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Woman Inventors in the US Patent System an Exploration Analysis and Literature Review – A Pilot Study

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November 30, 2022

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Abstract

In this pilot study, we explore patents for two fields: civil engineering and pharmaceuticals fields. These two fields were chosen based on their participation rate for women on patents. Civil engineering patents have a very low percentage of female patent inventors, whereas pharmaceutical patents have a higher percentage.
In this report, we cover the following topics for Civil Engineering and Pharmaceutical Patents
1. Inventor Locations– slides 5-30.
2. Patent inventor collaborations and gender composition– slides 31-40.
3. Comparing Name Gendering Techniques – slides 41-60.
4. Literature Review – policy ideas –slides 61- 79.
5. References - slides 80-83.
6. GitHub (code, data, literature, report) - https://github.com/uva-bisdad/us_patents_case_study/upload/main/01_documents/Literature (slide 84)

About the University of Virginia's Social and Decision Analytics Division

The **Social and Decision Analytics Division (SDAD)** is a leading Division in the Biocomplexity Institute at the University of Virginia. The Biocomplexity Institute is at the forefront of a scientific evolution, applying a deeply contextual approach to answering some of the most pressing challenges to human health and well-being within our changing environment. SDAD was created in the fall of 2013 to extend the Biocomplexity Institute's capabilities in social informatics, policy analytics, and program evaluation. The researchers at SDAD form a multidisciplinary team, with expertise in statistics, policy and program evaluation, economics, political science, psychology, computational social science, and data governance and information architecture. SDAD's mission is to embrace today's data revolution, developing evidence-based research and quantitative methods to inform policy decision-making and evaluation.

Women Inventors in the US Patent System An Exploratory Analysis and Literature Review - A Pilot Study

November 30, 2022

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BIOCOMPLEXITY INSTITUTE

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- Olivia Davis, 2nd-year student, SDAD intern, Biocomplexity Institute, University of Virginia

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- GitHub- uva-bi-sdad/us_patents_case_study https://github.com/uva-bi-sdad/us_patents_case_study/upload/main/01_documents/Literature

Agenda

Women Inventors in the US Patent System

- Explore patents for two fields: civil engineering and pharmaceuticals fields
- These two fields were chosen based on their participation rate for women on patents. Civil engineering patents have a very low percentage of female patent inventors, whereas pharmaceutical patents have a higher percentage.

Presentation order and references

Data Source Used

- PatentsView 1976 - 2021 (downloaded on August 17th, 2021)
    - We use the USPTO male_flag values for gender assignment, 1 for male and 0 for non male.
      Source: Yang et al 2022
    - This procedure implements a binary gender system to remain consistent with most existing gender
      studies in science (Pinho et al. 2020, Hahn & Bentley 2003), which is not designed to address the important issue
      of nonbinary gender distinctions in the data.

1. Inventor Locations

Civil Engineering & Pharmaceuticals

Explore patent inventor locations by gender for the Civil Engineering & pharmaceuticals fields

- If an inventor moved locations in a given year, that inventor is counted in all locations. For example, if an inventor lived in Boston and New York in the same year, the inventor would be represented in the count of inventors in Boston and in New York.
- **Data Download:** To download the data that we used to create these visualization (XLSX format) - https://uva-bi-sdad.github.io/uspto_gender_analysis/
- Source code: https://github.com/uva-bi-sdad/uspto_gender_analysis/tree/main

Civil Engineering Patents

PatentsView Data –Civil Engineering patents as of 8/17/22

- Data from 1976-2021
- 259,248 unique patents
- 228,583 unique inventors
- 38,668 unique locations

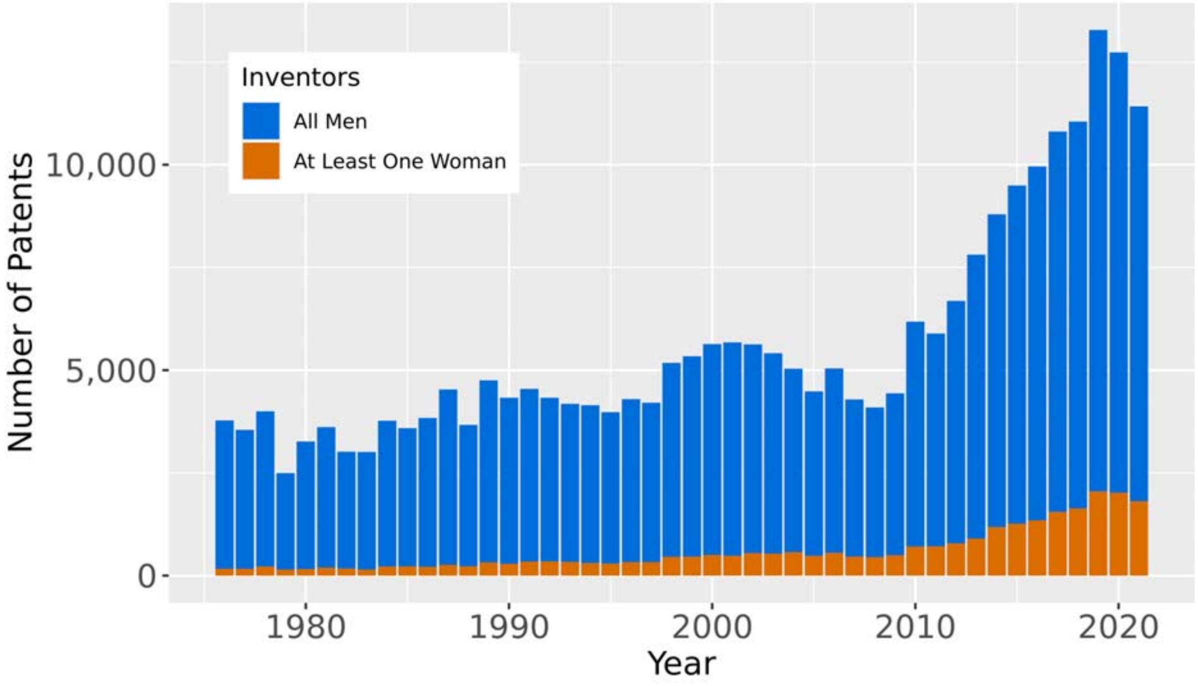
Inventor Gender Breakdown

Gender	Count	Percent
Male	203,615	89.1%
Female	16,584	7.3%
Unknown (NA)*	8,384	3.7%

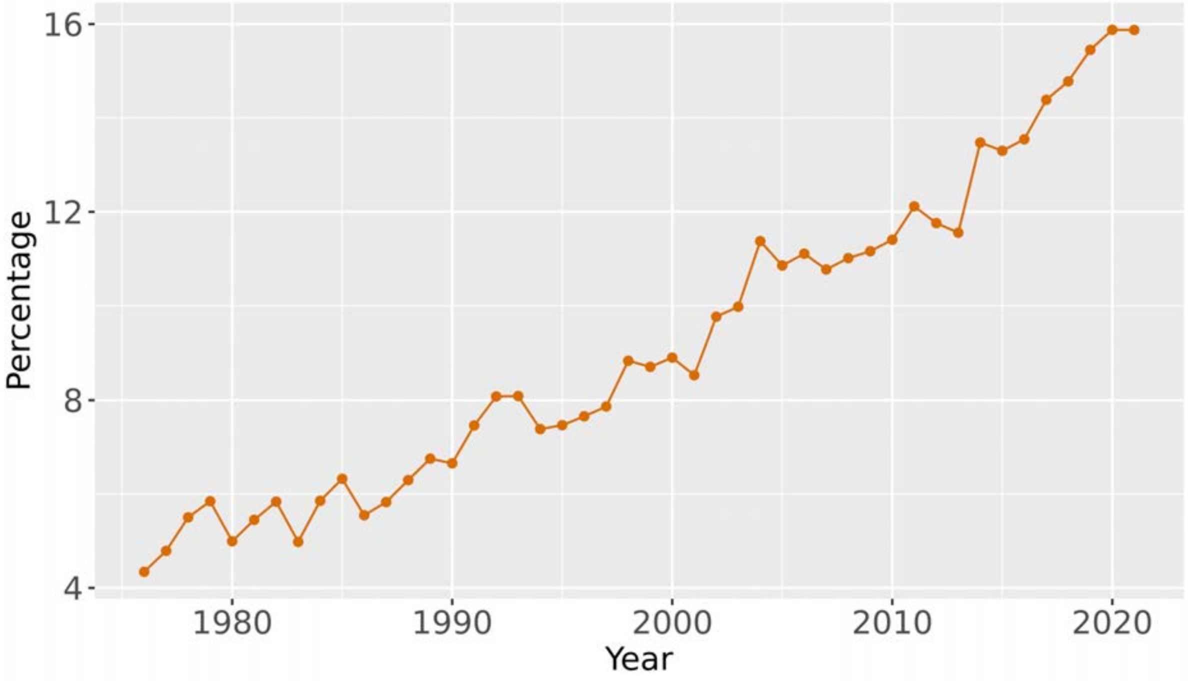
Source: Last Updated date from PatentsView: - all datasets except inventor: 3/29/22
- inventor data set: 5/22/22; *This includes inventors for which gender could not be attributed (7,160) and those which have not yet had gender attributed (1,224)

Civil Engineering Gender Breakdown

Number of Civil Engineering Patents by Gender, 1976-2021



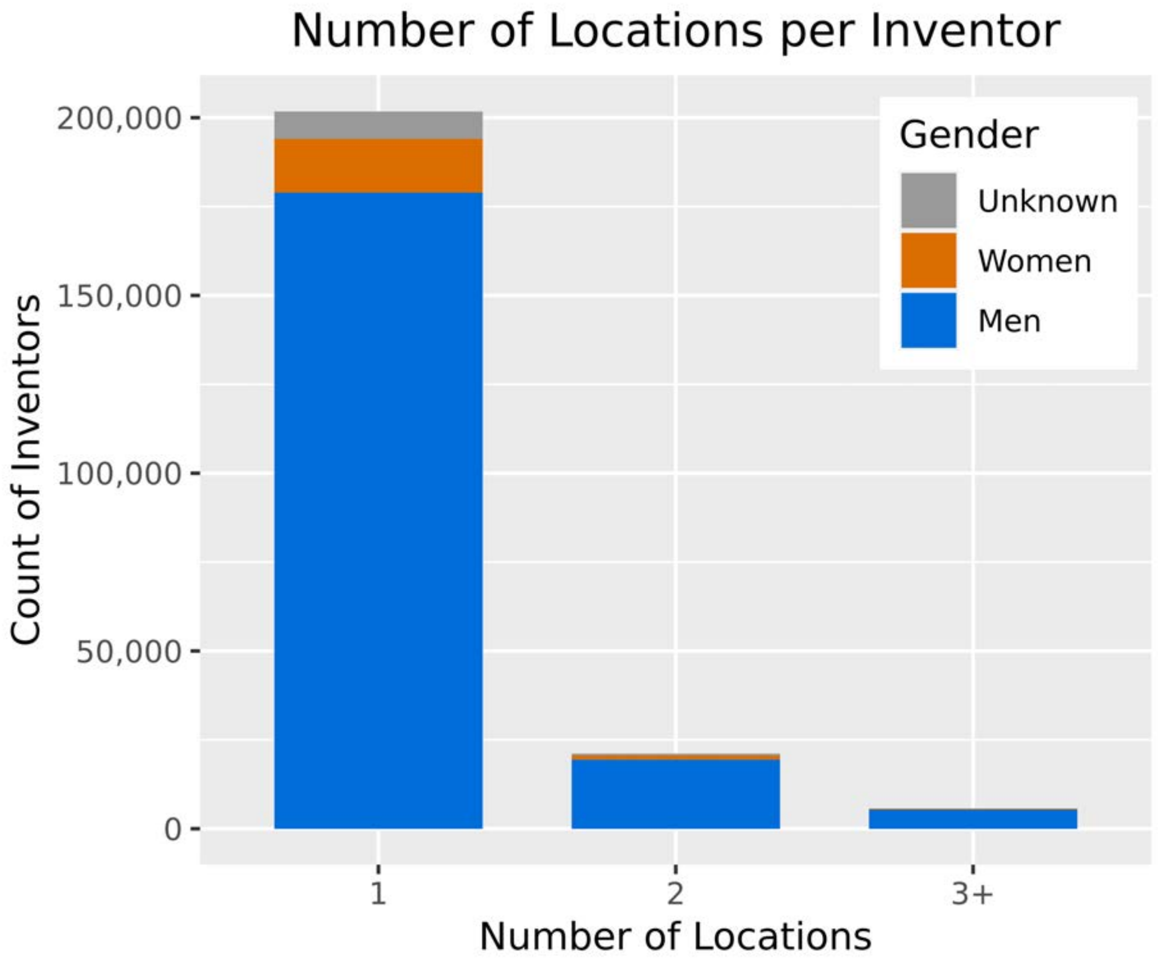
Percentage of Civil Engineering Patents
with at Least One Women Inventor, 1976-2021



