**Challenge June-2018**
**Credit Card Application**

**A solution with DT5GL by Jack Jansonius – 16 Sept 2018**

All details for this challenge can be found [here](#).

**Decision variable overview:**

Credit_Card
- Applicant_Demographic_Suitability
- Applicant_Years_of_Age
- Applicant_Card_Type
  - 'Applicant is existing customer'
- Product_holdings_number
- Applicant_Student_Creditcard_Demographic_Suitability
- Current_account_Type
- Applicant_Private_Creditcard_Demographic_Suitability
  - Sole_Annual_Income
  - Outstanding_Mortgage
  - Saving_and_Investment_balance
- Applicant_Creditcard_Eligibility
  - Applicant_Card_Type
  - Applicant_Credit_Score
    - Score_on_payments
    - Number_of_payments
    - Score_on_bankruptcy
      - 'Applicant has declared bankruptcy'
    - Score_on_current_account_bank_years
      - current_account_bank_years
    - Score_on_available_credit_used%
    - Amount_of_available_credit_used%
- Applicant_Balance_Transfer_CreditCard_Eligibility
- Sole_Annual_Income
- Residential_Status
  - 'CreditCard previously applied in last 6 month'
- Number_of_years_address_history

This overview is typical for a goal-oriented approach: a stepwise refinement of goals.

**Implementation of the decision tables in DT5GL:**

<table>
<thead>
<tr>
<th>Table 0: credit card application</th>
</tr>
</thead>
<tbody>
<tr>
<td>If:</td>
</tr>
<tr>
<td>Applicant_Demographic_Suitability is Suitable</td>
</tr>
<tr>
<td>Applicant_Creditcard_Eligibility is Eligible</td>
</tr>
<tr>
<td>Then:</td>
</tr>
<tr>
<td>Credit_Card is Accepted</td>
</tr>
<tr>
<td>Credit_Card is Rejected</td>
</tr>
</tbody>
</table>

GoalAttribute: Credit_Card
Case: Accepted
Print: "Credit card is accepted"
Case: Rejected
Print: "Credit card is rejected"
### rTable 1: Applicant Demographic Suitability

<table>
<thead>
<tr>
<th>Condition</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicant_Years_of_Age &lt; 18</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Applicant_Card_Type is Student</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Applicant_Card_Type is Private</td>
<td>-</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Applicant_Card_Type is Balance-Transfer</td>
<td>-</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>'Applicant is existing customer'</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>Applicant_Student_Creditcard_Demographic_Suitability is Suitable</td>
<td>Y</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Applicant_Private_Creditcard_Demographic_Suitability is Suitable</td>
<td>-</td>
<td>Y</td>
<td>-</td>
</tr>
</tbody>
</table>

Then:

| Applicant\_Demographic\_Suitability is Suitable | X | X | X |

### Attribute: Applicant\_Years\_of\_Age
Askable using: "What is the years of age of the applicant?"

### Attribute: Applicant\_Card\_Type
Askable using: "What is the desired cardtype?"

### rTable 2: Existing customer?

<table>
<thead>
<tr>
<th>Condition</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product_holdings_number &gt; 0</td>
<td>Y</td>
</tr>
</tbody>
</table>

Then:

| 'Applicant is existing customer'               | X |

### Attribute: Product\_holdings\_number
Askable using: "What is the number of products held?"

### rTable 3: Applicant Student Creditcard Demographic Suitability

<table>
<thead>
<tr>
<th>Condition</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current_account_Type is Student</td>
<td>Y</td>
</tr>
</tbody>
</table>

Then:

| Applicant\_Student\_Creditcard\_Demographic\_Suitability is Suitable | X |

### Attribute: Current\_account\_Type
Askable using: "What is the current account type?"

### Table 4: Applicant\_Private\_Creditcard\_Demographic\_Suitability

<table>
<thead>
<tr>
<th>Condition</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sole_Annual_Income &lt; 100000</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Outstanding_Mortgage &lt; 300000</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>-</td>
</tr>
<tr>
<td>Saving_and_Investment_balance &lt; 100000</td>
<td>Y</td>
<td>N</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Then:

| Applicant\_Private\_Creditcard\_Demographic\_Suitability is Suitable | X | X | X |

### Attribute: Sole\_Annual\_Income
Askable using: "What is the sole anual income (>=100000 expected)"

### Attribute: Outstanding\_Mortgage
Askable using: "What is the outstanding mortgage (>=300000 expected)"

### Attribute: Saving\_and\_Investment\_balance
Askable using: "What is the saving and investment balance (>=100000 expected)"
rTable 5: Applicant Creditcard Eligibility
If:                                                      | 0| 1| 2|
Applicant_Card_Type is Student                         | Y| N| N|
Applicant_Card_Type is Private                         | -| Y| N|
Applicant_Card_Type is Balance-Transfer                | -| -| Y|
Applicant_Credit_Score >= 500                          | Y| -| -|
Applicant_Credit_Score >= 750                          | -| Y| Y|
Applicant_Balance_Transfer_CreditCard is Eligible      | -| -| Y|
Then:
Applicant_Creditcard_Eligibility is Eligible           | X| X| X|
# .......

