

# Exemplar\_Address missing data

April 2, 2025

## 1 Exemplar: Address missing data

### 1.1 Introduction

The datasets that data professionals use to solve problems typically contain missing values, which must be dealt with in order to achieve clean, useful data. This is particularly crucial in exploratory data analysis (EDA). In this activity, you will learn how to address missing data.

You are a financial data consultant, and an investor has tasked your team with identifying new business opportunities. To help them decide which future companies to invest in, you will provide a list of current businesses valued at more than \$1 billion. These are sometimes referred to as “unicorns.” Your client will use this information to learn about profitable businesses in general.

The investor has asked you to provide them with the following data: - Companies in the hardware industry based in Beijing, San Francisco, and London - Companies in the artificial intelligence industry based in London - A list of the top 20 countries sorted by sum of company valuations in each country, excluding United States, China, India, and United Kingdom - A global valuation map of all countries except United States, China, India, and United Kingdom

Your dataset includes a list of businesses and data points, such as the year they were founded; their industry; and their city, country, and continent.

### 1.2 Step 1: Imports

#### 1.2.1 Import libraries

Import the following relevant Python libraries: \* numpy \* pandas \* matplotlib.pyplot \* plotly.express \* seaborn

```
[1]: # Import libraries and modules

### YOUR CODE HERE ###

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import plotly.express as px
import seaborn as sns
```

### 1.2.2 Load the dataset

The dataset is currently in CSV format and in a file named `Unicorn_Companies.csv`. As shown in this cell, the dataset has been automatically loaded in for you. You do not need to download the .csv file, or provide more code, in order to access the dataset and proceed with this lab. Please continue with this activity by completing the following instructions.

```
[2]: # Read the data into a dataframe

### YOUR CODE HERE ###

df_companies = pd.read_csv('Unicorn_Companies.csv')
```

### 1.3 Step 2: Data exploration

Explore the dataset and answer questions that will guide your management of missing values.

#### 1.3.1 Display top rows

Display the first 10 rows of the data to understand how the dataset is structured.

```
[3]: # Display the first 10 rows of the data.

### YOUR CODE HERE ###

df_companies.head(10)
```

```
[3]:
```

	Company	Valuation	Date Joined	Industry \
0	Bytedance	\$180B	4/7/17	Artificial intelligence
1	SpaceX	\$100B	12/1/12	Other
2	SHEIN	\$100B	7/3/18	E-commerce & direct-to-consumer
3	Stripe	\$95B	1/23/14	Fintech
4	Klarna	\$46B	12/12/11	Fintech
5	Canva	\$40B	1/8/18	Internet software & services
6	Checkout.com	\$40B	5/2/19	Fintech
7	Instacart	\$39B	12/30/14	Supply chain, logistics, & delivery
8	JUUL Labs	\$38B	12/20/17	Consumer & retail
9	Databricks	\$38B	2/5/19	Data management & analytics

	City	Country/Region	Continent	Year Founded	Funding \
0	Beijing	China	Asia	2012	\$8B
1	Hawthorne	United States	North America	2002	\$7B
2	Shenzhen	China	Asia	2008	\$2B
3	San Francisco	United States	North America	2010	\$2B
4	Stockholm	Sweden	Europe	2005	\$4B
5	Surry Hills	Australia	Oceania	2012	\$572M

6	London	United Kingdom	Europe	2012	\$2B
7	San Francisco	United States	North America	2012	\$3B
8	San Francisco	United States	North America	2015	\$14B
9	San Francisco	United States	North America	2013	\$3B

#### Select Investors

0	Sequoia Capital China, SIG Asia Investments, S...
1	Founders Fund, Draper Fisher Jurvetson, Rothen...
2	Tiger Global Management, Sequoia Capital China...
3	Khosla Ventures, LowercaseCapital, capitalG
4	Institutional Venture Partners, Sequoia Capita...
5	Sequoia Capital China, Blackbird Ventures, Mat...
6	Tiger Global Management, Insight Partners, DST...
7	Khosla Ventures, Kleiner Perkins Caufield & By...
8	Tiger Global Management
9	Andreessen Horowitz, New Enterprise Associates...

Hint 1

Refer to the materials about exploratory data analysis in Python.

Hint 2

There is a function in the `pandas` library that allows you to get a specific number of rows from the top of a `DataFrame`.

Hint 3

Call the `head(10)` method on the dataframe.

### 1.3.2 Statistical properties of the dataset

Use methods and attributes of the dataframe to get information and descriptive statistics for the data, including its range, data types, mean values, and shape.

```
[4]: # Get the shape of the dataset.

    ### YOUR CODE HERE ###

df_companies.shape
```

```
[4]: (1074, 10)
```

Hint 1

Refer to the material about exploratory data analysis in Python.

Hint 2

Call the `shape` attribute of the dataframe.

**Question:** What is the shape of the dataset? - (1074, 10)

```
[5]: # Get the data types and number of non-null values in the dataset.
```

```
### YOUR CODE HERE ###
```

```
df_companies.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1074 entries, 0 to 1073
Data columns (total 10 columns):
#   Column                Non-Null Count  Dtype
---  -
0   Company               1074 non-null  object
1   Valuation             1074 non-null  object
2   Date Joined           1074 non-null  object
3   Industry              1074 non-null  object
4   City                  1058 non-null  object
5   Country/Region        1074 non-null  object
6   Continent             1074 non-null  object
7   Year Founded          1074 non-null  int64
8   Funding               1074 non-null  object
9   Select Investors      1073 non-null  object
dtypes: int64(1), object(9)
memory usage: 84.0+ KB
```

Hint 1

Refer to the material about exploratory data analysis in Python.