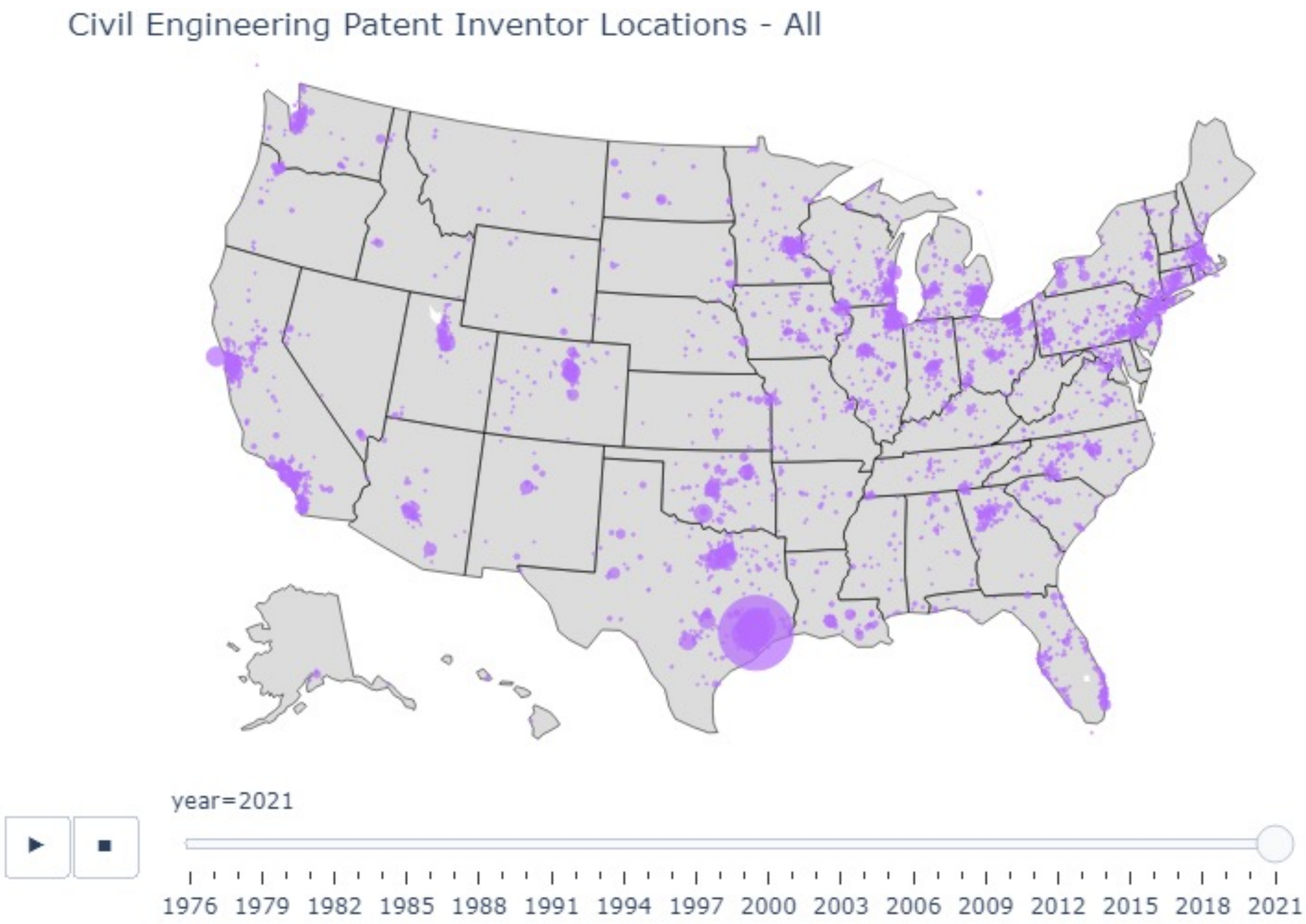
Civil Engineering Inventor Location Patterns

Research Questions:

- Where are inventors located?
- For those that do change locations, are there any source-destination patterns?
- Does gender play a role in location?



Civil Engineering Inventor Locations (US) - All



Interactive map: Go to https://uva-bi-sdad.github.io/uspto_gender_analysis/

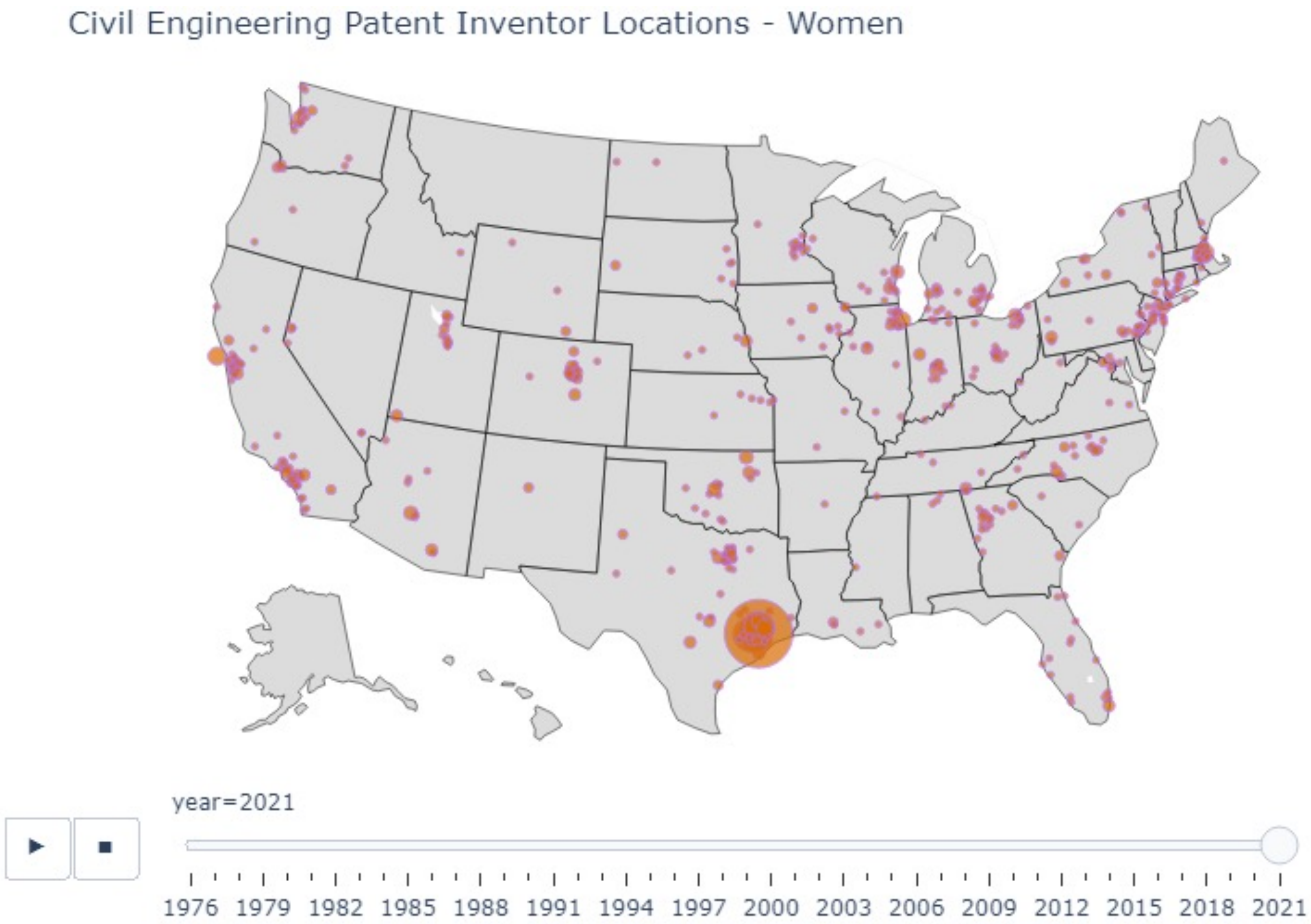
Notes: 1) Marker size is relative to the maximum number of inventors located in one city. 2) Latitude and longitude are plotted as given in the data - some cities were incorrectly geolocated. 3) Missing geolocations seem to occur from a misspelled city and/or state; we dropped these observations from the dataset.

Top Ten US Locations, 1976-2021

Location	Number of Inventors
Houston, TX	18,816
Spring, TX	3,120
Sugar Land, TX	2,614
Katy, TX	2,525
The Woodlands, TX	2,047
Duncan, OK	1,732
Dallas, TX	1,542
Cypress, TX	1,528
Tulsa, OK	1,146
Kingwood, TX	1,105

Key Takeaways:
- Civil engineering hub in Texas (near Houston)
- More civil engineering inventors over time

Civil Engineering Inventor Locations (US) - Women



Interactive map: Go to https://uva-bi-sdad.github.io/uspto_gender_analysis/

Notes: 1) Marker size is relative to the maximum number of women inventors located in one city. 2) Latitude and longitude are plotted as given in the data - some cities were incorrectly geolocated. 3) Missing geolocations seem to occur from a misspelled city and/or state; we dropped these observations from the dataset.

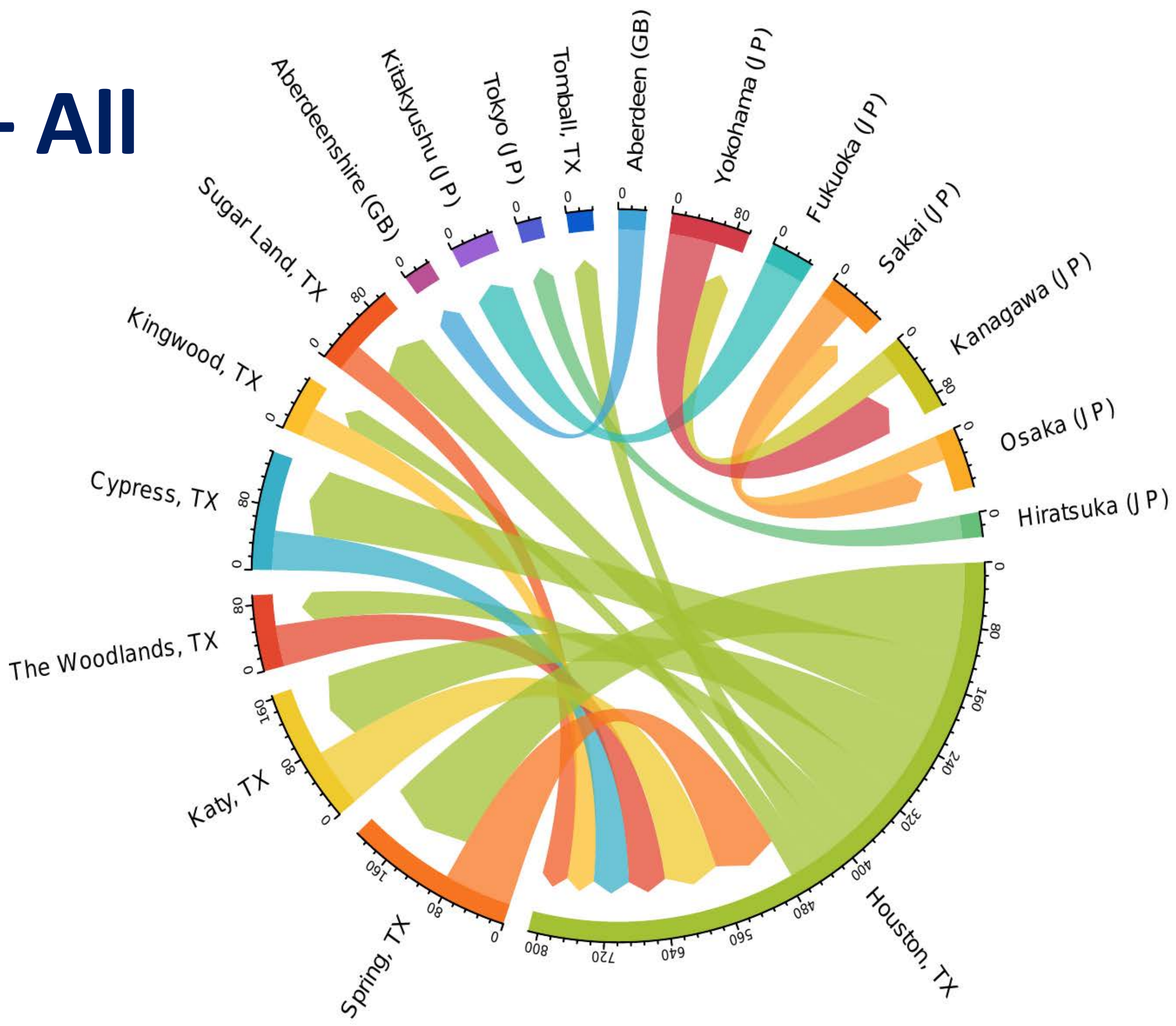
Top Ten US Locations, 1976-2021

Location	Number of Inventors
Houston, TX	1,296
Sugar Land, TX	226
Katy, TX	178
Spring, TX	172
The Woodlands, TX	124
Dallas, TX	97
Cypress, TX	91
Duncan, OK	90
New York, NY	78
Austin, TX	70

Key Takeaways:
- Women inventors appear to exist in more frequent numbers in the same cities where male inventors exist in more frequent numbers
- More women inventors over time

