

## VARIABLE CREATION

To detect the candidates of fraudulent applications within the data, unusualness within the linkage variables count were used. Variables were built by linking the current application to previous ones by 5 base variables, ssn, address, phone, bdnname and zipname:

Variable	Explanation
<b>same_ssn</b>	Number of times this SSN appears in the past
<b>same_address</b>	Number of times this address appears in the past
<b>same_phone</b>	Number of times this home phone number appears in the past
<b>same_bdnname</b>	Number of times this date of birth and name appears in the past
<b>same_zipname</b>	Number of times this zip code and name appears in the past

*Table 1. Table for Base Variables*

Furthermore, if a value of a base valuable appears several times in the past but with different values of other base valuable, it's also considered to be fraudulent. Take ssn for example, if a ssn appears several times in the past but with different address, home phone number, date of birth or zip code, this application seems to be abnormal.

Variable	Explanation
<b>same_ssn</b>	Number of times this SSN appears in the past
<b>same_ssn_diff_address</b>	Number of times this SSN with different address appears in the past
<b>same_ssn_diff_phone</b>	Number of times this SSN with different home phone number appears in the past
<b>same_ssn_diff_bdnname</b>	Number of times this SSN with different date of birth and name appears in the past
<b>same_ssn_diff_zipname</b>	Number of times this SSN with different zip code and name appears in the past

*Table 2. Table of ssn with different personal identifiable information (PII)*

Finally, 5 time windows, 1 day, 3 days, 7 days, 14 days and 30 days, were used. Each of the 5 base variables has 5 situations regarding other PIIs in 5 different time windows. Therefore, a total of 125 variables were created.

Variable	Explanation
<b>same_ssn_1</b>	Number of times this SSN appears in the past 1 day
<b>same_ssn_3</b>	Number of times this SSN appears in the past 3 days
<b>same_ssn_7</b>	Number of times this SSN appears in the past 7 days
<b>same_ssn_14</b>	Number of times this SSN appears in the past 14 days
<b>same_ssn_30</b>	Number of times this SSN appears in the past 30 days
<b>same_ssn_diff_address_1</b>	Number of times this SSN with different address appears in the past 1 day
<b>same_ssn_diff_address_3</b>	Number of times this SSN with different address appears in the past 3 days
<b>same_ssn_diff_address_7</b>	Number of times this SSN with different address appears in the past 7 days
<b>same_ssn_diff_address_14</b>	Number of times this SSN with different address appears in the past 14 days

<b>same_ssn_diff_address_30</b>	Number of times this SSN with different address appears in the past 30 days
<b>same_ssn_diff_phone_1</b>	Number of times this SSN with different home phone number appears in the past 3 days
<b>same_ssn_diff_phone_3</b>	Number of times this SSN with different home phone number appears in the past 3 days
<b>same_ssn_diff_phone_7</b>	Number of times this SSN with different home phone number appears in the past 7 days
<b>same_ssn_diff_phone_14</b>	Number of times this SSN with different home phone number appears in the past 14 days
<b>same_ssn_diff_phone_30</b>	Number of times this SSN with different home phone number appears in the past 30 days
<b>same_ssn_diff_bdtype_1</b>	Number of times this SSN with different date of birth and name appears in the past 1 day
<b>same_ssn_diff_bdtype_3</b>	Number of times this SSN with different date of birth and name appears in the past 3 days
<b>same_ssn_diff_bdtype_7</b>	Number of times this SSN with different date of birth and name appears in the past 7 days
<b>same_ssn_diff_bdtype_14</b>	Number of times this SSN with different date of birth and name appears in the past 14 days
<b>same_ssn_diff_bdtype_30</b>	Number of times this SSN with different date of birth and name appears in the past 30 days
<b>same_ssn_diff_zipname_1</b>	Number of times this SSN with different zip code and name appears in the past 1 day
<b>same_ssn_diff_zipname_3</b>	Number of times this SSN with different zip code and name appears in the past 3 days
<b>same_ssn_diff_zipname_7</b>	Number of times this SSN with different zip code and name appears in the past 7 days
<b>same_ssn_diff_zipname_14</b>	Number of times this SSN with different zip code and name appears in the past 14 days
<b>same_ssn_diff_zipname_30</b>	Number of times this SSN with different zip code and name appears in the past 30 days
<b>same_address_1</b>	Number of times this address appears in the past 1 day
<b>same_address_3</b>	Number of times this address appears in the past 3 days
<b>same_address_7</b>	Number of times this address appears in the past 7 days
<b>same_address_14</b>	Number of times this address appears in the past 14 days
<b>same_address_30</b>	Number of times this address appears in the past 30 days
<b>same_address_diff_ssn_1</b>	Number of times this SSN with different SSN appears in the past 1 day
<b>same_address_diff_ssn_3</b>	Number of times this SSN with different SSN appears in the past 3 days
<b>same_address_diff_ssn_7</b>	Number of times this SSN with different SSN appears in the past 7 days
<b>same_address_diff_ssn_14</b>	Number of times this SSN with different SSN appears in the past 14 days
<b>same_address_diff_ssn_30</b>	Number of times this SSN with different SSN appears in the past 30 days
<b>same_address_diff_phone_1</b>	Number of times this SSN with different home phone number appears in the past 1 day
<b>same_address_diff_phone_3</b>	Number of times this SSN with different home phone number appears in the past 3 days