Hint 2

Use the `info()` method.

**Question: What are the data types of various columns?** - Except for the Year Funded column, which is `int64`, the data type for all other columns is `object`. You can get this information using the `info()` method.

**Question: How many columns contain null values?** - Columns `City` and `Select Investors` contain fewer non-null values than the total number of rows in the dataset, which indicates that they are missing values. You can get this information using the `info()` method.

```
[6]: # Get descriptive statistics such as mean, standard deviation, and range of the
      ↪ numerical columns in the dataset.
```

```
### YOUR CODE HERE ###
```

```
df_companies.describe()
```

```
[6]:      Year Founded
count    1074.000000
mean     2012.895717
```

std	5.698573
min	1919.000000
25%	2011.000000
50%	2014.000000
75%	2016.000000
max	2021.000000

Hint 1

Refer to the material about exploratory data analysis in Python.

Hint 2

There is a function in the **pandas** library that allows you to find descriptive statistics for the numeric columns in a DataFrame.

Hint 3

Call the `describe()` method on the dataframe.

**Question: In what year was the oldest company founded?** - The oldest company in the list was founded in 1919. This is the minimum value in **Year Founded**. You can get this information using the `describe()` method.

### 1.3.3 Data Preprocessing

In order to answer the investor's questions, some data preprocessing steps are required. The first step is to add a new column to the dataframe containing just the year each company became a unicorn company. Call this new column **Year Joined**.

```
[7]: # Create a new column `Year Joined`

### YOUR CODE HERE ###

df_companies['Year_Joined'] = pd.to_datetime(df_companies['Date Joined']).dt.
    ↳year
```

For each country, you want to calculate the sum of all valuations of companies from that country. However, in order to do this, you'll need to first prepare the data. Currently, the data in the **Valuation** column is a string that starts with a \$ and ends with a B. Because this column is not in a numeric datatype, pandas cannot perform mathematical operations on its values. The data in this column needs to be converted to a numeric datatype.

In this step, define a function called `str_to_num()` that accepts as an argument:

- **x**: a string in the format of the values contained in the **Valuation** column

And returns:

- **x**: an `int` of the number represented by the input string

Example:

```
[IN]: str_to_num('$4B')
[OUT]: 4
```

To do this, use the string `strip()` method. This method is applied to a string. Its argument is a string that contains all the characters that you want to remove from the beginning and end of a given string—in any order. The specified characters will be removed until a valid character is encountered. This process is applied moving forward from the beginning of the string and also moving in reverse from the end of the string, thus removing unwanted beginning and trailing characters.

Example:

```
[IN]: my_string = '#..... Section 3.2.1 Issue #32 ..... '
      my_string = my_string.strip('.#! ')
      print(my_string)
```

```
[OUT]: 'Section 3.2.1 Issue #32'
```

Note that you must reassign the result back to a variable or else the change will not be permanent.

```
[8]: # Define the `str_to_num()` function

    ### YOUR CODE HERE ###
    def str_to_num(x):
        x = x.strip('$B')
        x = int(x)

        return x
```

Hint 1

The unwanted characters in the values contained in the `Valuation` column are '\$' and 'B'.

Hint 2

Pass a string of the unwanted values as an argument to the `strip()` string method.

Hint 3

The final step before returning `x` should be converting it to an integer.

Now, use this function to create a new column called `valuation_num` that represents the `Valuation` column as an integer value. To do this, use the series method `apply()` to apply the `str_to_num()` function to the `Valuation` column.

`apply()` is a method that can be used on a `DataFrame` or `Series` object. In this case, you're using it on the `Valuation` series. The method accepts a function as an argument and applies that function to each value in the series.

Example:

```
[IN]: def square(x):
      return x ** 2
```

```

my_series = pd.Series([0, 1, 2, 3])
my_series

[OUT]: 0    0
       1    1
       2    2
       3    3
       dtype: int64

[IN]: my_series = my_series.apply(square)
my_series

[OUT]: 0    0
       1    1
       2    4
       3    9
       dtype: int64

```

Notice that the function passed as an argument to the `apply()` method does not have parentheses. It's just the function name.

```

[9]: # Apply the `str_to_num()` function to the `Valuation` column
     # and assign the result back to a new column called `valuation_num`

     ### YOUR CODE HERE ###
df_companies['valuation_num'] = df_companies['Valuation'].apply(str_to_num)
df_companies[['Valuation', 'valuation_num']].head()

```

```

[9]:  Valuation  valuation_num
0      $180B           180
1      $100B           100
2      $100B           100
3       $95B            95
4       $46B            46

```

### 1.3.4 Find missing values

The unicorn companies dataset is fairly clean, with few missing values.

```

[10]: # Find the number of missing values in each column in this dataset.

      ### YOUR CODE HERE ###

df_companies.isna().sum()

```

```
[10]: Company          0
      Valuation        0
      Date_Joined      0
      Industry         0
      City             16
      Country/Region    0
      Continent         0
      Year_Founded      0
      Funding           0
      Select_Investors   1
      Year_Joined        0
      valuation_num      0
      dtype: int64
```

Hint 1

The `isna()` `DataFrame` method will return a dataframe of Boolean values in the same shape as your original dataframe. Values are `True` if the data is missing and `False` if it is not missing.