# Instead of the full table; see the notes on this version:
#
# Table 5: Applicant Creditcard Eligibility
# If:                                   | 0| 1| 2| 3| 4| 5| 6| 7|
# Applicant_Card_Type is Student         | Y| Y| N| N| N| N| N| N|
# Applicant_Card_Type is Private         | -| -| Y| Y| N| N| N| N|
# Applicant_Card_Type is Balance-Transfer| -| -| -| -| Y| Y| Y| N|
# Applicant_Credit_Score >= 500           | Y| N| -| -| -| -| -| -|
# Applicant_Credit_Score >= 750           | -| -| Y| N| Y| Y| N| -|
# Applicant_Balance_Transfer_CreditCard is Eligible | -| -| -| -| Y| N| -| -|
# Then:
# Applicant_Creditcard_Eligibility is Eligible         | X|  | X|  | X|  |  |  |

rTable 6: Applicant Balance Transfer CreditCard
If:                                                      | 0|
Sole_Annual_Income > 10000                             | Y|
Residential_Status is UK_resident                      | Y|
'CreditCard previously applied in last 6 month'         | N|
Number_of_years_address_history >= 3                   | Y|
Then:
Applicant_Balance_Transfer_CreditCard is Eligible      | X|
# .......

Proposition: 'CreditCard previously applied in last 6 month'
Askable using: "**?"
Attribute: Residential_Status
Askable using: "What is the residential status of the applicant?"
Attribute: Number_of_years_address_history
Askable using: "What is the number of years with a address history (3 or more expected)?"
Attribute: Applicant_Credit_Score
Summation_of: Score_on_payments + Score_on_bankruptcy + 
Score_on_current_account_bank_years + Score_on_available_credit_used%

Table 7: Score on payments
If:                      | 0| 1| 2| 3|
Number_of_payments = 0    | Y| N| N| N|
Number_of_payments <= 3   | -| Y| N| N|
Number_of_payments <= 6   | -| -| Y| N|
Then:
Score_on_payments = 250   | X| | | |
Score_on_payments = 100   | | X| | |
Score_on_payments = 50    | | | X| |
Score_on_payments = 0     | | | | X|
# .......

Attribute: Number_of_payments
Askable_using: "What is the number of default payments in the last 12 months (0,..3,..6,..)?"

Table 8: Score on bankruptcy
If:                      | 0| 1|
'Applicant has declared bankruptcy' | Y| N|
Then:
Score_on_bankruptcy = 0    | X| |
Score_on_bankruptcy = 250  | | X|
# .......

Proposition: 'Applicant has declared bankruptcy'
Askable_using: "**?"

Table 9: Score on current account bank years
If:                      | 0| 1| 2|
current_account_bank_years = 0 | Y| N| N|
current_account_bank_years <= 3 | -| Y| N|
Then:
Score_on_current_account_bank_years = 50 | X| | |
Score_on_current_account_bank_years = 150 | | X| |
Score_on_current_account_bank_years = 250 | | | X|
# .......

Attribute: current_account_bank_years
Askable_using: "Years with current account bank (0,..3,..)?"

Table 10: Score on available credit used percentage
If:                      | 0| 1| 2| 3|
Amount_of_available_credit_used% < 25 | Y| N| N| N|
Amount_of_available_credit_used% < 50 | -| Y| N| N|
Amount_of_available_credit_used% < 75 | -| -| Y| N|
Then:
Score_on_available_credit_used% = 200 | X| | | |
Score_on_available_credit_used% = 249 | | X| | |
Score_on_available_credit_used% = 150 | | | X| |
Score_on_available_credit_used% = 0   | | | | X|
# .......

Attribute: Amount_of_available_credit_used%
Askable_using: "Amount of available credit used percentage (0..24,..49,..74,..100)?"
Some notes on this version of DT5GL.