<b>same_address_diff_phone_7</b>	Number of times this SSN with different home phone number appears in the past 7 days
<b>same_address_diff_phone_14</b>	Number of times this SSN with different home phone number appears in the past 14 days
<b>same_address_diff_phone_30</b>	Number of times this SSN with different home phone number appears in the past 30 days
<b>same_address_diff_bdtype_1</b>	Number of times this SSN with different date of birth and name appears in the past 1 day
<b>same_address_diff_bdtype_3</b>	Number of times this SSN with different date of birth and name appears in the past 3 days
<b>same_address_diff_bdtype_7</b>	Number of times this SSN with different date of birth and name appears in the past 7 days
<b>same_address_diff_bdtype_14</b>	Number of times this SSN with different date of birth and name appears in the past 14 days
<b>same_address_diff_bdtype_30</b>	Number of times this SSN with different date of birth and name appears in the past 30 days
<b>same_address_diff_zipname_1</b>	Number of times this SSN with different zip code and name appears in the past 1 day
<b>same_address_diff_zipname_3</b>	Number of times this SSN with different zip code and name appears in the past 3 days
<b>same_address_diff_zipname_7</b>	Number of times this SSN with different zip code and name appears in the past 7 days
<b>same_address_diff_zipname_14</b>	Number of times this SSN with different zip code and name appears in the past 14 days
<b>same_address_diff_zipname_30</b>	Number of times this SSN with different zip code and name appears in the past 30 days
<b>same_phone_1</b>	Number of times this home phone number appears in the past 1 day
<b>same_phone_3</b>	Number of times this home phone number appears in the past 3 days
<b>same_phone_7</b>	Number of times this home phone number appears in the past 7 days
<b>same_phone_14</b>	Number of times this home phone number appears in the past 14 days
<b>same_phone_30</b>	Number of times this home phone number appears in the past 30 days
<b>same_phone_diff_address_1</b>	Number of times this home phone number with different address appears in the past 1 day
<b>same_phone_diff_address_3</b>	Number of times this home phone number with different address appears in the past 3 days
<b>same_phone_diff_address_7</b>	Number of times this home phone number with different address appears in the past 7 days
<b>same_phone_diff_address_14</b>	Number of times this home phone number with different address appears in the past 14 days
<b>same_phone_diff_address_30</b>	Number of times this home phone number with different address appears in the past 30 days
<b>same_phone_diff_ssn_1</b>	Number of times this home phone number with different SSN appears in the past 1 day
<b>same_phone_diff_ssn_3</b>	Number of times this home phone number with different SSN appears in the past 3 days

<b>same_phone_diff_ssn_7</b>	Number of times this home phone number with different SSN appears in the past 7 days
<b>same_phone_diff_ssn_14</b>	Number of times this home phone number with different SSN appears in the past 14 days
<b>same_phone_diff_ssn_30</b>	Number of times this home phone number with different SSN appears in the past 30 days
<b>same_phone_diff_bdname_1</b>	Number of times this home phone number with different date of birth and name appears in the past 1 day
<b>same_phone_diff_bdname_3</b>	Number of times this home phone number with different date of birth and name appears in the past 3 days
<b>same_phone_diff_bdname_7</b>	Number of times this home phone number with different date of birth and name appears in the past 7 days
<b>same_phone_diff_bdname_14</b>	Number of times this home phone number with different date of birth and name appears in the past 14 days
<b>same_phone_diff_bdname_30</b>	Number of times this home phone number with different date of birth and name appears in the past 30 days
<b>same_phone_diff_zipname_1</b>	Number of times this home phone number with different zip code and name appears in the past 1 day
<b>same_phone_diff_zipname_3</b>	Number of times this home phone number with different zip code and name appears in the past 3 days
<b>same_phone_diff_zipname_7</b>	Number of times this home phone number with different zip code and name appears in the past 7 days
<b>same_phone_diff_zipname_14</b>	Number of times this home phone number with different zip code and name appears in the past 14 days
<b>same_phone_diff_zipname_30</b>	Number of times this home phone number with different zip code and name appears in the past 30 days
<b>same_bdname_1</b>	Number of times this date of birth and name appears in the past 1 day
<b>same_bdname_3</b>	Number of times this date of birth and name appears in the past 3 days
<b>same_bdname_7</b>	Number of times this date of birth and name appears in the past 7 days
<b>same_bdname_14</b>	Number of times this date of birth and name appears in the past 14 days
<b>same_bdname_30</b>	Number of times this date of birth and name appears in the past 30 days
<b>same_bdname_diff_address_1</b>	Number of times this date of birth and name with different address appears in the past 1 day
<b>same_bdname_diff_address_3</b>	Number of times this date of birth and name with different address appears in the past 3 days
<b>same_bdname_diff_address_7</b>	Number of times this date of birth and name with different address appears in the past 7 days
<b>same_bdname_diff_address_14</b>	Number of times this date of birth and name with different address appears in the past 14 days
<b>same_bdname_diff_address_30</b>	Number of times this date of birth and name with different address appears in the past 30 days
<b>same_bdname_diff_phone_1</b>	Number of times this date of birth and name with different home phone number appears in the past 1 day
<b>same_bdname_diff_phone_3</b>	Number of times this date of birth and name with different home phone number appears in the past 3 days

