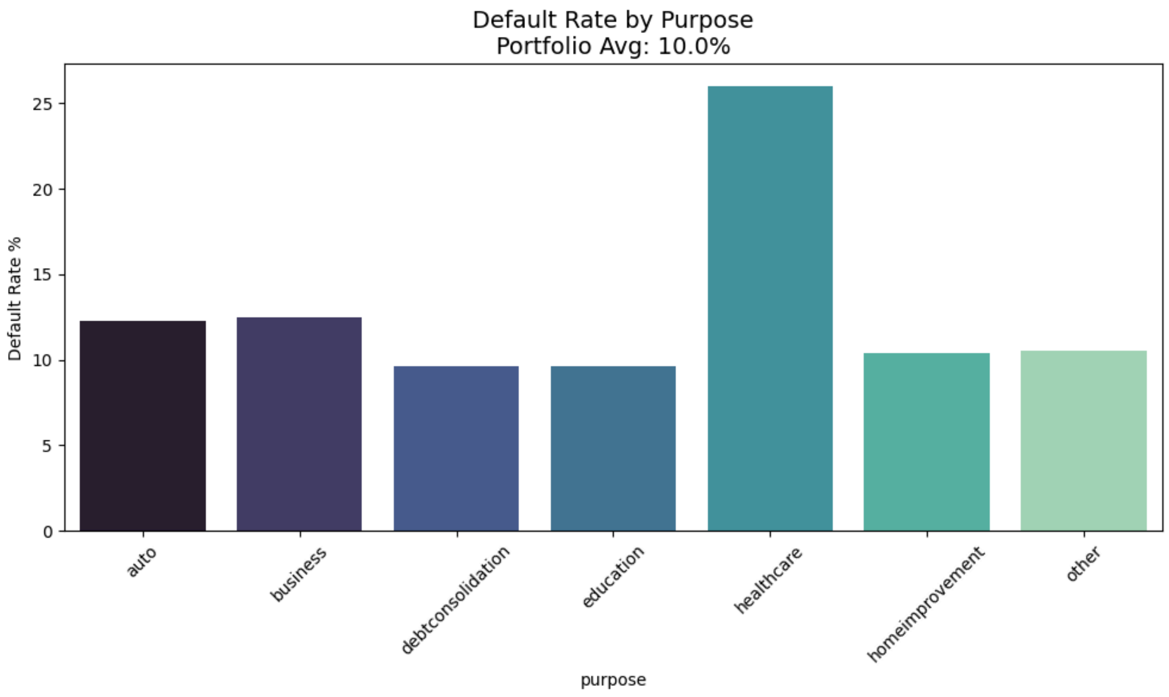
In [8]:
```
# Default rate by key segments
def plot_default_rates(df, col, title):
    rates = df.groupby(col)['default_flag'].agg(['count', 'sum', 'mean']).round(
    rates.columns = ['loans', 'defaults', 'default_rate']
    rates['default_rate_pct'] = rates['default_rate'] * 100

    plt.figure(figsize=(10, 6))
    sns.barplot(data=rates.reset_index(), x=col, y='default_rate_pct', hue=col,
    plt.title(f'{title}\nPortfolio Avg: {df["default_flag"].mean()*100:.1f}%', f
    plt.xticks(rotation=45)
    plt.ylabel('Default Rate %')
    plt.tight_layout()
    plt.show()
    return rates
```

```
# Plot key drivers
print("🔥 DEFAULT RATE BY SEGMENT")
print("-" * 50)

grade_rates = plot_default_rates(df, 'grade', 'Default Rate by Grade')
income_rates = plot_default_rates(df, 'income_band', 'Default Rate by Income Ban
purpose_rates = plot_default_rates(df, 'purpose', 'Default Rate by Purpose')
```

```
🔥 DEFAULT RATE BY SEGMENT
--------------------------------------------------
```