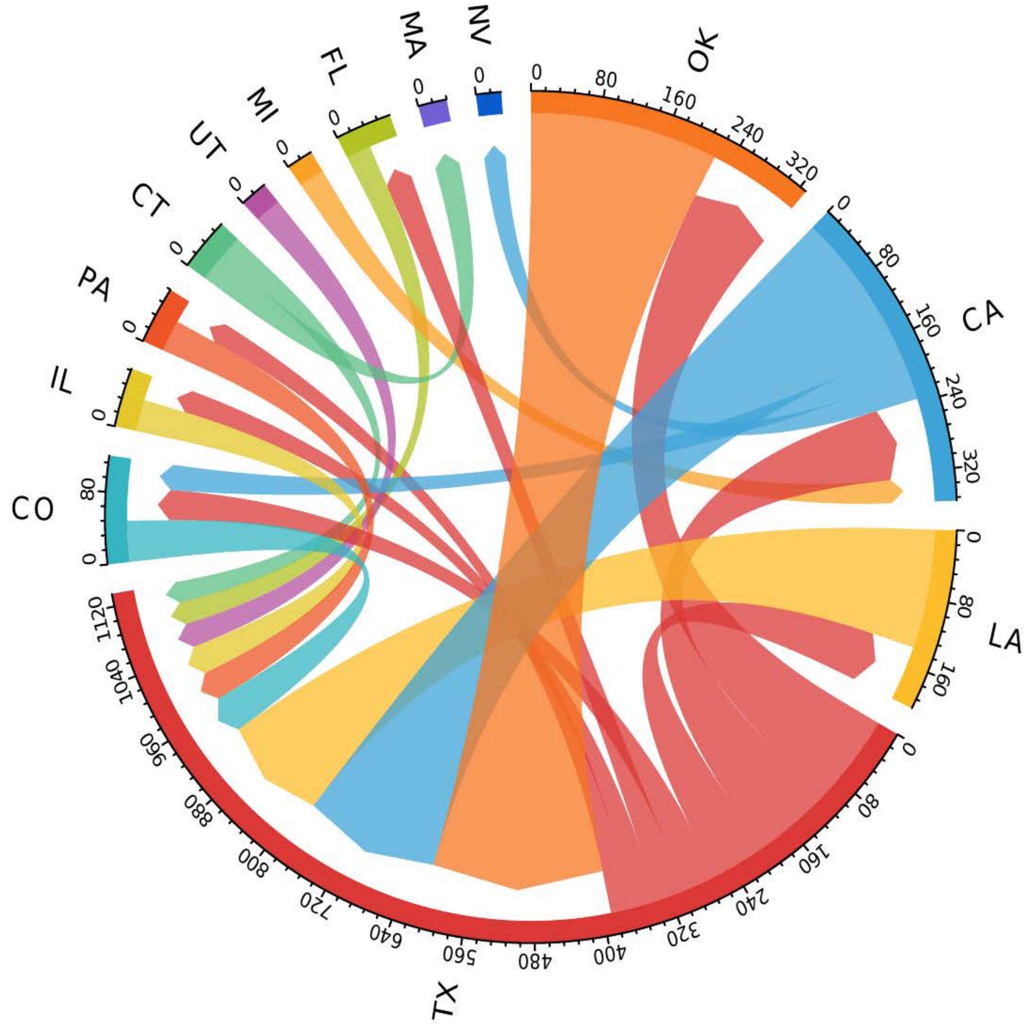
Civil Engineering Inventor Relocation – All

- Visualization of where inventors move from (source) and to (destination) for 1976-2021
  - The values represent number of moves
- Top 20 source-destination pairs
- **Most frequent relocations occur in Texas and involve Houston**
- **The inflow and outflow for Houston are almost equal**



Civil Engineering Inventor Relocation by State - All

Top 20 Moves Between States (US), 1976-2021



Key Takeaways between States

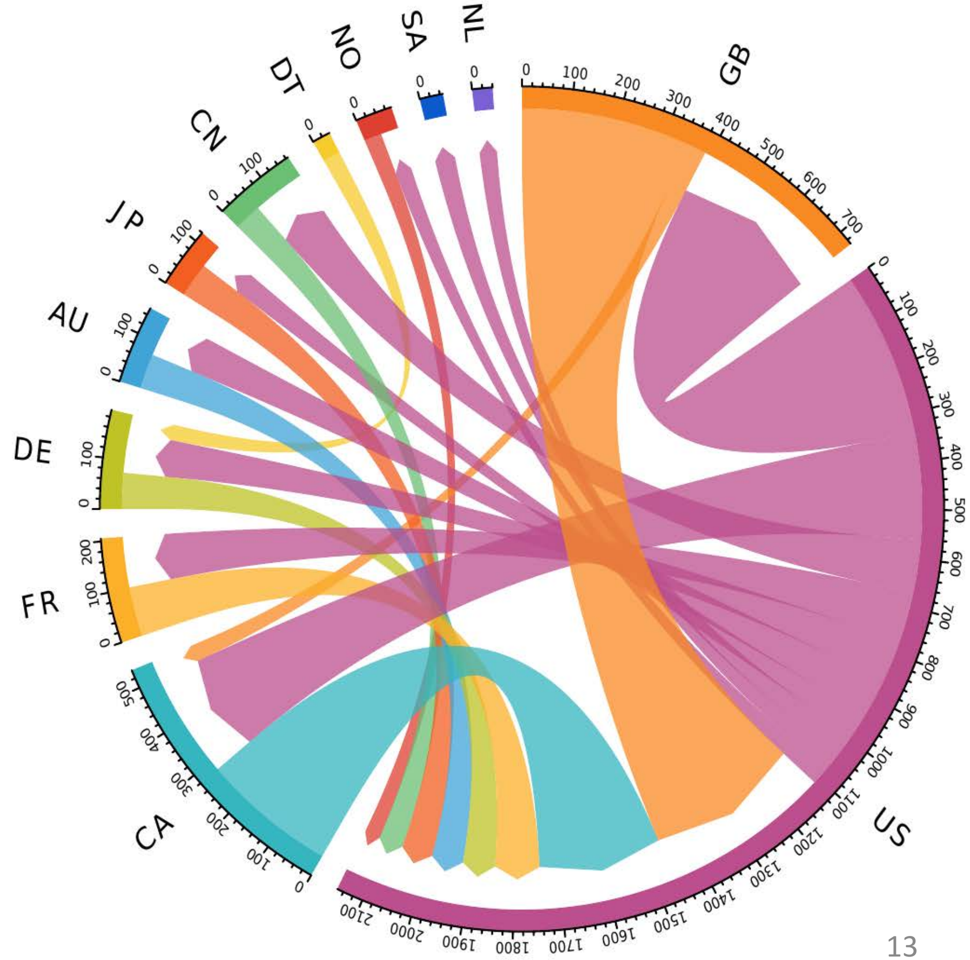
- TX has the largest inflow with large (comparatively) contributions from OK, CA, LA
- The inflow for TX is about double that of its outflow (i.e., more civil engineer inventors move to Texas than leave Texas)
- TX is the most popular relocation for inventors moving between states

Civil Engineering Inventor Relocation between Countries – All Inventors

<u>Key Takeaway between Countries</u>

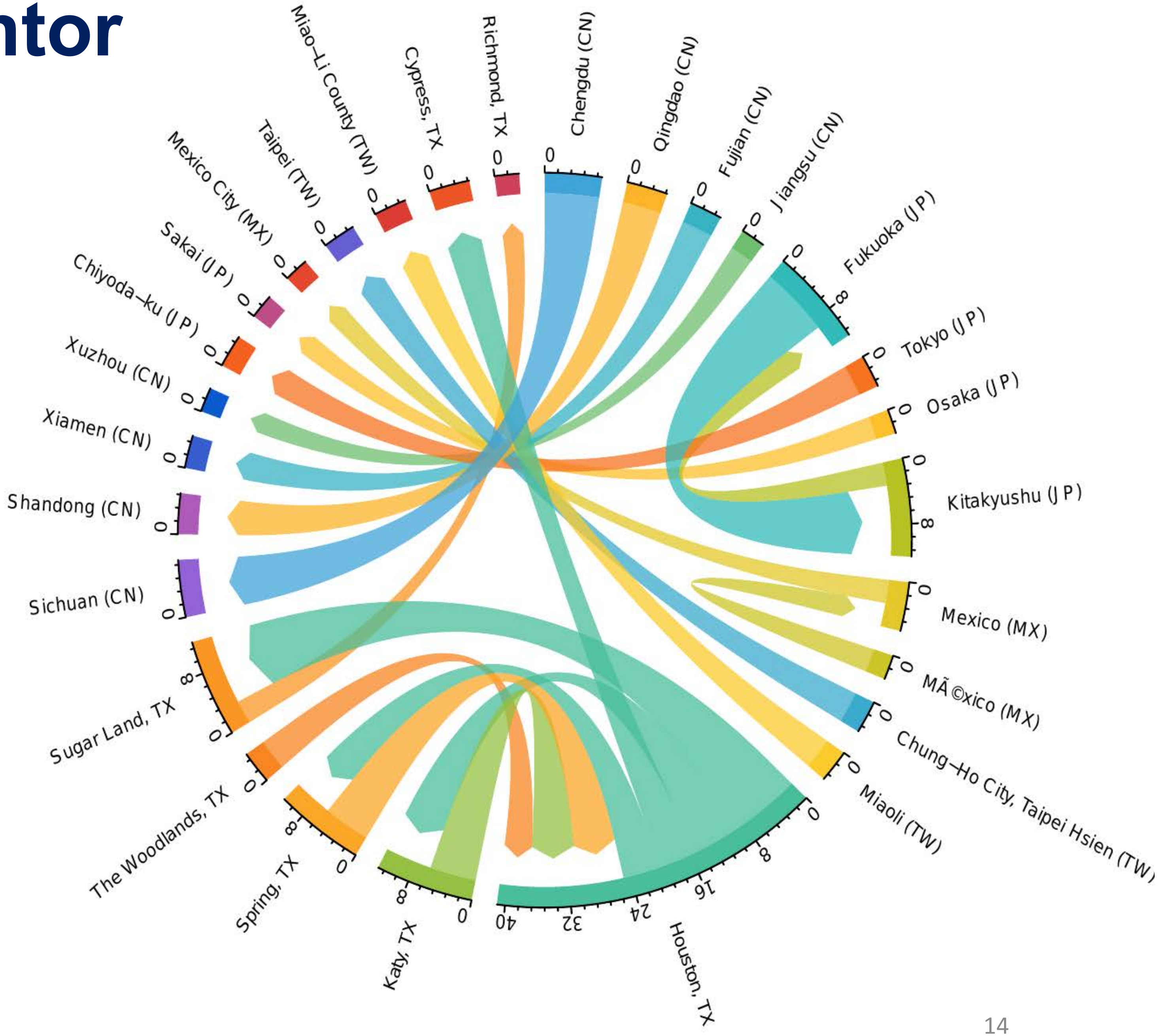
- The US has the largest inflow with large (comparatively) contributions from Canada and Great Britain
    - Canada and Great Britain have about an equal exchange of inventors coming from the US and leaving to go to the US
- The inflow for the US is about the same as its outflow
- US is the most popular relocation for inventors moving between countries

Top 20 Moves Between Countries, 1976-2021



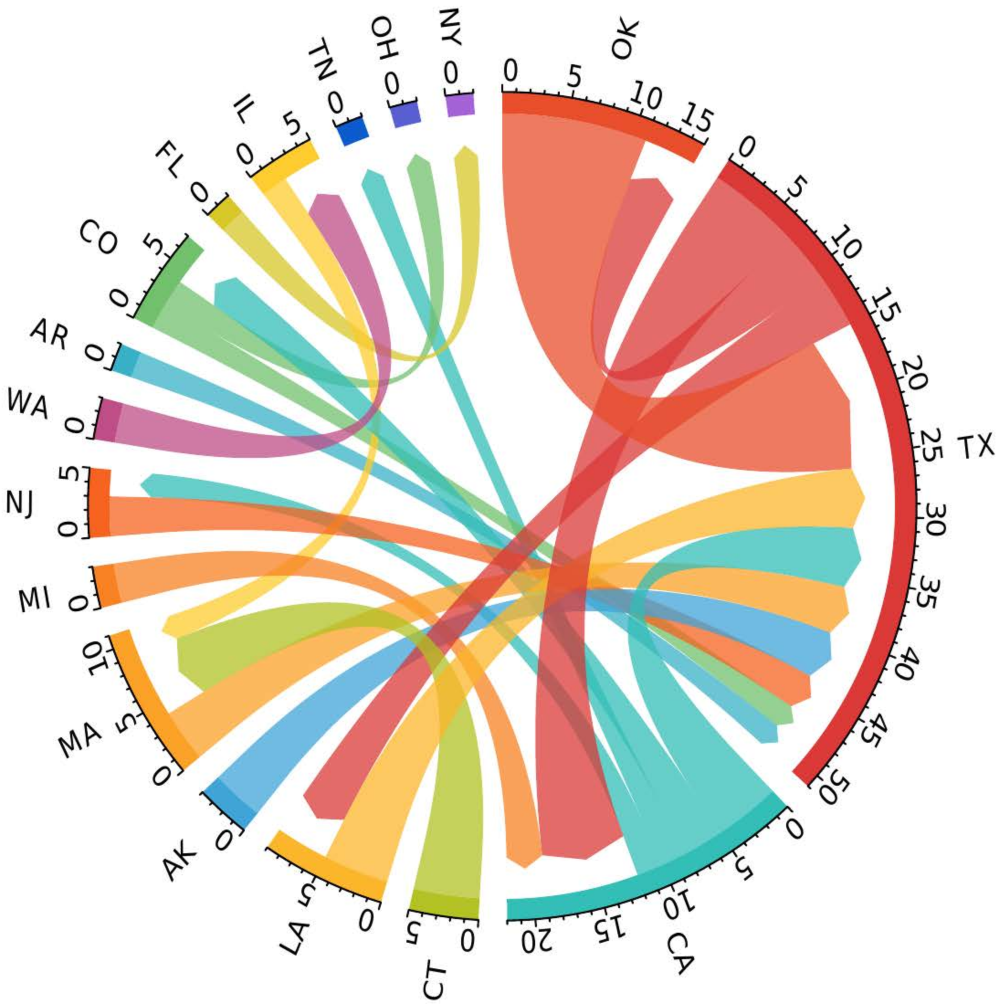
Civil Engineering Inventor Relocation – Women