Hint 2

You'll need to convert Boolean values into numerical values. Remember that `True` values are considered 1 and `False` values are considered 0.

Hint 3

After applying the `isna()` method to the `df_companies` dataframe, apply the `sum()` method to the results to return a pandas `Series` object with each column name and the number of `NaN` values it contains.

**Question: How many missing values are in each column in the dataset?** - There is a single missing value in the `Select Investors` column and 16 missing cities. There are no missing values in other columns.

### 1.3.5 Review rows with missing values

Before dealing with missing values, it's important to understand the nature of the missing value that is being filled. Display all rows with missing values from `df_companies`. To do this, perform the following three steps:

1. Apply the `isna()` method to the `df_companies` dataframe as you did in the last step. Remember, this results in a dataframe of the same shape as `df_companies` where each value is `True` if its contents are `NaN` and a `False` if its contents are not `NaN`. Assign the results to a variable called `mask`.

```
[11]: # 1. Apply the `isna()` method to the `df_companies` dataframe and assign back
      ↪to `mask`
      mask = df_companies.isna()
      mask.tail()
```



```
[11]:
```

	Company	Valuation	Date Joined	Industry	City	Country/Region	\
1069	False	False	False	False	False	False	
1070	False	False	False	False	False	False	
1071	False	False	False	False	False	False	
1072	False	False	False	False	False	False	
1073	False	False	False	False	False	False	

	Continent	Year Founded	Funding	Select Investors	Year_Joined	\
1069	False	False	False	False	False	
1070	False	False	False	False	False	
1071	False	False	False	False	False	
1072	False	False	False	False	False	
1073	False	False	False	False	False	

	valuation_num
1069	False
1070	False
1071	False
1072	False
1073	False

You're not done yet. You still need to go from this dataframe of Boolean values to a dataframe of just the rows of `df_companies` that contain at least one `NaN` value. This means that you need a way to find the indices of the rows of the Boolean dataframe that contain at least one `True` value, then extract those indices from `df_companies`.

You can do this using the `any()` method for `DataFrame` objects. This method returns a `Boolean Series` indicating whether any value is `True` over a specified axis.

Example:

```
df =
```

	A	B	C
0	0	a	10
1	False	0	1
2	NaN	NaN	NaN

```
[IN]: df.any(axis=0)
```

```
[OUT]: A    False
       B     True
       C     True
       dtype: bool
```

```
[IN]: df.any(axis=1)
```

```
[OUT]: 0     True
```

```
1    True
2    False
dtype: bool
```

Note that 0, False, and NaN are considered False and anything else is considered True.

2. Apply the `any()` method to the Boolean dataframe you created to make a Boolean series where each element in the series represents True if a row of the dataframe contains any True values and False if any row in the dataframe contains any False values. Assign the results back to `mask`.

```
[12]: # 2. Apply the `any()` method to `mask` and assign the results back to `mask`

#### YOUR CODE HERE ####

mask = mask.any(axis=1)
mask.head()
```

```
[12]: 0    False
1    False
2    False
3    False
4    False
dtype: bool
```

Hint 1

Refer to the example given for how to use the `any()` method for dataframes.

Hint 2

Using the provided example as a guide, which axis returns **rows** that have at least one True value?

Hint 3

`mask.any(axis=1)` will return a Boolean series that represents whether each row of `mask` contains at least one True value.

3. Because `mask` is now a series of Boolean values, you can use it as a Boolean mask. Apply the Boolean mask to the `df_companies` dataframe to return a filtered dataframe containing just the rows that contain a missing value. Assign the results to a variable called `df_missing_rows`.

```
[13]: # 3. Apply `mask` as a Boolean mask to `df_companies` and assign results to
      ↪ `df_missing_rows`

#### YOUR CODE HERE ####

df_missing_rows = df_companies[mask]
df_missing_rows
```

```
[13]:
```

	Company	Valuation	Date Joined	\
12	FTX	\$32B	7/20/21	

170		HyalRoute	\$4B	5/26/20
242		Moglix	\$3B	5/17/21
251		Trax	\$3B	7/22/19
325		Amber Group	\$3B	6/21/21
382		Ninja Van	\$2B	9/27/21
541	Advance Intelligence Group		\$2B	9/23/21
629		LinkSure Network	\$1B	1/1/15
811		Carousell	\$1B	9/15/21
848		Matrixport	\$1B	6/1/21
880		bolttech	\$1B	7/1/21
889		Carro	\$1B	6/14/21
893		Cider	\$1B	9/2/21
980		NIUM	\$1B	7/13/21
986		ONE	\$1B	12/8/21
994		PatSnap	\$1B	3/16/21
1061		WeLab	\$1B	11/8/17