To meet up with the requirements of this challenge I had to introduce a new construction in DT5GL, namely:

Attribute: Applicant_Credit_Score
Summation_of: Score_on_payments + Score_on_bankruptcy + Score_on_current_account_bank_years + Score_on_available_credit_used%

Also interesting is the notion of ‘reduced table’ with the keyword ‘rTable’.
The use of ‘rTable’ instead of ‘Table’ simply disables the check on completeness, what leads to more compact decisions tables. Example:

\[
\begin{array}{|c|c|c|c|}
\hline
& 0 & 1 & 2 \\
\hline
\text{Applicant} \_ \text{Years} \_ \text{of} \_ \text{Age} < 18 & N & N & N \\
\text{Applicant} \_ \text{Card} \_ \text{Type} \ is \ \text{Student} & Y & N & N \\
\text{Applicant} \_ \text{Card} \_ \text{Type} \ is \ \text{Private} & - & Y & N \\
\text{Applicant} \_ \text{Card} \_ \text{Type} \ is \ \text{Balance-Transfer} & - & - & Y \\
\text{Applicant} \_ \text{is} \ \text{existing} \ \text{customer} \ & Y & Y & - \\
\text{Applicant} \_ \text{Student} \_ \text{Creditcard} \_ \text{Demographic} \_ \text{Suitability} \ is \ \text{Suitable} & Y & - & - \\
\text{Applicant} \_ \text{Private} \_ \text{Creditcard} \_ \text{Demographic} \_ \text{Suitability} \ is \ \text{Suitable} & - & Y & - \\
\hline
\end{array}
\]

rTable 1: Applicant Demographic Suitability
If:
\[
\begin{array}{|c|c|c|c|c|c|c|c|c|c|}
\hline
 & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\
\hline
\text{Applicant} \_ \text{Years} \_ \text{of} \_ \text{Age} < 18 & Y & N & N & N & N & N & N & N & N \\
\text{Applicant} \_ \text{Card} \_ \text{Type} \ is \ \text{Student} & - & Y & Y & Y & N & N & N & N & N \\
\text{Applicant} \_ \text{Card} \_ \text{Type} \ is \ \text{Private} & - & - & - & - & Y & Y & Y & Y & N \\
\text{Applicant} \_ \text{Card} \_ \text{Type} \ is \ \text{Balance-Transfer} & - & - & - & - & - & - & Y & Y & Y \\
\text{Applicant} \_ \text{is} \ \text{existing} \ \text{customer} \ & - & Y & Y & N & Y & Y & N & N & Y \\
\text{Applicant} \_ \text{Student} \_ \text{Creditcard} \_ \text{Demographic} \_ \text{Suitability} \ is \ \text{Suitable} & - & - & - & - & - & - & - & Y & N \\
\text{Applicant} \_ \text{Private} \_ \text{Creditcard} \_ \text{Demographic} \_ \text{Suitability} \ is \ \text{Suitable} & - & - & - & - & - & - & - & - & - \\
\hline
\end{array}
\]

Then:
\[
\begin{array}{|c|c|c|c|c|c|c|c|c|c|}
\hline
\text{Applicant} \_ \text{Demographic} \_ \text{Suitability} \ is \ \text{Suitable} & X & X & X \\
\hline
\end{array}
\]

is the reduced version of:

Table 1: Applicant Demographic Suitability
If:
\[
\begin{array}{|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline
 & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\
\hline
\text{Applicant} \_ \text{Years} \_ \text{of} \_ \text{Age} < 18 & Y & N & N & N & N & N & N & N & N \\
\text{Applicant} \_ \text{Card} \_ \text{Type} \ is \ \text{Student} & - & Y & Y & Y & N & N & N & N & N \\
\text{Applicant} \_ \text{Card} \_ \text{Type} \ is \ \text{Private} & - & - & - & - & Y & Y & Y & Y & N \\
\text{Applicant} \_ \text{Card} \_ \text{Type} \ is \ \text{Balance-Transfer} & - & - & - & - & - & - & Y & Y & Y \\
\text{Applicant} \_ \text{is} \ \text{existing} \ \text{customer} \ & - & Y & Y & N & Y & Y & N & N & Y \\
\text{Applicant} \_ \text{Student} \_ \text{Creditcard} \_ \text{Demographic} \_ \text{Suitability} \ is \ \text{Suitable} & - & - & - & - & - & - & - & Y & N \\
\text{Applicant} \_ \text{Private} \_ \text{Creditcard} \_ \text{Demographic} \_ \text{Suitability} \ is \ \text{Suitable} & - & - & - & - & - & - & - & - & - \\
\hline
\end{array}
\]