- Visualization of where inventors move from (source) and to (destination)
- Top 20 source-destination pairs
- Small frequencies of moves compared to those for all inventors
- **Most popular relocations occur in Texas and involve Houston**
- **The inflow to Houston, TX is slightly less than the outflow**



Civil Engineering Inventor Relocation by State – Women Inventors

Top 20 Moves Between States (US), 1976-2021



Key Takeaways:
- Small frequency of moves compared to all inventors so it is difficult as a comparison to all inventors
- TX is a hub just as it is for all inventors

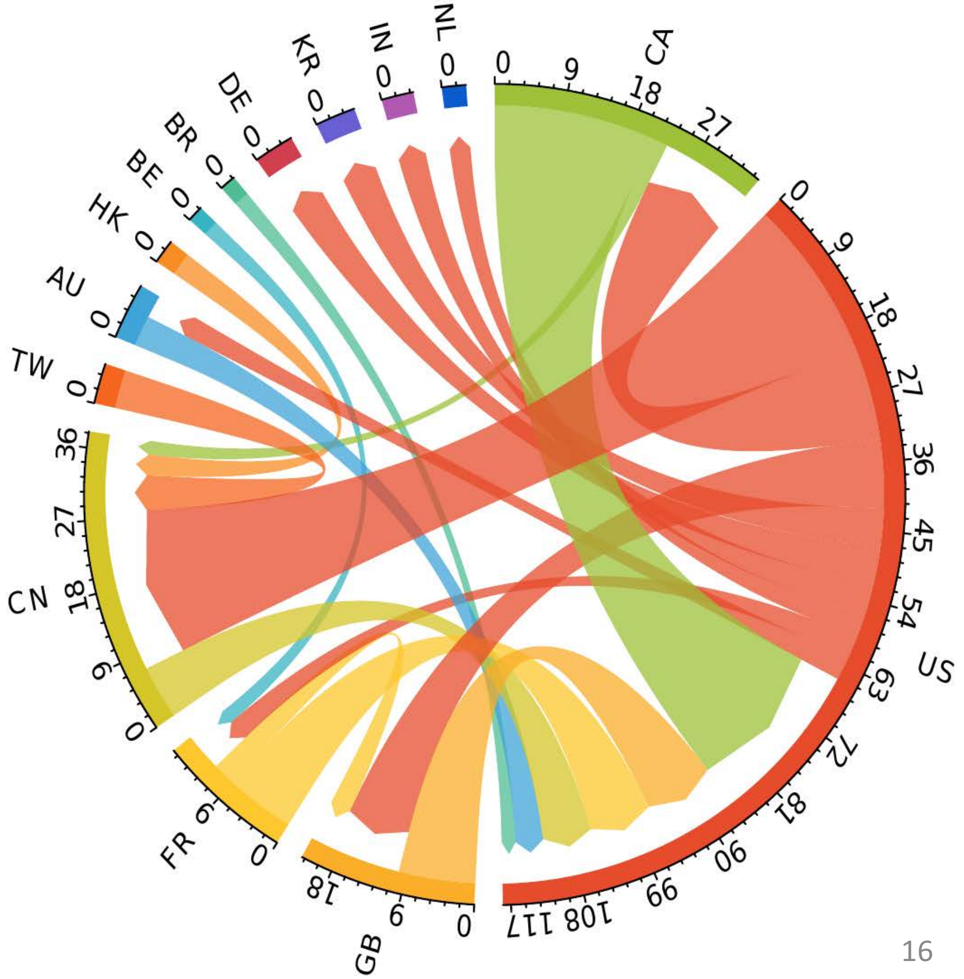
By State:
- TX has the largest inflow with a large (comparatively) contribution from OK
- The inflow for TX is about triple that of its outflow (ie. more civil engineering inventors move to Texas than leave Texas)
- TX is the most popular relocation for inventors moving between states

Civil Engineering Inventor Relocation Between Countries – Women Inventors

Key Takeaways between Countries

- Small frequency of moves compared to all inventors so it is difficult as a comparison to all inventors
- US is a hub just as it is for all inventors
- The US has the largest inflow with a large (comparatively) contribution from Canada
- The inflow for is the US is about the same as its outflow
- China's inflow is 4 times its outflow

Top 20 Moves Between Countries, 1976-2021



PHARMACEUTICAL Patents - Inventor Location

Pharmaceuticals Patents

PatentsView Data – downloaded on 8/17/22

- Data from 1976-2021
- 309,335 unique patents
- 283,382 unique inventors
- 33,809 unique locations

Inventor Gender Breakdown

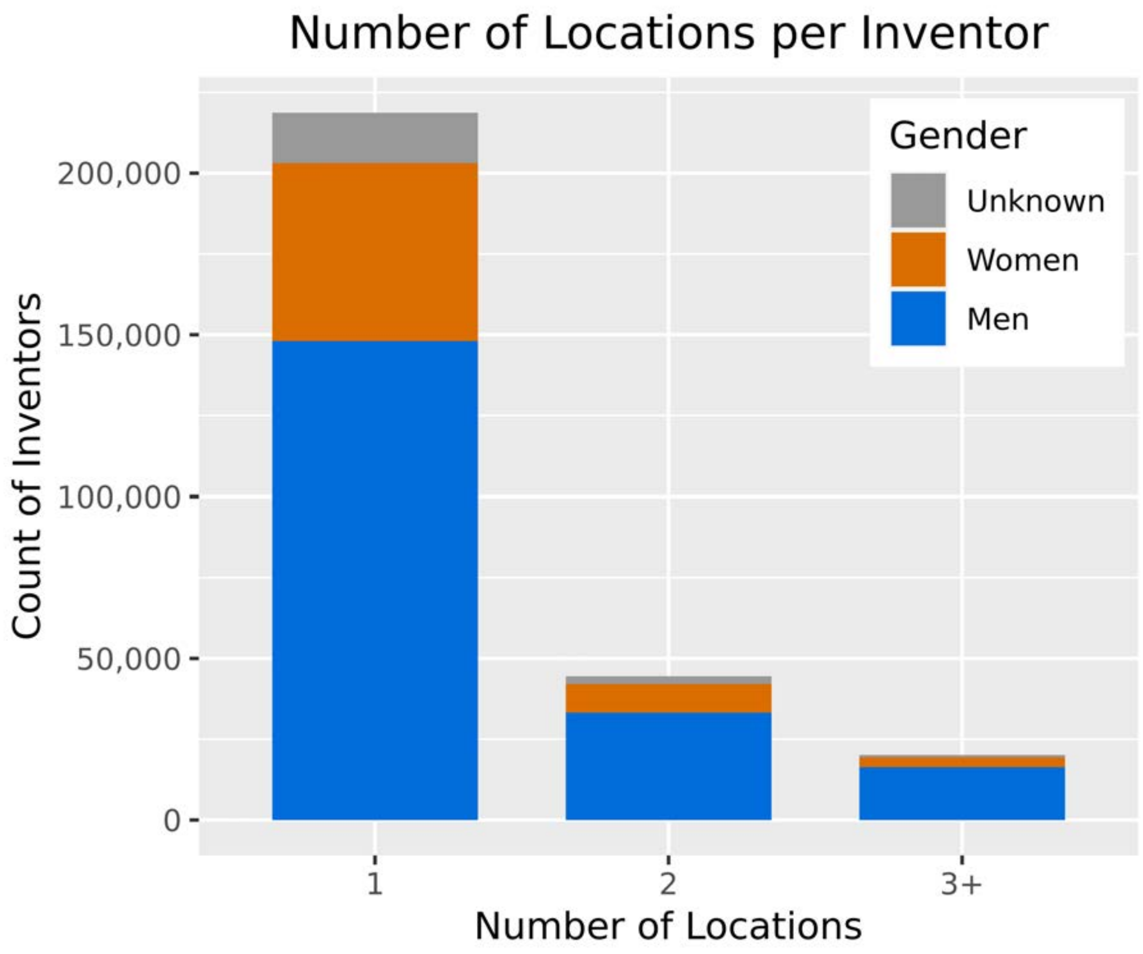
Gender	Count	Percent
Male	197,650	69.7%
Female	66,877	23.6%
Unknown (NA)*	18,855	6.7%

Source: Last Updated date from PatentsView: - all datasets except inventor: 3/29/22 - inventor data set: 5/22/22; *This includes inventors for which gender could not be attributed (7,160) and those which have not yet had gender attributed (1,224)

Pharmaceuticals - Inventor Location Patterns

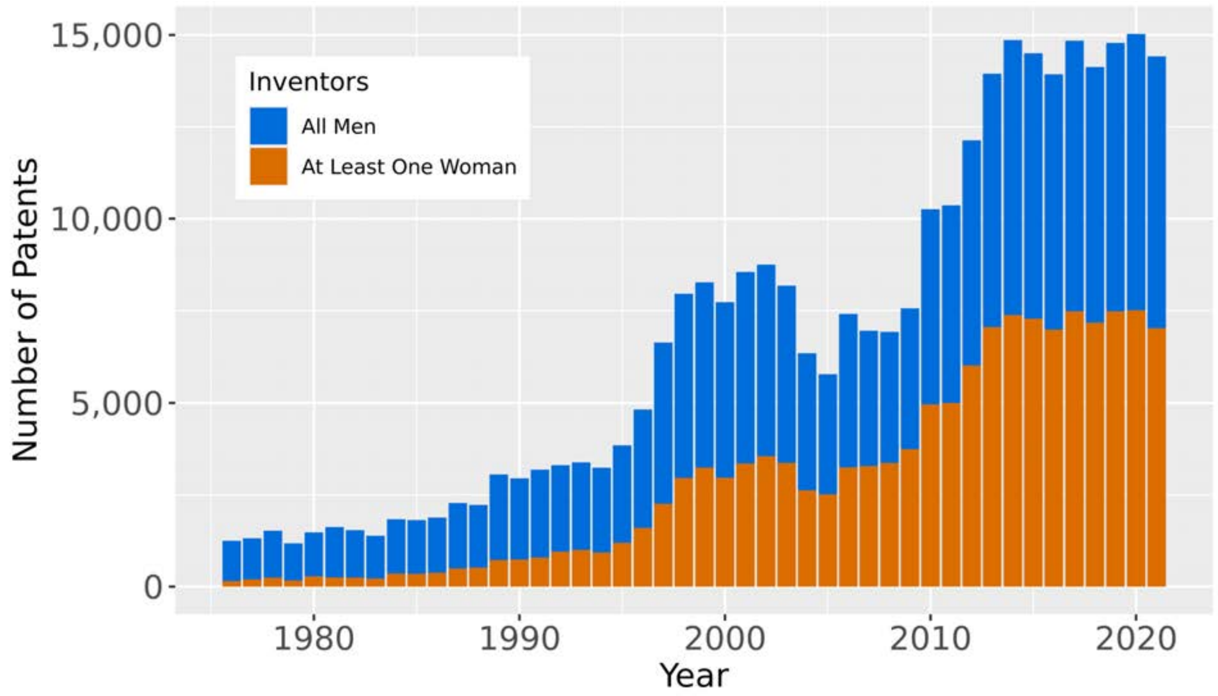
Research Questions

- Where are inventors located?
- For those that do change locations, are there any source-destination patterns?
- Does gender play a role in location?