		Industry	City	Country/Region \
12		Fintech	NaN	Bahamas
170		Mobile & telecommunications	NaN	Singapore
242		E-commerce & direct-to-consumer	NaN	Singapore
251		Artificial intelligence	NaN	Singapore
325		Fintech	NaN	Hong Kong
382	Supply chain, logistics, & delivery		NaN	Singapore
541		Artificial intelligence	NaN	Singapore
629		Mobile & telecommunications	Shanghai	China
811		E-commerce & direct-to-consumer	NaN	Singapore
848		Fintech	NaN	Singapore
880		Fintech	NaN	Singapore
889		E-commerce & direct-to-consumer	NaN	Singapore
893		E-commerce & direct-to-consumer	NaN	Hong Kong
980		Fintech	NaN	Singapore
986		Internet software & services	NaN	Singapore
994		Internet software & services	NaN	Singapore
1061		Fintech	NaN	Hong Kong

	Continent	Year Founded	Funding \
12	North America	2018	\$2B
170	Asia	2015	\$263M
242	Asia	2015	\$471M
251	Asia	2010	\$1B
325	Asia	2015	\$328M
382	Asia	2014	\$975M
541	Asia	2016	\$536M
629	Asia	2013	\$52M
811	Asia	2012	\$288M
848	Asia	2019	\$100M

880	Asia	2018	\$210M
889	Asia	2015	\$595M
893	Asia	2020	\$140M
980	Asia	2014	\$285M
986	Asia	2011	\$515M
994	Asia	2007	\$352M
1061	Asia	2013	\$871M

	Select Investors	Year_Joined \
12	Sequoia Capital, Thoma Bravo, Softbank	2021
170	Kuang-Chi	2020
242	Jungle Ventures, Accel, Venture Highway	2021
251	Hopu Investment Management, Boyu Capital, DC T...	2019
325	Tiger Global Management, Tiger Brokers, DCM Ve...	2021
382	B Capital Group, Monk's Hill Ventures, Dynamic...	2021
541	Vision Plus Capital, GSR Ventures, ZhenFund	2021
629	NaN	2015
811	500 Global, Rakuten Ventures, Golden Gate Vent...	2021
848	Dragonfly Captial, Qiming Venture Partners, DS...	2021
880	Mundi Ventures, Doqling Capital Partners, Acti...	2021
889	SingTel Innov8, Alpha JWC Ventures, Golden Gat...	2021
893	Andreessen Horowitz, DST Global, IDG Capital	2021
980	Vertex Ventures SE Asia, Global Founders Capit...	2021
986	Temasek, Guggenheim Investments, Qatar Investm...	2021
994	Sequoia Capital China, Shunwei Capital Partner...	2021
1061	Sequoia Capital China, ING, Alibaba Entreprene...	2017

	valuation_num
12	32
170	4
242	3
251	3
325	3
382	2
541	2
629	1
811	1
848	1
880	1
889	1
893	1
980	1
986	1
994	1
1061	1

Question: Is there a specific country/region that shows up a lot in this missing values

**dataframe? Which one?** - Twelve of the 17 rows with missing values are for companies from Singapore.

**Question: What steps did you take to find missing data?** - `DataFrame.isna()` will return a Boolean dataframe indicating every location that is NaN with `True` - You can use `sum()` in conjunction with `isna()` to get the counts of NaN values in each column. - You can use `any()` in conjunction with `isna()` to create a Boolean mask, which can be applied to the original dataframe to obtain just the rows with at least one NaN value.

**Question: What observations can be made about the forms and context of missing data?** - Missing values can take different forms and are usually context-specific. Not every missing value is labeled as `na` or `None`, or `Null`.

**Question: What other methods could you use to address missing data?** - If possible, ask the business users for insight into the causes of missing values and, if possible, get domain knowledge to intelligently impute these values.

## 1.4 Step 3: Model building

Think of the model you are building as the completed dataset, which you will then use to inform the questions the investor has asked of you.

### 1.4.1 Two ways to address missing values

There are several ways to address missing values, which is critical in EDA. The two primary methods are removing them and imputing other values in their place. Choosing the proper method depends on the business problem and the value the solution will add or take away from the dataset.

Here, you will try both.

To compare the the effect of different actions, first store the original number of values in a variable. Create a variable called `count_total` that is an integer representing the total number of values in `df_companies`. For example, if the dataframe had 5 rows and 2 columns, then this number would be 10.

```
[14]: # Store the total number of values in a variable called `count_total`  
  
      ### YOUR CODE HERE ###  
  
      count_total = df_companies.size  
      count_total
```

[14]: 12888

Now, remove all rows containing missing values and store the total number of remaining values in a variable called `count_dropna_rows`.

```
[15]: # Drop the rows containing missing values, determine number of remaining values
```

```
### YOUR CODE HERE ###

count_dropna_rows = df_companies.dropna().size
count_dropna_rows
```

[15]: 12684

Hint

Use the `dropna()` dataframe method to drop rows with missing values.

Now, remove all columns containing missing values and store the total number of cells in a variable called `count_dropna_columns`.

```
[16]: # Drop the columns containing missing values, determine number of remaining
      ↪ values

      ### YOUR CODE HERE ###

count_dropna_columns = df_companies.dropna(axis=1).size
count_dropna_columns
```

[16]: 10740

Hint

Specify `axis=1` to the `dropna()` method to drop columns with missing values.