Then:
\[
\begin{array}{|c|c|c|c|c|c|c|c|c|c|}
\hline
\text{Applicant} \_ \text{Demographic} \_ \text{Suitability} \ is \ \text{Suitable} & X & X & X \\
\hline
\end{array}
\]

...Weights for completeness
\[
\begin{array}{|c|c|c|c|c|c|}
\hline
 & 64 & 8 & 8 & 16 & 4 & 4 & 8 & 8 \\
\hline
\end{array}
\]

Every dash “-“ in a column stands for a factor 2, so 2 dashes in a column gives a weight of 4 (2*2), 3 dashes a weight of 8 (2*2*2), 4 dashes a weight of 16 (2*2*2*2), and so forth..

With this weights, the completeness of the table can be checked: for every condition in the table the number of weighed Y’s must be equal to the number of weighed N’s.

The full table will pass this check; the reduced table will give an error when using “Table”:

Decisiontable 1 is not correct.
For condition 1 the number of Y’s differs from the number of N’s.
Number of Y’s: 0
Number of N’s: 20

In my opinion it is highly recommended to keep the full version with the reduced version in regards to future changes; see table 5 for another example. On the other hand, many people find it difficult to make complete decision tables, so maybe the use of reduced tables solely is not a problem at all.
Various testruns

1. Age=17 ➔ rejected

"What is the years of age of the applicant?"
> 17
"Credit card is rejected"

Credit Cardtype=Student

2. Age=18, not existing customer ➔ rejected

"What is the years of age of the applicant?"
> 18
"What is the desired cardtype?"
1. Student
2. Private
3. Balance-Transfer
4. Otherwise
> 1

"What is the number of products held?"
> 0
"Credit card is rejected"

3. Age=18, existing customer, current account type <> Student ➔ rejected

"What is the years of age of the applicant?"
> 18
"What is the desired cardtype?"
1. Student
2. Private
3. Balance-Transfer
4. Otherwise
> 1
"What is the number of products held?"
> 1
"What is the current account type?"
1. Student
2. Otherwise
> 2
"Credit card is rejected"
4. Age=18, existing customer, current account type=Student, Application Credit Score<500 ➔ rejected

"What is the years of age of the applicant?" > 18
"What is the desired cardtype?"
1. Student
2. Private
3. Balance-Transfer
4. Otherwise > 1
"What is the number of products held?" > 2
"What is the current account type?"
1. Student
2. Otherwise > 1
"What is the number of default payments in the last 12 months (0,..3,..6,..)?" > 7
'Applicant has declared bankruptcy' (y/n)? * > y
"Years with current account bank (0,..3,..)?" > 4
"Amount of available credit used percentage (0,..24,..49,..74,..100)?" > 49
"Credit card is rejected"

5. Age=18, existing customer, current account type=Student, Application Credit Score>=500 ➔ accepted

"What is the years of age of the applicant?" > 18
"What is the desired cardtype?"
1. Student
2. Private
3. Balance-Transfer
4. Otherwise > 1
"What is the number of products held?" > 2
"What is the current account type?"
1. Student
2. Otherwise > 1
"What is the number of default payments in the last 12 months (0,..3,..6,..)?" > 0
'Applicant has declared bankruptcy' (y/n)? * > y
"Years with current account bank (0,..3,..)?" > 0
"Amount of available credit used percentage (0,..24,..49,..74,..100)?" > 24
"Credit card is accepted"
Credit Cardtype=Private

6. Age=18, existing customer, Sole_Annual_Income<100000, Outstanding_Mortgage<300000, Saving_and_Investment_balance<100000 ➔ rejected

"What is the years of age of the applicant?" > 18
"What is the desired cardtype?"
1. Student
2. Private
3. Balance-Transfer
4. Otherwise
> 2
"What is the number of products held?" > 2
"What is the sole anual income" > 99000
"What is the outstanding mortgage" > 299000
"What is the saving and investment balance" > 99000
"Credit card is rejected"

7. Age=18, existing customer, Sole_Annual_Income>=100000, Applicant_Credit_Score >= 750 ➔ accepted

"What is the years of age of the applicant?" > 18
"What is the desired cardtype?"
1. Student
2. Private
3. Balance-Transfer
4. Otherwise
> 2
"What is the number of products held?" > 2
"What is the sole anual income" > 100000
"What is the number of default payments in the last 12 months (0,..3,..6,..)?" > 0
'Applicant has declared bankruptcy' (y/n)? *> n
"Years with current account bank (0,..3,..)?" > 4
"Amount of available credit used percentage (0..24,..49,..74,..100)?" > 88
"Credit card is accepted"
Credit Cardtype = Balance-Transfer