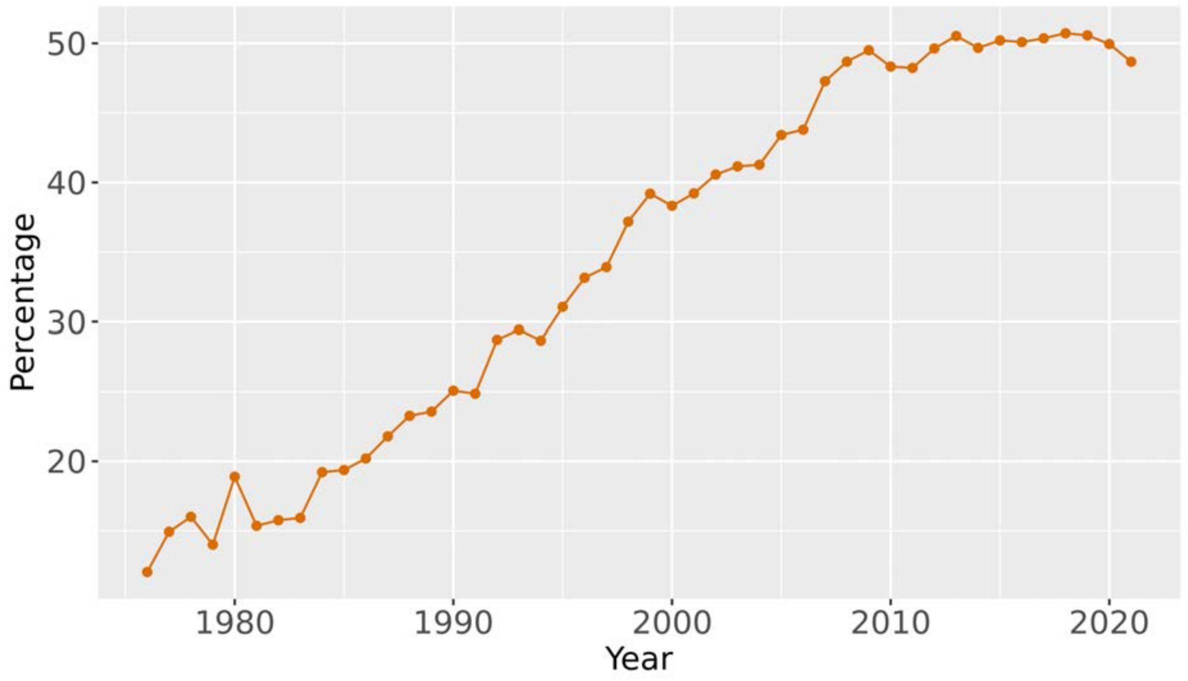


Pharmaceuticals - Gender Breakdown

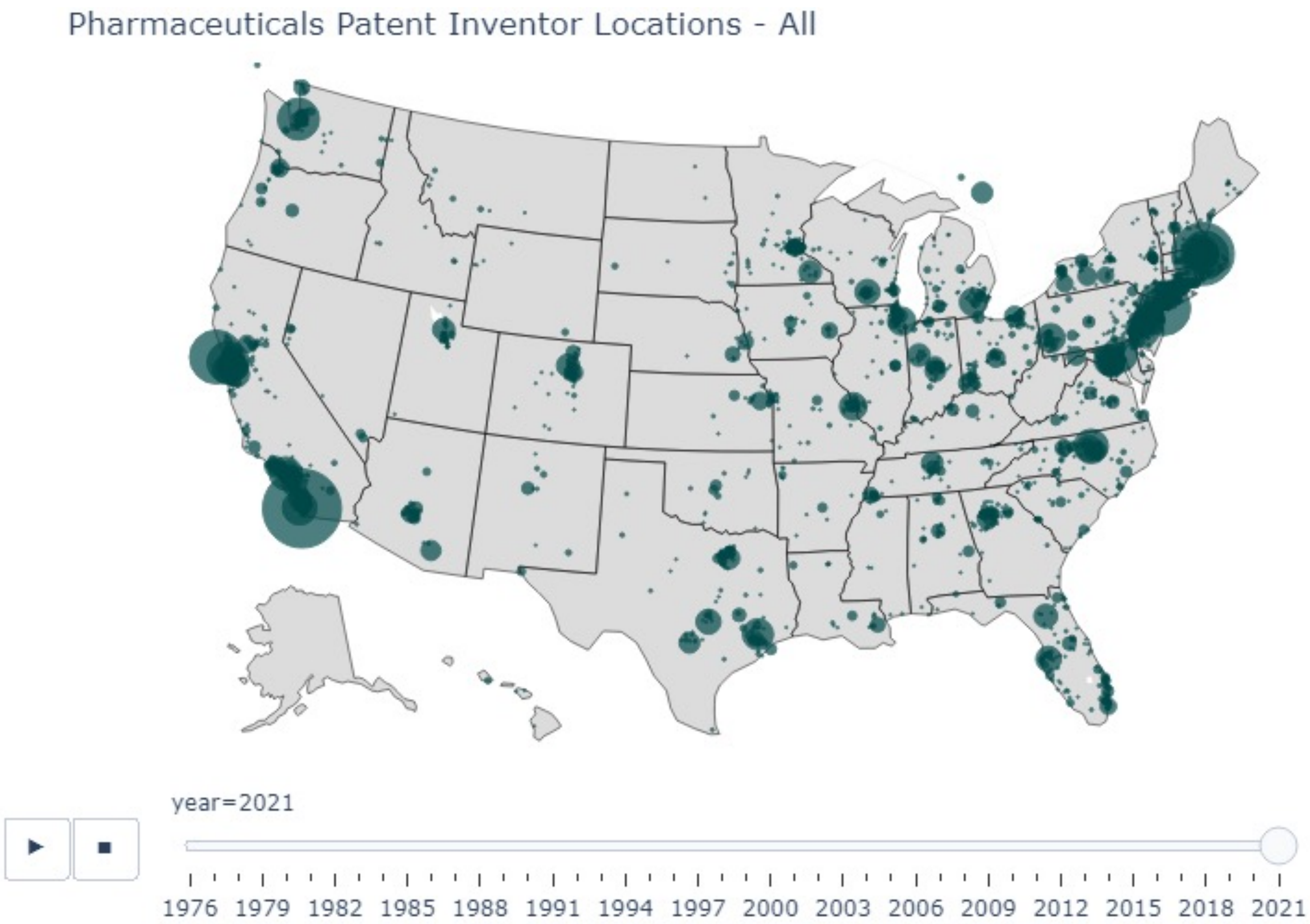
Number of Pharmaceutical Patents by Gender, 1976-2021



Percentage of Pharmaceutical Patents with at Least One Women Inventor, 1976-2021



Pharmaceutical Inventor Locations (US) - All



Interactive map: Go to https://uva-bi-sdad.github.io/uspto_gender_analysis/

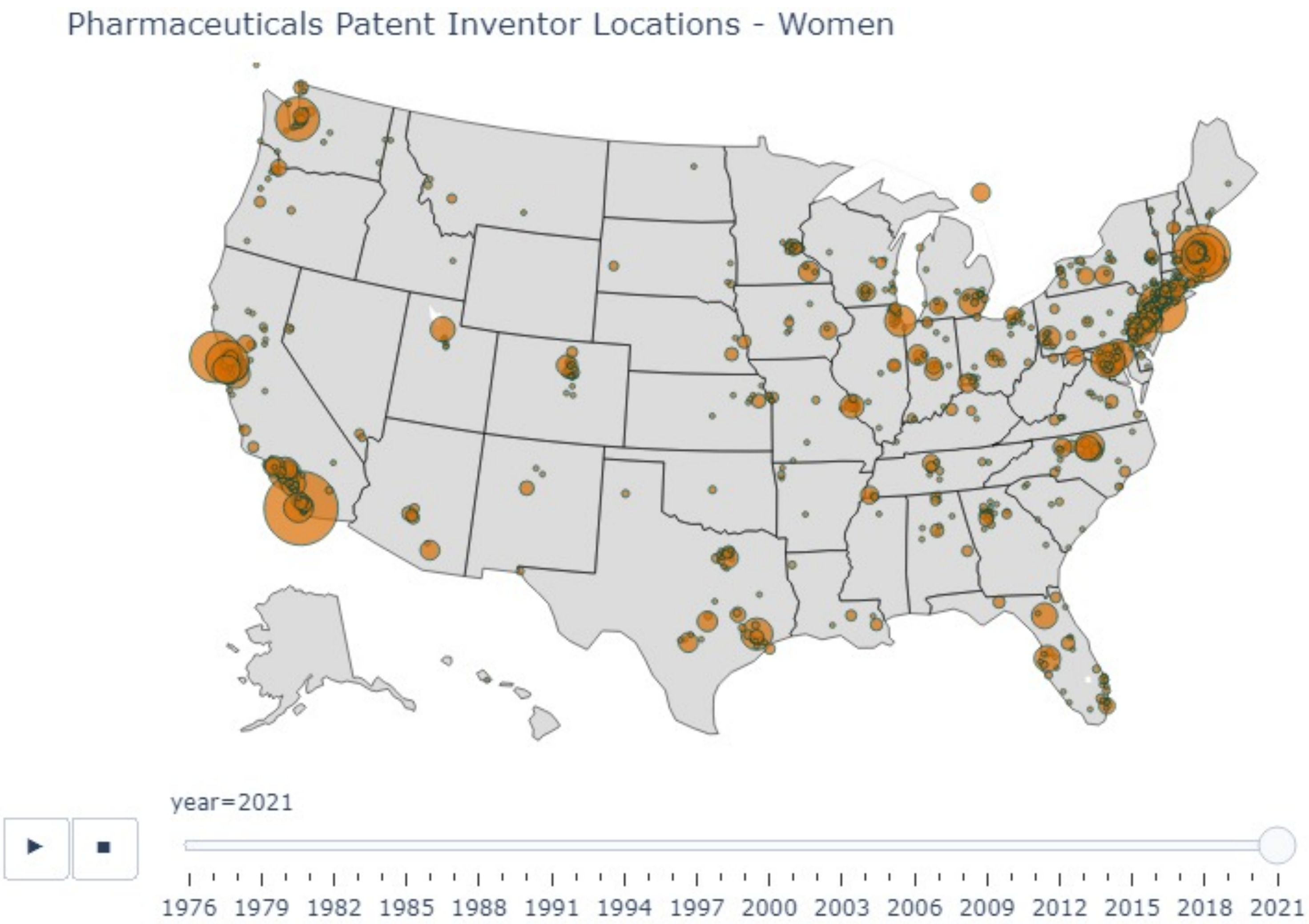
Notes: 1) Marker size is relative to the maximum number of inventors located in one city. 2) Latitude and longitude are plotted as given in the data - some cities were incorrectly geolocated. 3) Missing geolocations seem to occur from a misspelled city and/or state; we dropped these observations from the dataset.

Top Ten US Locations, 1976-2021

Location	Number of Inventors
San Diego, CA	14,083
San Francisco, CA	6,819
New York, NY	6,346
Cambridge, MA	5,205
Seattle, WA	4,223
Boston, MA	3,452
Indianapolis, IN	3,201
Ann Arbor, MI	3,060
Houston, TX	2,956
Palo Alto, CA	2,933

Key Takeaways:
- Pharma hubs in CA and the Northeast
- More pharma inventors over time

Pharmaceutical Inventor Locations (US) - Women



Interactive map: Go to https://uva-bi-sdad.github.io/uspto_gender_analysis/

Notes: 1) Marker size is relative to the maximum number of women inventors located in one city. 2) Latitude and longitude are plotted as given in the data - some cities were incorrectly geolocated. 3) Missing geolocations seem to occur from a misspelled city and/or state; we dropped these observations from the dataset.

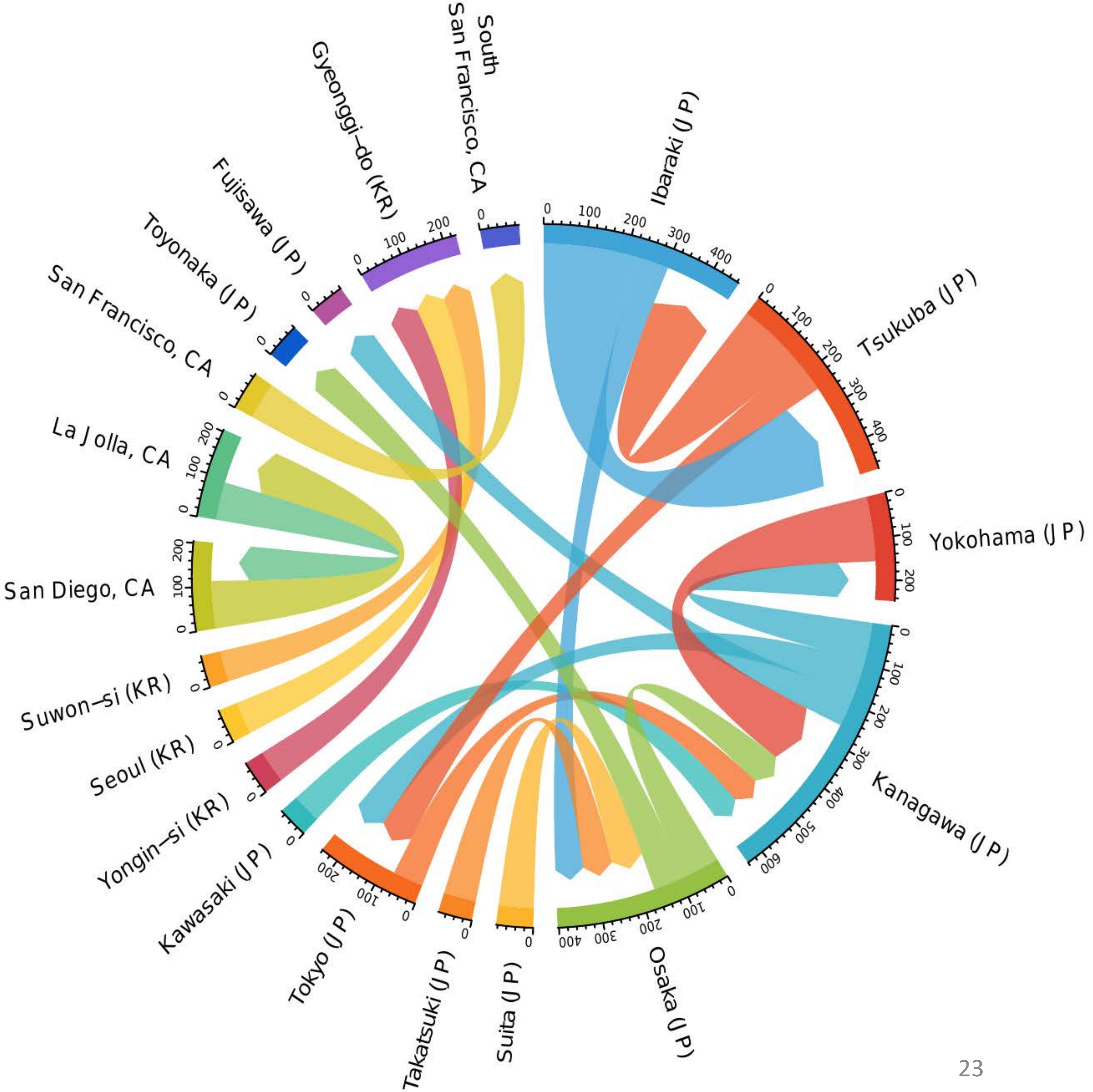
Top Ten US Locations, 1976-2021

Location	Number of Inventors
San Diego, CA	3,121
San Francisco, CA	1,550
New York, NY	1,312
Cambridge, MA	1,177
Seattle, WA	1,052
Palo Alto, CA	626
Houston, TX	595
Boston, MA	588
Ann Arbor, MI	586
Brookline, MA	557