Next, print the percentage of values removed by each method and compare them.

```
[17]: # Print the percentage of values removed by dropping rows.

      ### YOUR CODE HERE ###

row_percent = ((count_total - count_dropna_rows) / count_total) * 100
print(f'Percentage removed, rows: {row_percent:.3f}')

# Print the percentage of values removed by dropping columns.

      ### YOUR CODE HERE ###

col_percent = ((count_total - count_dropna_columns) / count_total) * 100
print(f'Percentage removed, columns: {col_percent:.3f}')
```

Percentage removed, rows: 1.583

Percentage removed, columns: 16.667

**Question: Which method was most effective? Why?**

The percentage removed was significantly higher for columns than it was for rows. Since both approaches result in a dataset with no missing values, the “most effective” method depends on how

much data you have and what you want to do with it. It might be best to use the way that leaves the most data intact—in this case, dropping rows. Or, if you don't have many samples and don't want to lose any, but you don't need all your columns, then dropping columns might be best. With this data, it would probably be best to drop rows in the majority of cases.

Now, practice the second method: imputation. Perform the following steps:

1. Use the `fillna()` dataframe method to fill each missing value with the next non-`NaN` value in its column. Assign the results to a new dataframe called `df_companies_backfill`.

Example:

```
df =
```

	A	B	C
0	5	a	NaN
1	10	NaN	False
2	NaN	c	True

```
[IN]: df.fillna(method='backfill')
```

```
[OUT]:
```

	A	B	C
0	5	a	False
1	10	c	False
2	NaN	c	True

Notice that if there is a `NaN` value in the last row, it will not backfill because there is no subsequent value in the column to refer to.

2. Show the rows that previously had missing values.

```
[18]: # 1. Fill missing values using the 'fillna()' method, back-filling
```

```
### YOUR CODE HERE ###
```

```
df_companies_backfill = df_companies.fillna(method='backfill')
```

```
# 2. Show the rows that previously had missing values
```

```
### YOUR CODE HERE ###
```

```
df_companies_backfill.iloc[df_missing_rows.index, :]
```

```
[18]:
```

	Company	Valuation	Date Joined	\
12	FTX	\$32B	7/20/21	
170	HyalRoute	\$4B	5/26/20	
242	Moglix	\$3B	5/17/21	
251	Trax	\$3B	7/22/19	
325	Amber Group	\$3B	6/21/21	
382	Ninja Van	\$2B	9/27/21	

541	Advance Intelligence Group	\$2B	9/23/21
629	LinkSure Network	\$1B	1/1/15
811	Carousell	\$1B	9/15/21
848	Matrixport	\$1B	6/1/21
880	bolttech	\$1B	7/1/21
889	Carro	\$1B	6/14/21
893	Cider	\$1B	9/2/21
980	NIUM	\$1B	7/13/21
986	ONE	\$1B	12/8/21
994	PatSnap	\$1B	3/16/21
1061	WeLab	\$1B	11/8/17

	Industry	City	Country/Region \
12	Fintech	Jacksonville	Bahamas
170	Mobile & telecommunications	El Segundo	Singapore
242	E-commerce & direct-to-consumer	San Francisco	Singapore
251	Artificial intelligence	Amsterdam	Singapore
325	Fintech	San Francisco	Hong Kong
382	Supply chain, logistics, & delivery	San Francisco	Singapore
541	Artificial intelligence	Helsinki	Singapore
629	Mobile & telecommunications	Shanghai	China
811	E-commerce & direct-to-consumer	New York	Singapore
848	Fintech	San Francisco	Singapore
880	Fintech	Englewood	Singapore
889	E-commerce & direct-to-consumer	Lincoln	Singapore
893	E-commerce & direct-to-consumer	Mexico City	Hong Kong
980	Fintech	Bengaluru	Singapore
986	Internet software & services	New York	Singapore
994	Internet software & services	London	Singapore
1061	Fintech	Beijing	Hong Kong

	Continent	Year Founded	Funding \
12	North America	2018	\$2B
170	Asia	2015	\$263M
242	Asia	2015	\$471M
251	Asia	2010	\$1B
325	Asia	2015	\$328M
382	Asia	2014	\$975M
541	Asia	2016	\$536M
629	Asia	2013	\$52M
811	Asia	2012	\$288M
848	Asia	2019	\$100M
880	Asia	2018	\$210M
889	Asia	2015	\$595M
893	Asia	2020	\$140M
980	Asia	2014	\$285M
986	Asia	2011	\$515M



994	Asia	2007	\$352M
1061	Asia	2013	\$871M

	Select Investors	Year_Joined \
12	Sequoia Capital, Thoma Bravo, Softbank	2021
170	Kuang-Chi	2020
242	Jungle Ventures, Accel, Venture Highway	2021
251	Hopu Investment Management, Boyu Capital, DC T...	2019
325	Tiger Global Management, Tiger Brokers, DCM Ve...	2021
382	B Capital Group, Monk's Hill Ventures, Dynamic...	2021
541	Vision Plus Capital, GSR Ventures, ZhenFund	2021
629	Sequoia Capital India, The Times Group, GMO Ve...	2015
811	500 Global, Rakuten Ventures, Golden Gate Vent...	2021
848	Dragonfly Captial, Qiming Venture Partners, DS...	2021
880	Mundi Ventures, Doqling Capital Partners, Acti...	2021
889	SingTel Innov8, Alpha JWC Ventures, Golden Gat...	2021
893	Andreessen Horowitz, DST Global, IDG Capital	2021
980	Vertex Ventures SE Asia, Global Founders Capit...	2021
986	Temasek, Guggenheim Investments, Qatar Investm...	2021
994	Sequoia Capital China, Shunwei Capital Partner...	2021
1061	Sequoia Capital China, ING, Alibaba Entreprene...	2017

	valuation_num
12	32
170	4
242	3
251	3
325	3
382	2
541	2
629	1
811	1
848	1
880	1
889	1
893	1
980	1
986	1
994	1
1061	1

Hint 1

To backfill missing values, refer to the example provided.