<b>same_bdname_diff_phone_7</b>	Number of times this date of birth and name with different home phone number appears in the past 7 days
<b>same_bdname_diff_phone_14</b>	Number of times this date of birth and name with different home phone number appears in the past 14 days
<b>same_bdname_diff_phone_30</b>	Number of times this date of birth and name with different home phone number appears in the past 30 days
<b>same_bdname_diff_ssn_1</b>	Number of times this date of birth and name with different SSN appears in the past 1 day
<b>same_bdname_diff_ssn_3</b>	Number of times this date of birth and name with different SSN appears in the past 3 days
<b>same_bdname_diff_ssn_7</b>	Number of times this date of birth and name with different SSN appears in the past 7 days
<b>same_bdname_diff_ssn_14</b>	Number of times this date of birth and name with different SSN appears in the past 14 days
<b>same_bdname_diff_ssn_30</b>	Number of times this date of birth and name with different SSN appears in the past 30 days
<b>same_bdname_diff_zipname_1</b>	Number of times this date of birth and name with different zip code and name appears in the past 1 day
<b>same_bdname_diff_zipname_3</b>	Number of times this date of birth and name with different zip code and name appears in the past 3 days
<b>same_bdname_diff_zipname_7</b>	Number of times this date of birth and name with different zip code and name appears in the past 7 days
<b>same_bdname_diff_zipname_14</b>	Number of times this date of birth and name with different zip code and name appears in the past 14 days
<b>same_bdname_diff_zipname_30</b>	Number of times this date of birth and name with different zip code and name appears in the past 30 days
<b>same_zipname_1</b>	Number of times this zip code and name appears in the past 1 day
<b>same_zipname_3</b>	Number of times this zip code and name appears in the past 3 days
<b>same_zipname_7</b>	Number of times this zip code and name appears in the past 7 days
<b>same_zipname_14</b>	Number of times this zip code and name appears in the past 14 days
<b>same_zipname_30</b>	Number of times this zip code and name appears in the past 30 days
<b>same_zipname_diff_address_1</b>	Number of times this zip code and name with different address appears in the past 1 day
<b>same_zipname_diff_address_3</b>	Number of times this zip code and name with different address appears in the past 3 days
<b>same_zipname_diff_address_7</b>	Number of times this zip code and name with different address appears in the past 7 days
<b>same_zipname_diff_address_14</b>	Number of times this zip code and name with different address appears in the past 14 days
<b>same_zipname_diff_address_30</b>	Number of times this zip code and name with different address appears in the past 30 days
<b>same_zipname_diff_phone_1</b>	Number of times this zip code and name with different home phone number appears in the past 1 day
<b>same_zipname_diff_phone_3</b>	Number of times this zip code and name with different home phone number appears in the past 3 days
<b>same_zipname_diff_phone_7</b>	Number of times this zip code and name with different home phone number appears in the past 7 days
<b>same_zipname_diff_phone_14</b>	Number of times this zip code and name with different home phone number appears in the past 14 days

<b>same_zipname_diff_phone_30</b>	Number of times this zip code and name with different home phone number appears in the past 30 days
<b>same_zipname_diff_ssn_1</b>	Number of times this zip code and name with different SSN appears in the past 1 day
<b>same_zipname_diff_ssn_3</b>	Number of times this zip code and name with different SSN appears in the past 3 days
<b>same_zipname_diff_ssn_7</b>	Number of times this zip code and name with different SSN appears in the past 7 days
<b>same_zipname_diff_ssn_14</b>	Number of times this zip code and name with different SSN appears in the past 14 days
<b>same_zipname_diff_ssn_30</b>	Number of times this zip code and name with different SSN appears in the past 30 days
<b>same_zipname_diff_bdnname_1</b>	Number of times this zip code and name with different date of birth and name appears in the past 1 day
<b>same_zipname_diff_bdnname_3</b>	Number of times this zip code and name with different date of birth and name appears in the past 3 days
<b>same_zipname_diff_bdnname_7</b>	Number of times this zip code and name with different date of birth and name appears in the past 7 days
<b>same_zipname_diff_bdnname_14</b>	Number of times this zip code and name with different date of birth and name appears in the past 14 days
<b>same_zipname_diff_bdnname_30</b>	Number of times this zip code and name with different date of birth and name appears in the past 30 days

*Table 3. Table for All Expert Variables*