Key Takeaways:
- Women are located more frequently in the same locations where all inventors are located more frequently
- More women inventors over time

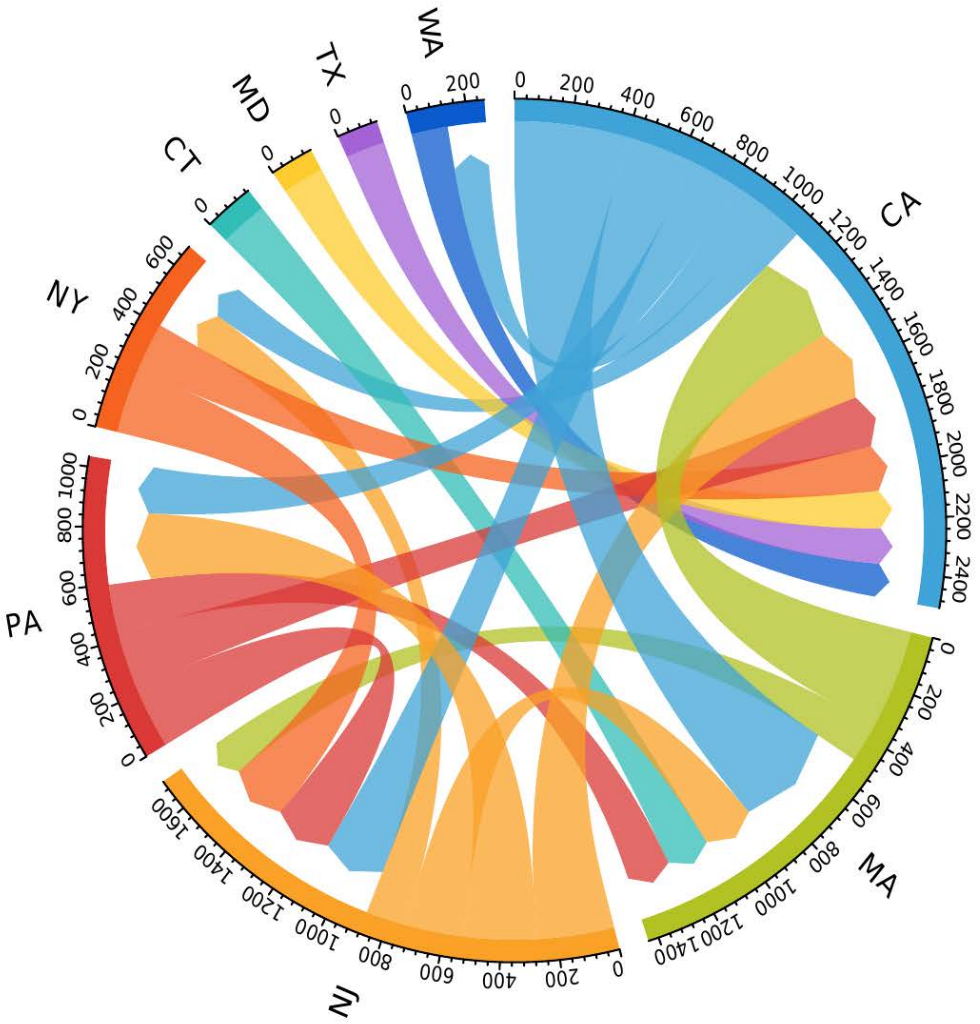
Pharma Inventor Relocation – All

- Visualization of where inventors move from (source) and to (destination) for 1976-2021
  - The values represent number of moves.
- Top 20 source-destination pairs
- **Most popular relocations occur in Japan, Korea and California**
- **Relocation is generally intra-country and intra-state (US)**



Pharma Inventor Relocation between States - All

Top 20 Moves Between States, 1976-2021 (US)



<u>Key Takeaways between States</u>

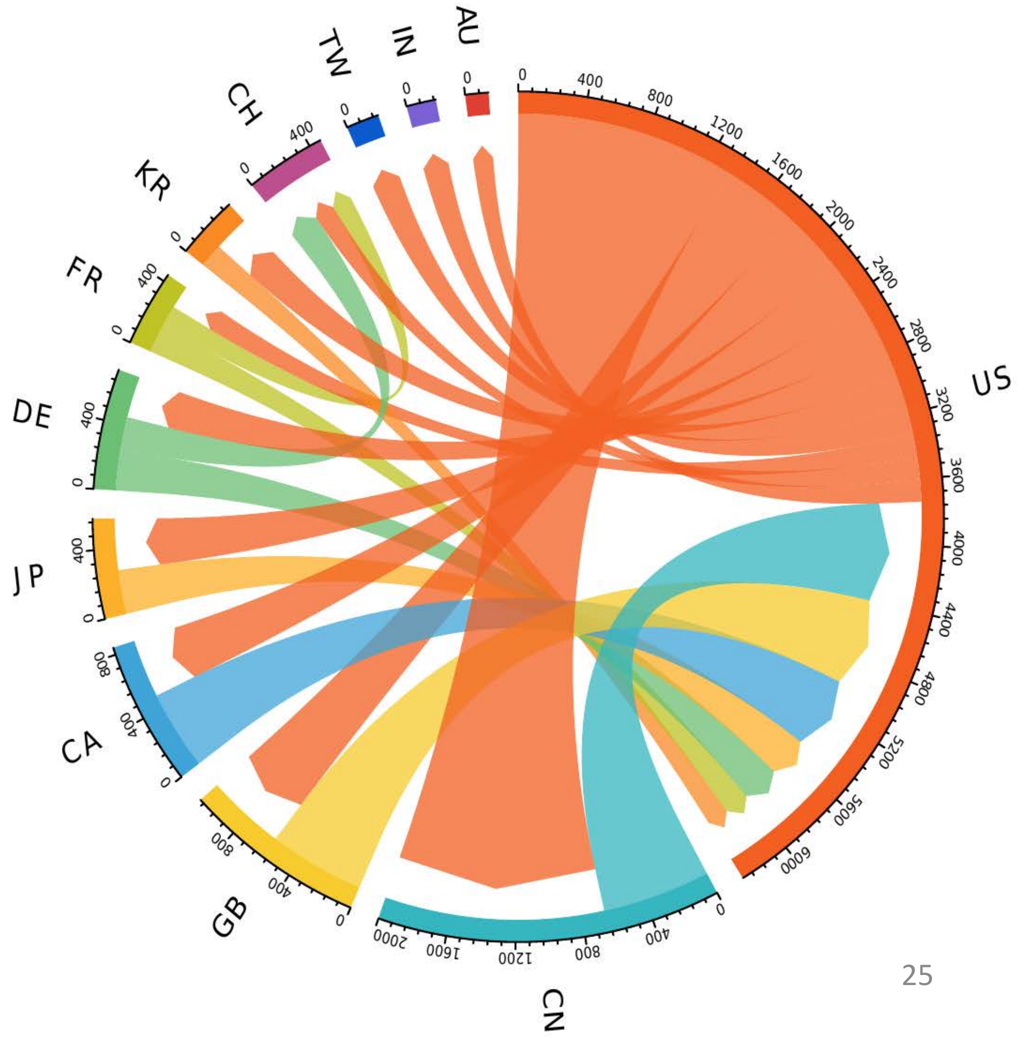
- Popular relocations involve CA, MA, NJ, NY, and PA
- There are relocations within the Northeast and between the Northeast and California

Pharma Inventor Relocation Between Countries – All Inventors

Key Takeaways between Countries

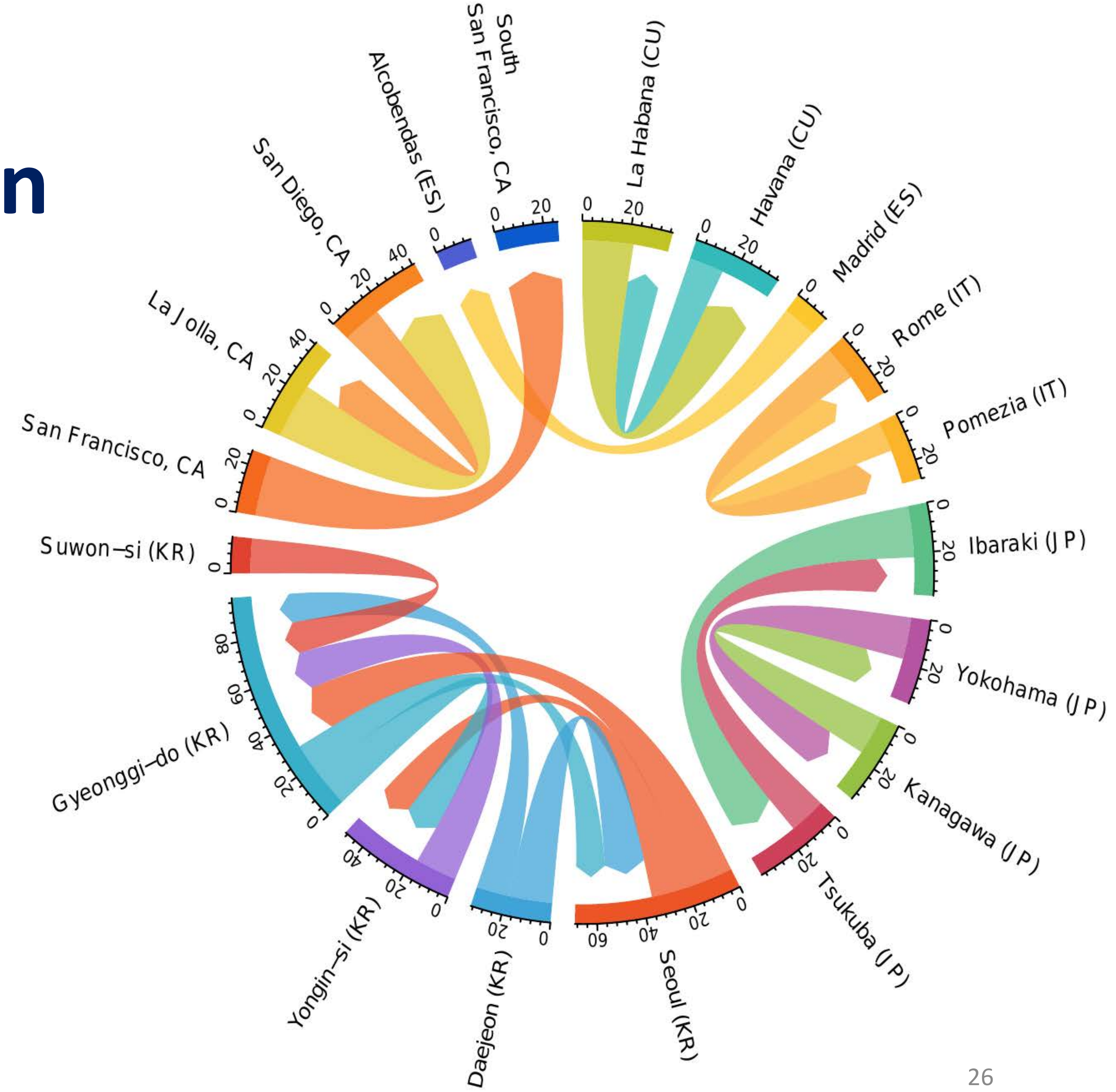
- Outflow for the US is larger than inflow, with the main countries contributing to inflow being Great Britain, China (CN), and Canada (CA)
- Inventors move from the US to China about twice as often as inventors move from China to the US