Hint 2

To show the rows that previously had missing values, you'll need the indices of the rows that had missing values.

### Hint 3

- You already have a dataframe of rows with missing values. It's stored in a variable called `df_missing_rows`.
- To access its index, call `df_missing_rows.index`. This will give you the row numbers of rows with missing values.
- Use these index numbers in an `iloc[]` selection statement on the `df_companies_backfill` dataframe to extract those row numbers.

**Question: Do the values that were used to fill in for the missing values make sense?** - No, the values seem to be added without consideration of the country those cities are located in.

Another option is to fill the values with a certain value, such as 'Unknown'. However, doing so doesn't add any value to the dataset and could make finding the missing values difficult in the future. Reviewing the missing values in this dataset determines that it is fine to leave the values as they are. This also avoids adding bias to the dataset.

## 1.5 Step 4: Results and evaluation

Now that you've addressed your missing values, provide your investor with their requested data points.

### 1.5.1 Companies in the Hardware Industry

Your investor is interested in identifying unicorn companies in the **Hardware** industry in the following cities: **Beijing**, **San Francisco**, and **London**. They are also interested in companies in the **Artificial intelligence** industry in **London**.

Write a selection statement that extracts the rows that meet these criteria. This task requires complex conditional logic. Break the process into the following parts.

1. Create a mask to apply to the `df_companies` dataframe. The following logic is a pseudo-code representation of how this mask could be structured.

```
((Industry==Hardware) and (City==Beijing, San Francisco, or London))  
OR  
((Industry==Artificial intelligence) and (City==London))
```

You're familiar with how to create Boolean masks based on conditional logic in pandas. However, you might not know how to write a conditional statement that selects rows that have *any one of several possible values* in a given column. In this case, this is the `(City==Beijing, San Francisco, or London)` part of the expression.

For this type of construction, use the `isin()` **Series** method. This method is applied to a pandas series and, for each value in the series, checks whether it is a member of whatever is passed as its argument.

Example:

```
[IN]: my_series = pd.Series([0, 1, 2, 3])
      my_series
```

```
[OUT]: 0    0
        1    1
        2    2
        3    3
        dtype: int64
```

```
[IN]: my_series.isin([1, 2])
```

```
[OUT]: 0    False
        1     True
        2     True
        3    False
        dtype: bool
```

2. Apply the mask to the `df_companies` dataframe and assign the result to a new variable called `df_invest`.

```
[19]: # 1. Create a Boolean mask using conditional logic

      ### YOUR CODE HERE ###

      cities = ['Beijing', 'San Francisco', 'London']
      mask = (
          (df_companies['Industry']=='Hardware') & (df_companies['City'].isin(cities))
      ) | (
          (df_companies['Industry']=='Artificial intelligence') &
          (df_companies['City']=='London')
      )

      # 2. Apply the mask to the `df_companies` dataframe and assign the results to
      ↪ `df_invest`

      ### YOUR CODE HERE ###
      df_invest = df_companies[mask]
      df_invest
```

```
[19]:
```

	Company	Valuation	Date Joined	Industry \
36	Bitmain	\$12B	7/6/18	Hardware
43	Global Switch	\$11B	12/22/16	Hardware
147	Chipone	\$5B	12/16/21	Hardware
845	Density	\$1B	11/10/21	Hardware
873	BenevolentAI	\$1B	6/2/15	Artificial intelligence
923	Geek+	\$1B	11/21/18	Hardware
1040	TERMINUS Technology	\$1B	10/25/18	Hardware

1046	Tractable	\$1B	6/16/21	Artificial intelligence
------	-----------	------	---------	-------------------------

	City	Country/Region	Continent	Year Founded	Funding \
36	Beijing	China	Asia	2015	\$765M
43	London	United Kingdom	Europe	1998	\$5B
147	Beijing	China	Asia	2008	\$1B
845	San Francisco	United States	North America	2014	\$217M
873	London	United Kingdom	Europe	2013	\$292M
923	Beijing	China	Asia	2015	\$439M
1040	Beijing	China	Asia	2015	\$623M
1046	London	United Kingdom	Europe	2014	\$120M

	Select Investors	Year_Joined \
36	Coatue Management, Sequoia Capital China, IDG ...	2018
43	Aviation Industry Corporation of China, Essenc...	2016
147	China Grand Prosperity Investment, Silk Road H...	2021
845	Founders Fund, Upfront Ventures, 01 Advisors	2021
873	Woodford Investment Management	2015
923	Volcanics Ventures, Vertex Ventures China, War...	2018
1040	China Everbright Limited, IDG Capital, iFLYTEK	2018
1046	Insight Partners, Ignition Partners, Georgian ...	2021

	valuation_num
36	12
43	11
147	5
845	1
873	1
923	1
1040	1
1046	1

Hint 1

- Remember that pandas uses & for “and”, | for “or”, and ~ for “not”.
  - Remember that each condition needs to be in its own set of parentheses. Refer to the above pseudo-code for an example.