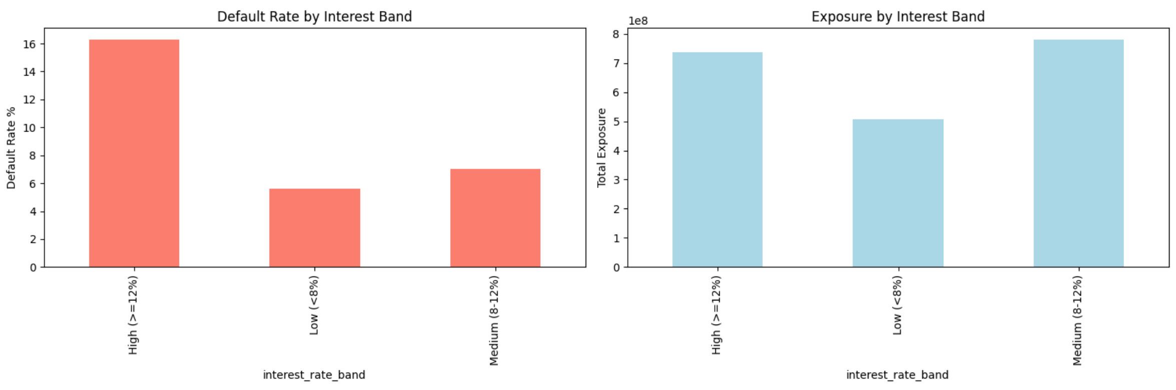






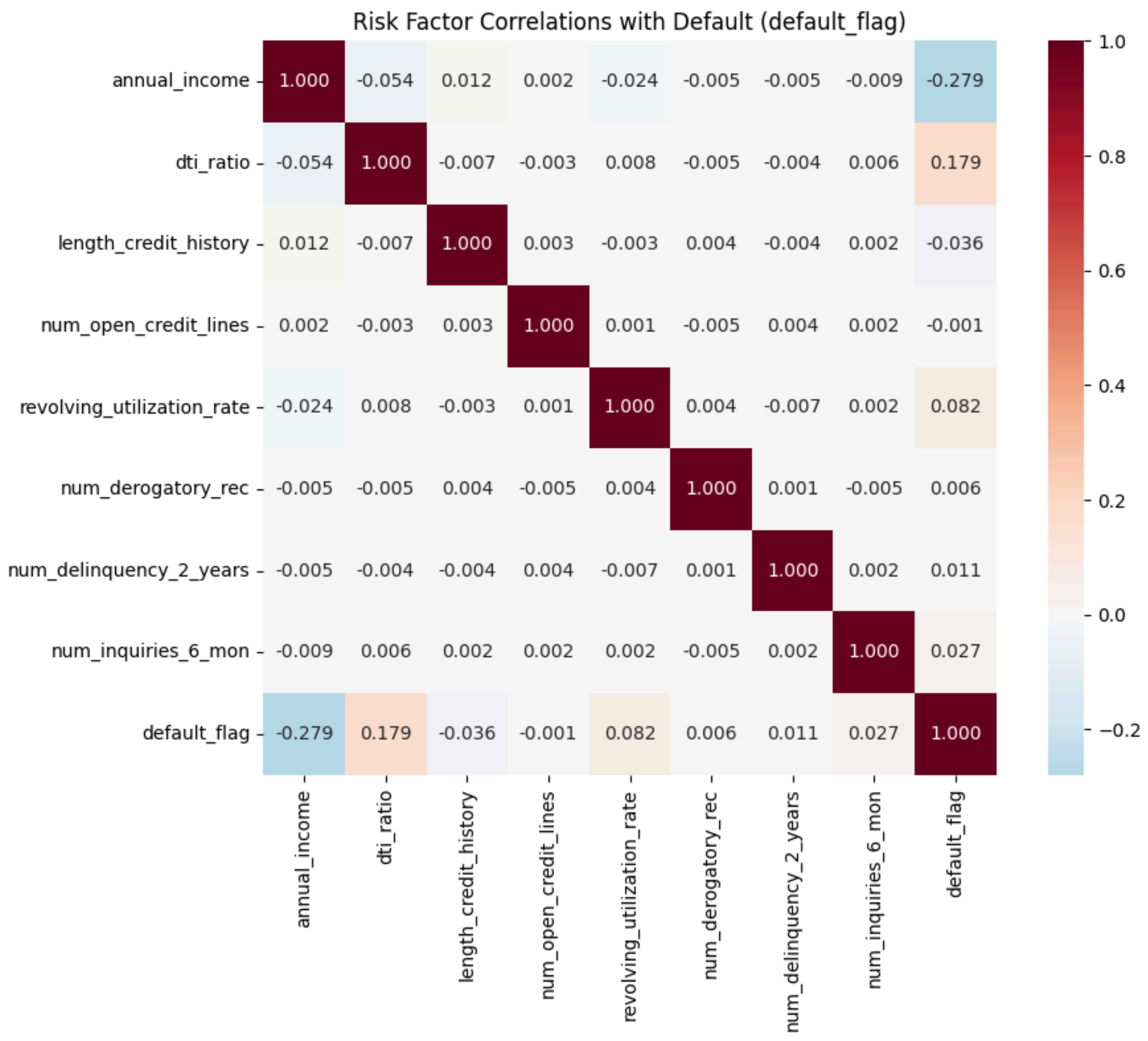
In [9]:
```python
# Interest rate bands vs default
rate_analysis = df.groupby('interest_rate_band').agg({
    'default_flag': ['count', 'sum', 'mean'],
    'loan_amount': 'sum',
    'interest_rate': 'mean'
}).round(3)

rate_analysis.columns = ['loans', 'defaults', 'default_rate', 'exposure', 'avg_r
rate_analysis['default_rate_pct'] = rate_analysis['default_rate'] * 100

print("📊 INTEREST RATE vs DEFAULT RISK")
print(rate_analysis[['loans', 'default_rate_pct', 'exposure', 'avg_rate']])

fig, ax = plt.subplots(1, 2, figsize=(15, 5))

# Default rate
rate_analysis['default_rate_pct'].plot(kind='bar', ax=ax[0], color='salmon')
ax[0].set_title('Default Rate by Interest Band')
ax[0].set_ylabel('Default Rate %')

# Exposure
rate_analysis['exposure'].plot(kind='bar', ax=ax[1], color='lightblue')
ax[1].set_title('Exposure by Interest Band')
ax[1].set_ylabel('Total Exposure')

plt.tight_layout()
plt.show()
```

```
📊 INTEREST RATE vs DEFAULT RISK
                    loans  default_rate_pct   exposure  avg_rate
interest_rate_band
High (>=12%)        35439              16.3  736277411    15.191
Low (<8%)           24579               5.6  505789272     6.515
Medium (8-12%)      37922               7.0  780955453     9.928
```