Top 20 Moves Between Countries, 1976-2021



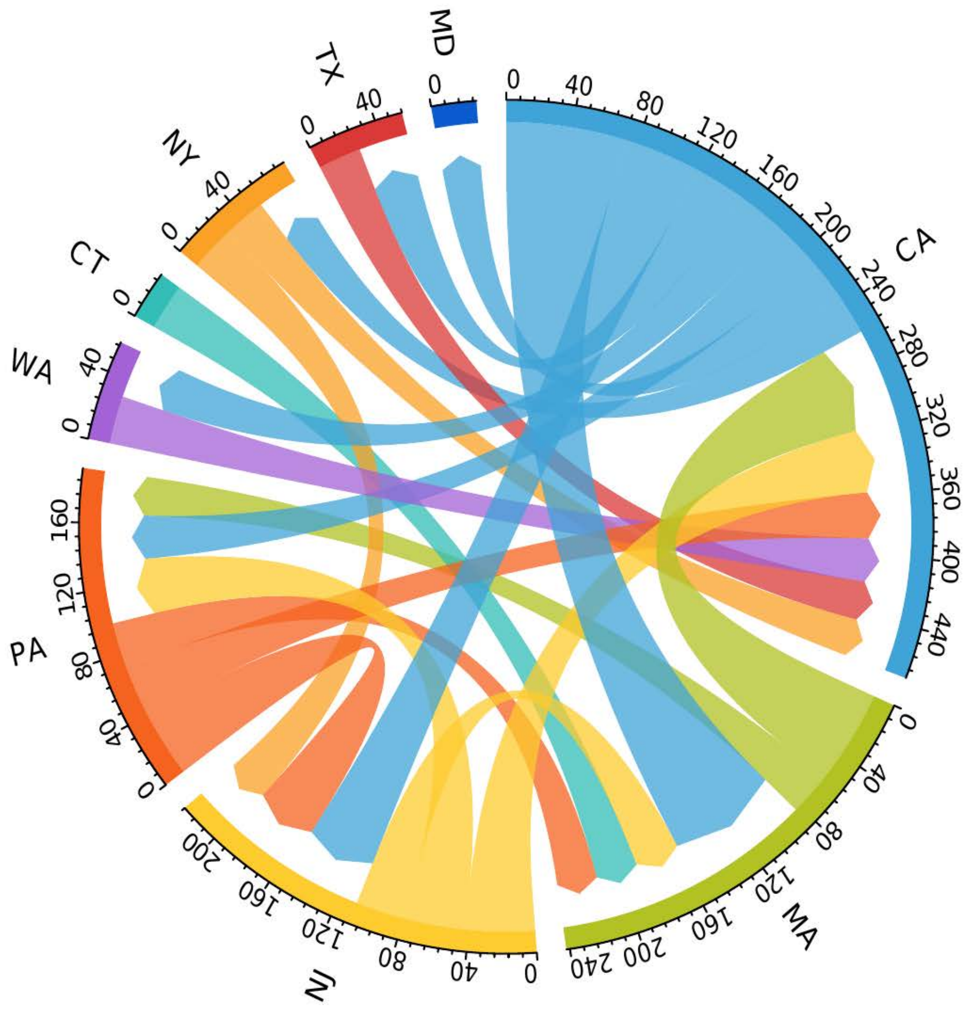
Pharma Inventor Relocation – Women

- Visualization of where inventors move from (source) and to (destination) for 1976-2021
- Top 20 source-destination pairs
- **Small frequencies of moves compared to those for all inventors**
- **Relocation is generally intra-country and intra-state (US)**



Pharma Inventor Relocation between States – Women Inventors

Top 20 Moves Between States, 1976-2021 (US)



<u>Key Takeaways</u>

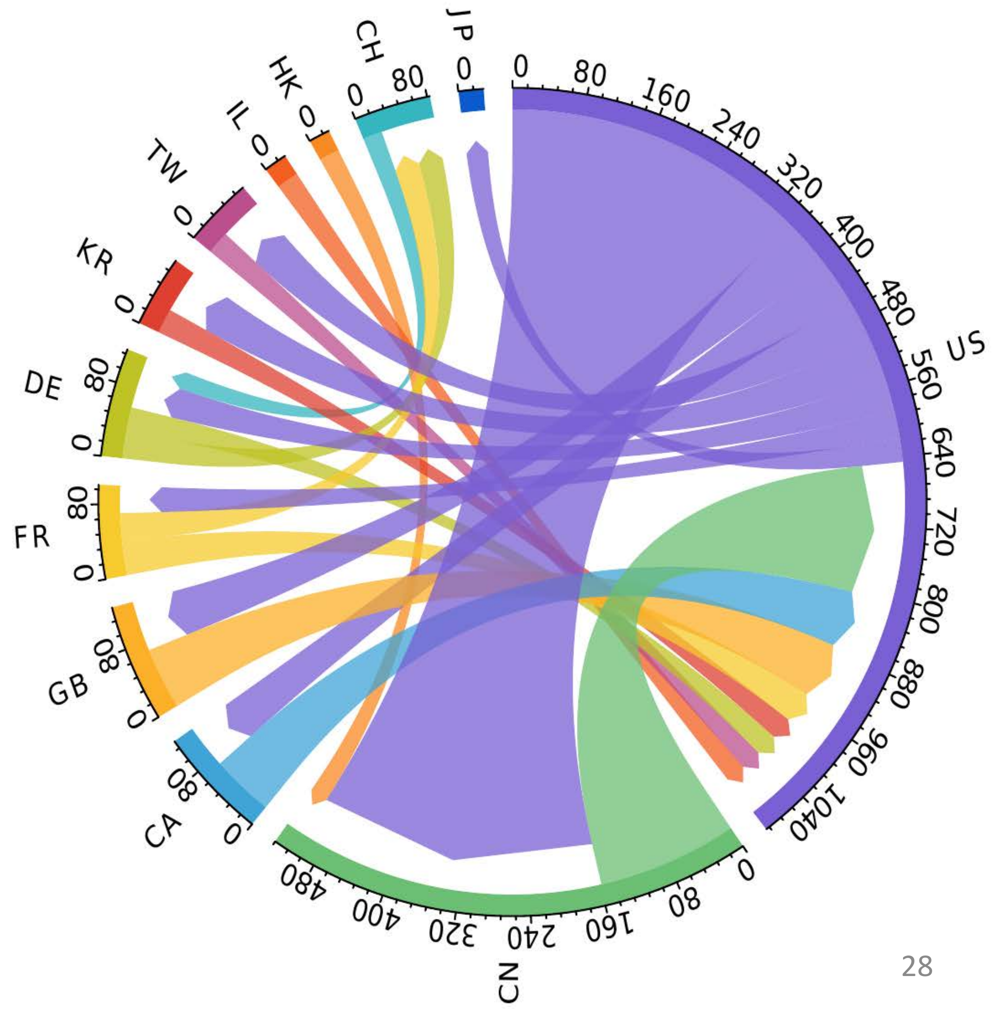
- Small frequency of moves for women inventors compared to all inventors
- Outflows from California (CA) are slightly larger than inflows to CA
- Proportionally similar patterns to moves of all inventors between states

Pharma Inventor Relocation between Countries – Women Inventors

<u>Key Takeaways</u>

- Small frequency of moves compared to all inventors
-Inflows to the US are slightly larger than outflows
-Outflows from the US are to China, other Asian countries and France, Great Britain, and Canada
- Proportionally similar patterns to moves of all inventors between countries

Top 20 Moves Between Countries, 1974-2021



Key Takeaways

Where are inventors located?

- There are more unique patents and inventors in pharmaceuticals, but fewer unique inventor locations.
- The hub for civil engineering patent inventors is in Texas, specifically in the Houston area.
- Hubs for pharma patent inventors include San Diego, San Francisco, and the Northeast.

Key Takeaways

For inventors who change locations, are there any source-destination patterns?

- Civil engineering inventors tend to move into Texas at about double the rate at which inventors move out of Texas
- Popular relocations for pharmaceutical inventors involve California, Massachusetts, New Jersey, New York, and Pennsylvania

Does gender play a role in location?

- Proportionally, it does not appear that inventors who are women live in different locations than inventors who are men
- Inventor relocations generally show similar patterns for men and women

2. Collaborative Patents & Gender Diversity on Civil Engineering & Pharmaceuticals

- Explore inventor collaboration, seniority, and mentorship on Civil Engineering and Pharmaceuticals patents by gender
  - **Collaboration**
    - **Collaborative:** patents have more than one inventor
    - **Solo:** patents have one inventor
  - **Seniority** is defined at a given year, e.g., someone is senior in 2000, if they created a patent prior to 2000
    - **Women-to-Women Mentorship – new (first-time) inventor; senior inventor**
      - **Senior – new** inventor mentorship
      - **New – new relationship**
      - **Senior – senior** relationship

Percentage of women inventors on Pharmaceuticals and Civil Engineering patents

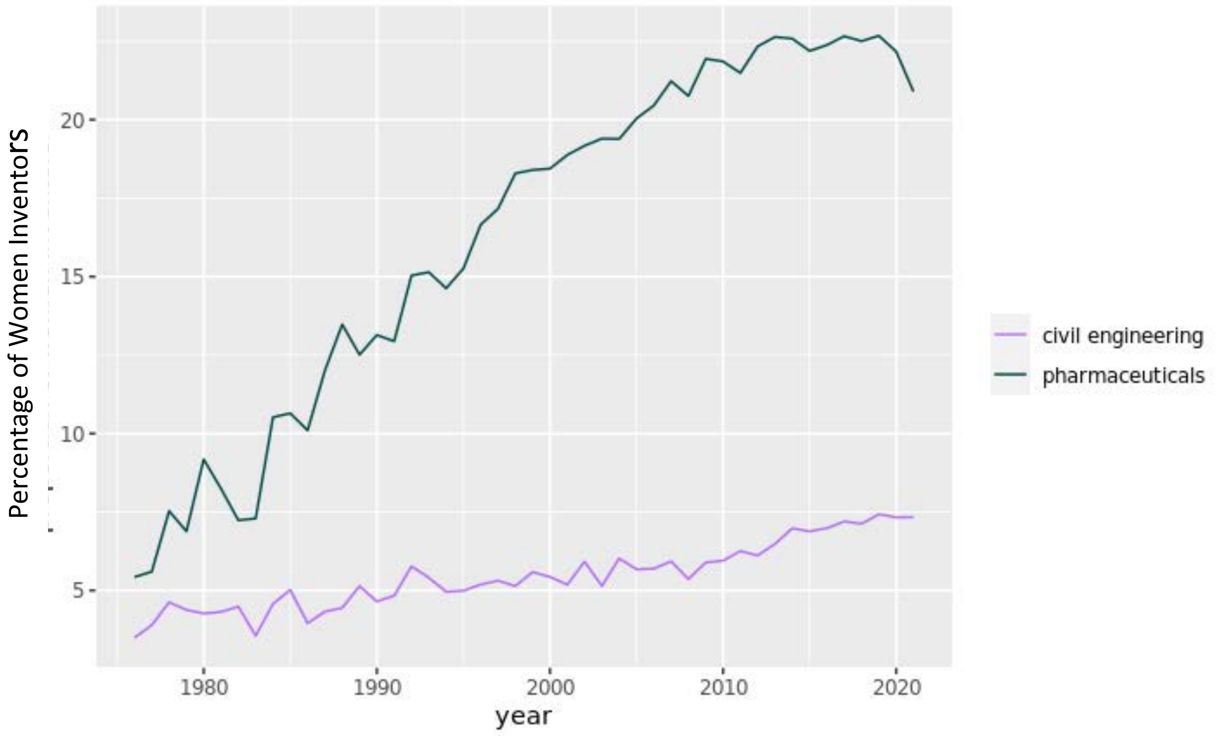


Figure : Percentage of women inventors in Pharmaceuticals and Civil Engineering, 1976-2021

Source: USPTO PatentsView, 1976-2021

- In 1976, the percentage of women inventors on pharmaceuticals and civil engineering patents was almost the same in those fields.
- Over time, there has been an increasing gap in the percentage of women between the two fields.
- In 2021, the percentage of women on pharmaceuticals patents was 3 times higher than the proportion of women on civil patents

Pharmaceuticals and Civil Engineering Patents by Number of Collaborators per Patent

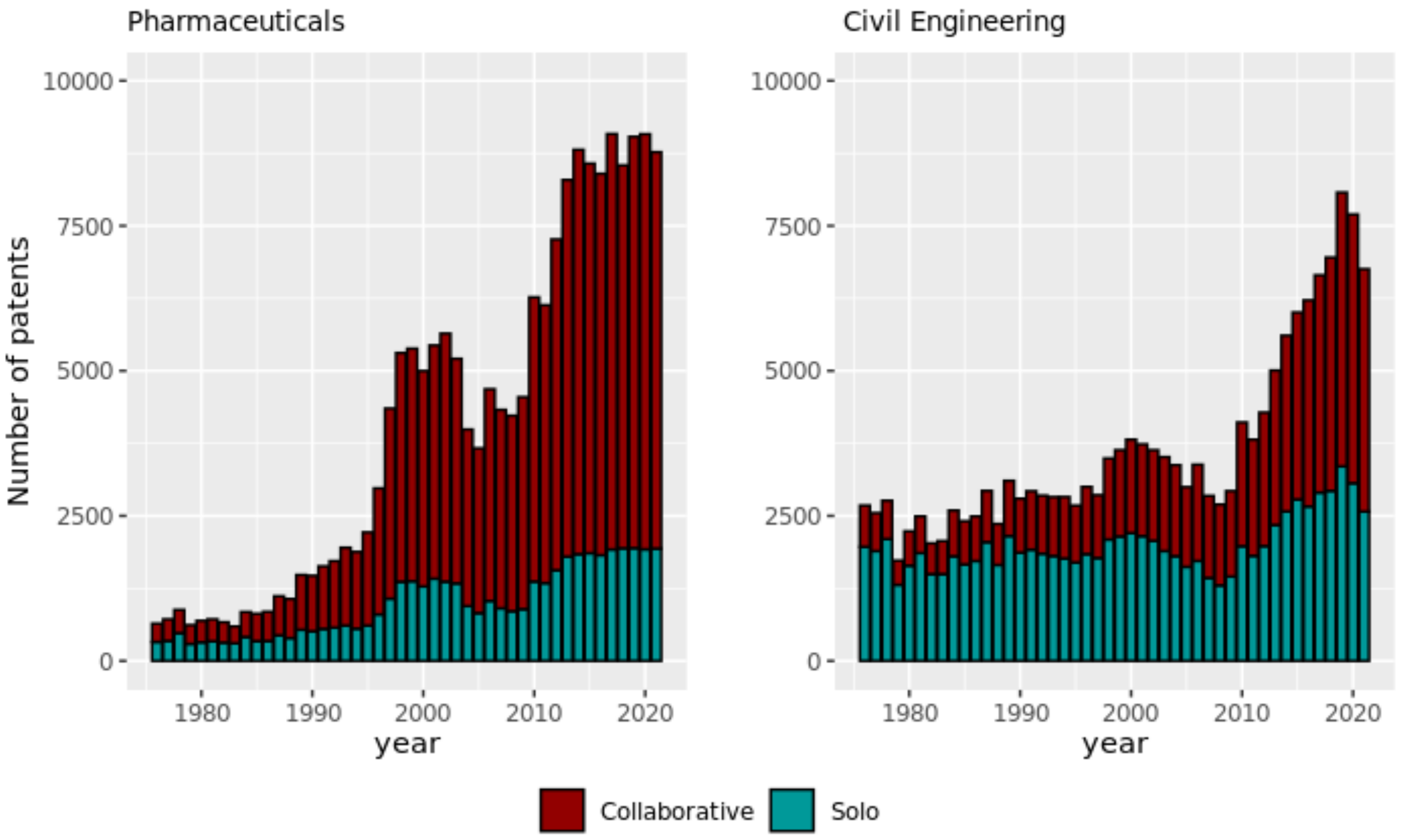


Figure: Distribution of patents by collaborative status

Source: USPTO PatentsView, 1976-2021

Patents categories:

- **Collaborative:** patents with more than one inventor
- **Solo:** patents with only one inventor

In both fields, the number of solo patents is almost constant (or grows at a lower rate). Collaborative patents are driving the growth in the number of patents over time.