Hint 2

- Use (Series.isin(list\_of\_cities)) to represent the logic: (City==Beijing, San Francisco, or London)’.
  - There are two sets of conditional pairs: ((A) and (B)) or ((C) and (D)). Make sure the parentheses reflect this logic.

Hint 3

Consider using the following code:

```
cities = ['Beijing', 'San Francisco', 'London']    mask = (
```

```
(df_companies['Industry']=='Hardware') & (df_companies['City'].isin(cities))
) | (
(df_companies['Industry']=='Artificial intelligence') &
(df_companies['City']=='London')
)
df_invest = df_companies[mask]
```

**Question:** How many companies meet the criteria given by the investor? - Eight companies meet the stated criteria.

### 1.5.2 List of countries by sum of valuation

For each country, sum the valuations of all companies in that country, then sort the results in descending order by summed valuation. Assign the results to a variable called `national_valuations`.

```
[20]: # Group the data by `Country/Region`

### YOUR CODE HERE ###

national_valuations = df_companies.groupby(['Country/Region'])['valuation_num'].
    ↪sum(
).sort_values(ascending=False).reset_index()

# Print the top 15 values of the DataFrame.

### YOUR CODE HERE ###

national_valuations.head(15)
```

```
[20]:
```

	Country/Region	valuation_num
0	United States	1933
1	China	696
2	India	196
3	United Kingdom	195
4	Germany	72
5	Sweden	63
6	Australia	56
7	France	55
8	Canada	49
9	South Korea	41
10	Israel	39
11	Brazil	37
12	Bahamas	32
13	Indonesia	28
14	Singapore	21

Hint

Use a `groupby()` statement to group by `Country/Region`, then isolate the `valuation_num` column, sum it, and use the `sort_values()` method to sort the results.

**Question:** Which countries have the highest sum of valuation?

The sorted data indicates that the four countries with highest total company valuations are the United States, China, India, and the United Kingdom. However, your investor specified that these countries should not be included in the list because they are outliers.

### 1.5.3 Filter out top 4 outlying countries

Use this grouped and summed data to plot a barplot. However, to meet the needs of your stakeholder, you must first remove the United States, China, India, and the United Kingdom. Remove these countries from `national_valuations` and reassign the results to a variable called `national_valuations_no_big4`.

```
[21]: # Remove outlying countries

#### YOUR CODE HERE ####

national_valuations_no_big4 = national_valuations.iloc[4:, :]

national_valuations_no_big4.head()
```

```
[21]: Country/Region  valuation_num
4      Germany      72
5      Sweden      63
6      Australia    56
7      France      55
8      Canada      49
```

Hint

There are a number of ways to accomplish this task. One of the easiest ways is to use a simple `iloc[]` selection statement to select row indices 4–end and all columns of `national_valuations`.

### 1.5.4 BONUS CONTENT: Alternative approach (optional)

You can also use `isin()` to create a Boolean mask to filter out specific values of the `Country/Region` column. In this case, this process is longer and more complicated than simply using the `iloc[]` statement. However, there will be situations where this is the most direct approach.

How could you use `isin()` and your knowledge of pandas conditional operators and Boolean masks to accomplish the same task?

```
[22]: # (Optional) Use `isin()` to create a Boolean mask to accomplish the same task

#### YOUR CODE HERE ####

mask = ~national_valuations['Country/Region'].isin(['United States', 'China', 'India', 'United Kingdom'])
national_valuations_no_big4 = national_valuations[mask]
national_valuations_no_big4.head()
```

```
[22]: Country/Region  valuation_num
      4      Germany           72
      5      Sweden           63
      6    Australia           56
      7      France           55
      8      Canada           49
```

Answer

In this case, there are 46 total countries and you want to keep countries 5–46 and filter out countries 1–4. To use `isin()` would require you to list out 42 countries:

```
mask = national_valuations['Country/Region'].isin(['country_5', 'country_6', ... 'country_46'])
```

This is very impractical. However, you can invert the statement to simplify the job. The above impractical statement becomes:

```
mask = ~national_valuations['Country/Region'].isin(['country_1', 'country_2', 'country_3', 'country_4'])
```

Notice the `~` that precedes the whole statement. This transforms the meaning from “country is in this list” to “country is NOT in this list.”

Then, simply apply the mask to `national_valuations` and assign the result back to `national_valuations_no_big4`.