4. CORRELATION HEATMAP (Risk Drivers)

In [10]:
```
# Select numeric risk features
risk_features = [
    'annual_income', 'dti_ratio', 'length_credit_history',
    'num_open_credit_lines', 'revolving_utilization_rate',
    'num_derogatory_rec', 'num_delinquency_2_years',
    'num_inquiries_6_mon', 'default_flag'
]

corr_matrix = df[risk_features].corr()

plt.figure(figsize=(10, 8))
sns.heatmap(corr_matrix, annot=True, cmap='RdBu_r', center=0,
            square=True, fmt='.3f')
plt.title('Risk Factor Correlations with Default (default_flag)')
plt.tight_layout()
plt.show()

# Strongest correlations
print("🔍 STRONGEST CORRELATIONS WITH DEFAULT:")
correlations = corr_matrix['default_flag'].sort_values(ascending=False)
print(correlations[1:6])  # Top 5 excluding self
```



	annual_income	dti_ratio	length_credit_history	num_open_credit_lines	revolving_utilization_rate	num_derogatory_rec	num_delinquency_2_years	num_inquiries_6_mon	default_flag
annual_income	1.000	-0.054	0.012	0.002	-0.024	-0.005	-0.005	-0.009	-0.279
dti_ratio	-0.054	1.000	-0.007	-0.003	0.008	-0.005	-0.004	0.006	0.179
length_credit_history	0.012	-0.007	1.000	0.003	-0.003	0.004	-0.004	0.002	-0.036
num_open_credit_lines	0.002	-0.003	0.003	1.000	0.001	-0.005	0.004	0.002	-0.001
revolving_utilization_rate	-0.024	0.008	-0.003	0.001	1.000	0.004	-0.007	0.002	0.082
num_derogatory_rec	-0.005	-0.005	0.004	-0.005	0.004	1.000	0.001	-0.005	0.006
num_delinquency_2_years	-0.005	-0.004	-0.004	0.004	-0.007	0.001	1.000	0.002	0.011
num_inquiries_6_mon	-0.009	0.006	0.002	0.002	0.002	-0.005	0.002	1.000	0.027
default_flag	-0.279	0.179	-0.036	-0.001	0.082	0.006	0.011	0.027	1.000

```
🔍 STRONGEST CORRELATIONS WITH DEFAULT:
dti_ratio                     0.178866
revolving_utilization_rate    0.081806
num_inquiries_6_mon           0.027479
num_delinquency_2_years       0.010556
num_derogatory_rec            0.005552
Name: default_flag, dtype: float64
```