8. Age=18, Applicant_Credit_Score < 750 ➔ rejected

"What is the years of age of the applicant?" ➔ 18
"What is the desired cardtype?"
1. Student
2. Private
3. Balance-Transfer
4. Otherwise ➔ 3
"What is the number of default payments in the last 12 months (0..3..6..)?" ➔ 0
'Applicant has declared bankruptcy' (y/n)? ➔ y
"Years with current account bank (0..3..)?" ➔ 4
"Amount of available credit used percentage (0..24..49..74..100)?" ➔ 49
"Credit card is rejected"

9. Age=18, Applicant_Credit_Score >= 750, Sole_Annual_Income > 10000, Residential_Status is UK_resident, 'CreditCard previously applied in last 6 month' = False, Number_of_years_address_history >= 3 ➔ accepted

"What is the years of age of the applicant?" ➔ 18
"What is the desired cardtype?"
1. Student
2. Private
3. Balance-Transfer
4. Otherwise ➔ 3
"What is the number of default payments in the last 12 months (0..3..6..)?" ➔ 0
'Applicant has declared bankruptcy' (y/n)? ➔ n
"Years with current account bank (0..3..)?" ➔ 4
"Amount of available credit used percentage (0..24..49..74..100)?" ➔ 88
"What is the sole anual income" ➔ 10001
"What is the residential status of the applicant?"
1. UK_resident
2. Otherwise ➔ 1
'CreditCard previously applied in last 6 month' (y/n)? ➔ n
"What is the number of years with a adress history (3 or more expected)?" ➔ 3
"Credit card is accepted"
Demo Goal-driven/Backward-chaining reasoning with condition subtables.

Credit Cardtype=Private
7. Age=18, existing customer, Sole_Annual_Income>=100000,
Applicant_Credit_Score >= 750 ➔ accepted

Prove (Credit_Card is Accepted)
  >> Conditions Table 0 Rule 0:
    Prove (Applicant_Demographic_Suitability is Suitable)
      >> Conditions Table 1 Rule 0:
        "What is the years of age of the applicant?"
        > 18
        "What is the desired cardtype?"
        1. Student
        2. Private
        3. Balance-Transfer
        4. Otherwise
        > 2
        >> Failed...
      >> Conditions Table 1 Rule 1:
        Prove ('Applicant is existing customer')
        >> Conditions Table 2 Rule 0:
          "What is the number of products held?"
          > 2
          >> Succeed...
        Succeed
      Prove (Applicant_Private_Creditcard_Demographic_Suitability is Suitable)
        >> Conditions Table 4 Rule 1:
          "What is the sole annual income"
          > 100000
          >> Failed...
        >> Conditions Table 4 Rule 2:
          >> Failed...
        >> Conditions Table 4 Rule 3:
          >> Succeed...
        Succeed
      >> Succeed...
    Succeed

Succeed
Prove (Applicant_Creditcard_Eligibility is Eligible)

>> Conditions Table 5 Rule 0:
   >> Failed...

>> Conditions Table 5 Rule 1:
   Prove (Applicant_Credit_Score >= 750)
       >> Conditions Table 7 Rule 0:
          "What is the number of default payments in the last 12 months (0,..3,..6,..)?"
          > 0
          >> Succeed...
          Derived value for Score_on_payments is: 250
       >> Conditions Table 8 Rule 0:
          'Applicant has declared bankruptcy' (y/n)? * > n
          >> Failed...
       >> Conditions Table 8 Rule 1:
          >> Succeed...
          Derived value for Score_on_bankruptcy is: 250
       >> Conditions Table 9 Rule 0:
          "Years with current account bank (0,..3,..)?"
          > 4
          >> Failed...
       >> Conditions Table 9 Rule 1:
          >> Failed...
       >> Conditions Table 9 Rule 2:
          >> Succeed...
          Derived value for Score_on_current_account_bank_years is: 250
       >> Conditions Table 10 Rule 0:
          "Amount of available credit used percentage (0..24,..49,..74,..100) ?"
          > 88
          >> Failed...
       >> Conditions Table 10 Rule 1:
          >> Failed...
       >> Conditions Table 10 Rule 2:
          >> Failed...
       >> Conditions Table 10 Rule 3:
          >> Succeed...
          Derived value for Score_on_available_credit_used% is: 0
          Derived value for Applicant_Credit_Score is: 750
          Succeed
       >> Succeed...

Succeed

>> Succeed...

"Credit card is accepted"
Succeed