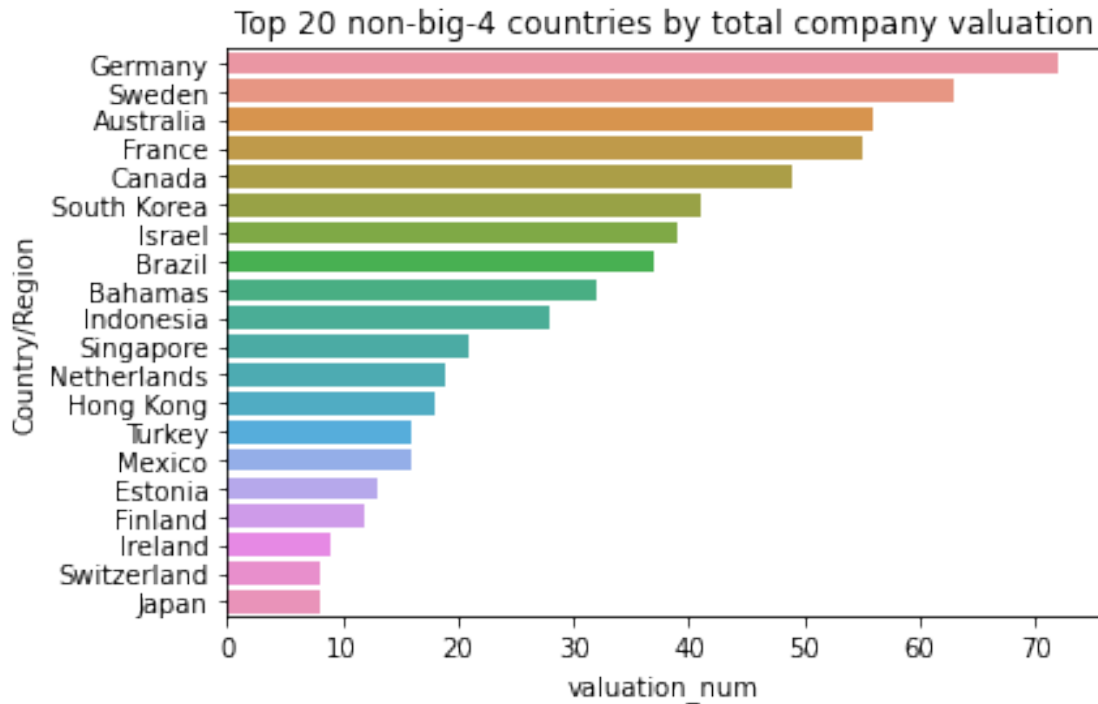
### 1.5.5 Create barplot for top 20 non-big-4 countries

Now, the data is ready to reveal the top 20 non-big-4 countries with the highest total company valuations. Use seaborn’s `barplot()` function to create a plot showing national valuation on one axis and country on the other.

```
[23]: # Create a barplot to compare the top 20 non-big-4 countries with highest
      ↪ company valuations

      ### YOUR CODE HERE ###

      sns.barplot(data=national_valuations_no_big4.head(20),
                  y='Country/Region',
                  x='valuation_num')
      plt.title('Top 20 non-big-4 countries by total company valuation')
      plt.show();
```



Hint 1

Select the top 20 rows in `national_valuations_no_big4`.

Hint 2

- Select the top 20 rows in `df_companies_sum_outliers_removed` by using the `head(20)` method.
- Specify `Country/Region` for the `x` parameter of the function and `valuation_num` for the `y` parameter of the function (or vice versa).

### 1.5.6 Plot maps

Your investor has also asked for a global valuation map of all countries except **United States**, **China**, **India**, and **United Kingdom** (a.k.a. “big-four countries”).

You have learned about using `scatter_geo()` from the `plotly.express` library to create plot data on a map. Create a `scatter_geo()` plot that depicts the total valuations of each non-big-four country on a world map, where each valuation is shown as a circle on the map, and the size of the circle is proportional to that country’s summed valuation.

**NOTE:** The output of the following code is a dynamic plot that requires you to run the code to display it. To do this, go to the Cell menu at the top of the page and select Run All.

```
[24]: # Plot the sum of valuations per country.
```



```
data = national_valuations_no_big4

px.scatter_geo(data,
               locations='Country/Region',
               size='valuation_num',
               locationmode='country names',
               color='Country/Region',
               title='Total company valuations by country (non-big-four)')
```

Hint 1

Use the `national_valuations_no_big4` dataframe that you already created.

Hint 2

To plot the data: \* Use `national_valuations_no_big4` as the `data_frame` argument of the `scatter_geo()` function. \* Use `'Country/Region'` as the `locations` argument. \* Use `'country names'` as the `locationmode` argument. \* Use `'Country/Region'` as the `color` argument.

Don't forget to include a title!

**Question: How is the valuation sum per country visualized in the plot?** - Valuation sum per country is visualized by the size of circles around the map.

**Question: Does any region stand out as having a lot of activity?** - Europe has a lot of unicorn companies in a concentrated area.

## 1.6 Conclusion

**What are some key takeaways that you learned during this lab?** \* Missing data is a common problem for data professionals anytime they work with a data sample. \* Addressing missing values is a part of the data-cleaning process and an important step in EDA. \* Address missing values by either removing them or filling them in. \* When considering how to address missing values, keep in mind the business, the data, and the questions to be answered. Always ensure you are not introducing bias into the dataset. \* Addressing the missing values enabled you to answer your investor's questions.

**How would you present your findings from this lab to others? Consider the information you would provide (and what you would omit), how you would share the various data insights, and how data visualizations could help your presentation.** \* For the industry specific companies in certain locations, you could provide a short list of company names and locations. \* For the top 20 countries by sum of valuations, you could use the plot you created in this lab or share a list. - For the top 20 countries sorted by sum of company valuations in each country, you would exclude United States, China, India, and United Kingdom. \* For the questions concerning the valuation map, in addition to your visuals, you would provide a short summary of the data points. This is because the investor did not request a further breakdown of this data.

## Reference

Bhat, M.A. *Unicorn Companies*

**Congratulations!** You've completed this lab. However, you may not notice a green check mark next to this item on Coursera's platform. Please continue your progress regardless of the check mark. Just click on the "save" icon at the top of this notebook to ensure your work has been logged.