There are more collaborative pharmaceutical patents compared to civil engineering patents.

Collaborative Patents by Gender

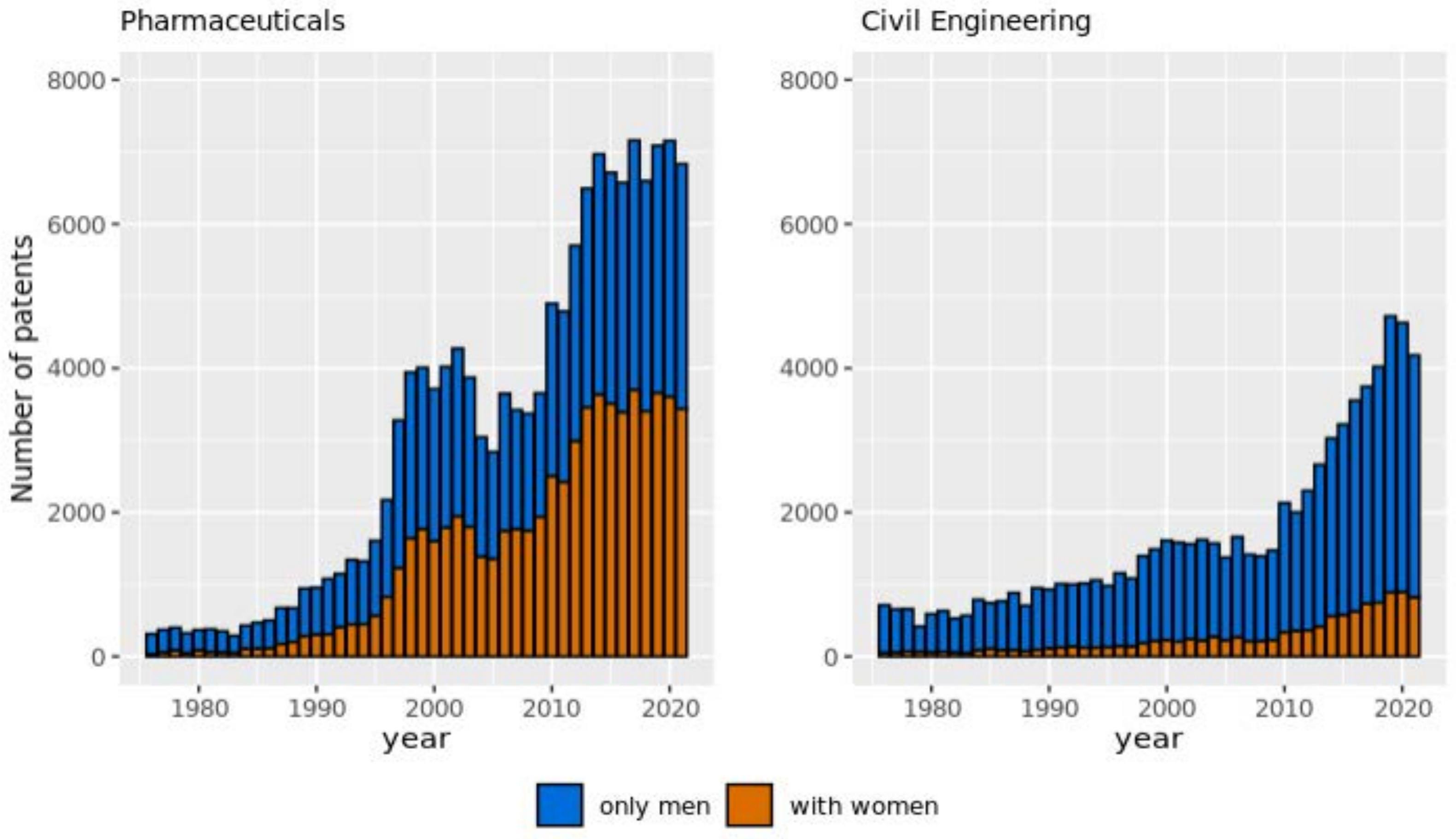


Figure: Distribution of (collaborative) patents according to the presence of women

Source: USPTO PatentsView, 1976-2021

- About half of collaborative patents in pharma include women, compared with a low number of women on civil engineering patents
- The share of collaborative patents with only men is very large in civil engineering and has increased over time

Collaborative patents with at least one woman

Table 1: Gender diversity in collaborative patents

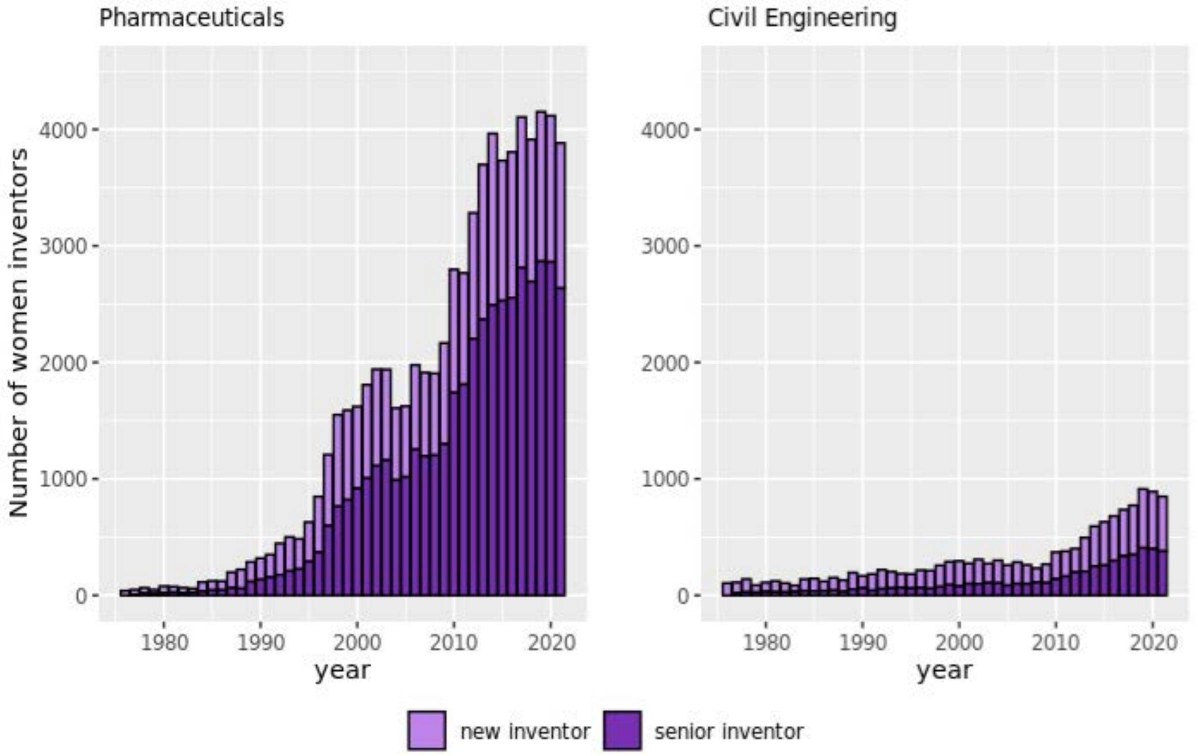
The table only considers collaborative patents with at least one women

field	period	Number of inventors per patents in a year		Percentage of women on patents in a year (%)		Percentage of patents by number of women included by year (%)		
		mean	sd	mean	sd	one woman	two women	3 or more women
civil engineering	1976-1990	2.56	0.97	44.72	0.13	89.13	9.78	1.09
civil engineering	1990-2000	3.11	1.64	40.42	0.15	92.09	6.67	1.24
civil engineering	2000-2010	3.84	2.30	35.83	0.16	90.81	7.58	1.61
civil engineering	2010-2021	3.91	2.07	34.96	0.15	86.82	10.96	2.22
pharmaceuticals	1976-1990	3.03	1.24	41.33	0.15	86.19	11.28	2.53
pharmaceuticals	1990-2000	3.80	1.97	39.51	0.17	76.87	18.39	4.74
pharmaceuticals	2000-2010	4.70	3.07	37.43	0.18	66.61	22.91	10.48
pharmaceuticals	2010-2021	4.98	3.21	36.88	0.18	62.64	24.78	12.58

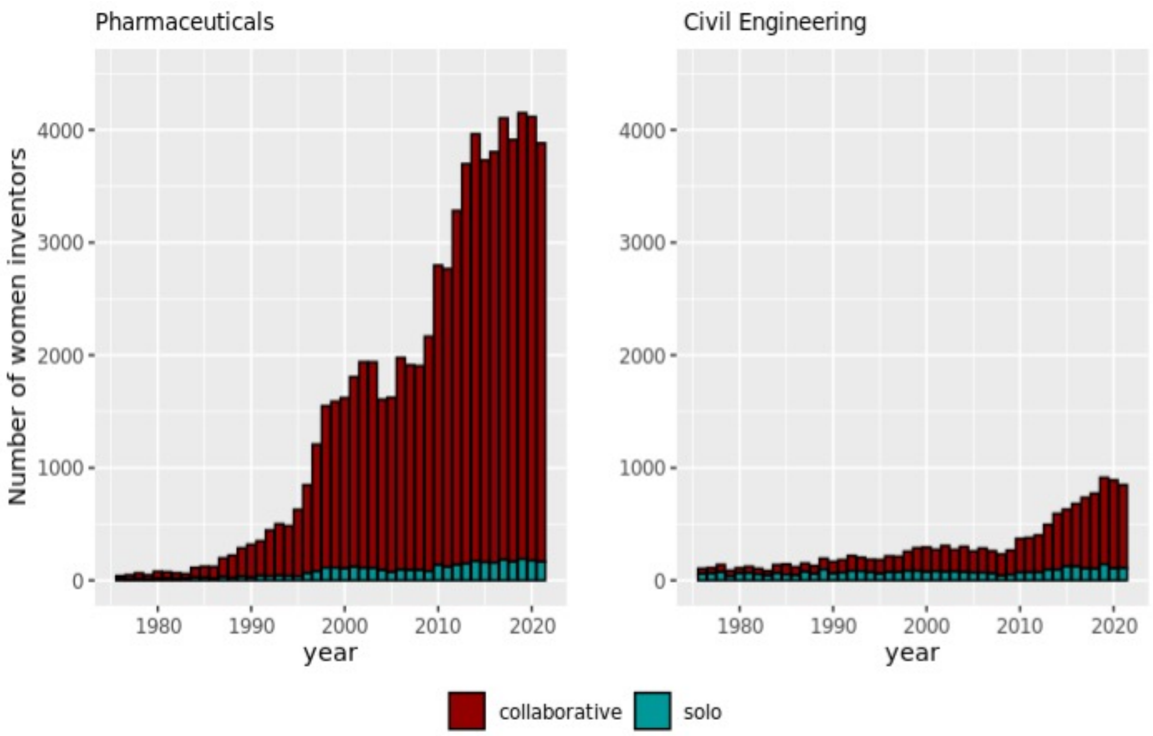
- Over time, while the number of inventors on a patent is growing, **the percentage of women (overall) on collaborative patents is declining** – 45% to 35% on civil engineering and 41% to 37% on pharmaceutical patents
- The percentage of patents with two women and three or more women has increased more on pharmaceuticals than on civil engineering patents.
  - Pharmaceutical patents 11 to 25% (2 women on patents); 3 to 13% (3 or more women on patents)
  - Civil engineering patents 10 to 11% (2 women on patents); 1 to 2% (3 or women on patents)

Source: USPTO PatentsView, 1976-2021

Distribution of women inventors by seniority and collaborative status



Women inventors are more likely to participate on collaborative patents than those submitting a solo patent in both Pharmaceuticals than Civil Engineering.



- **There are more new and senior women inventors in pharma than civil engineering**
- Senior inventor - already has a patent in the prior year or earlier; New inventor- first time inventor

Source: USPTO PatentsView 1976-2021

Distribution of new and senior women inventors by collaboration type

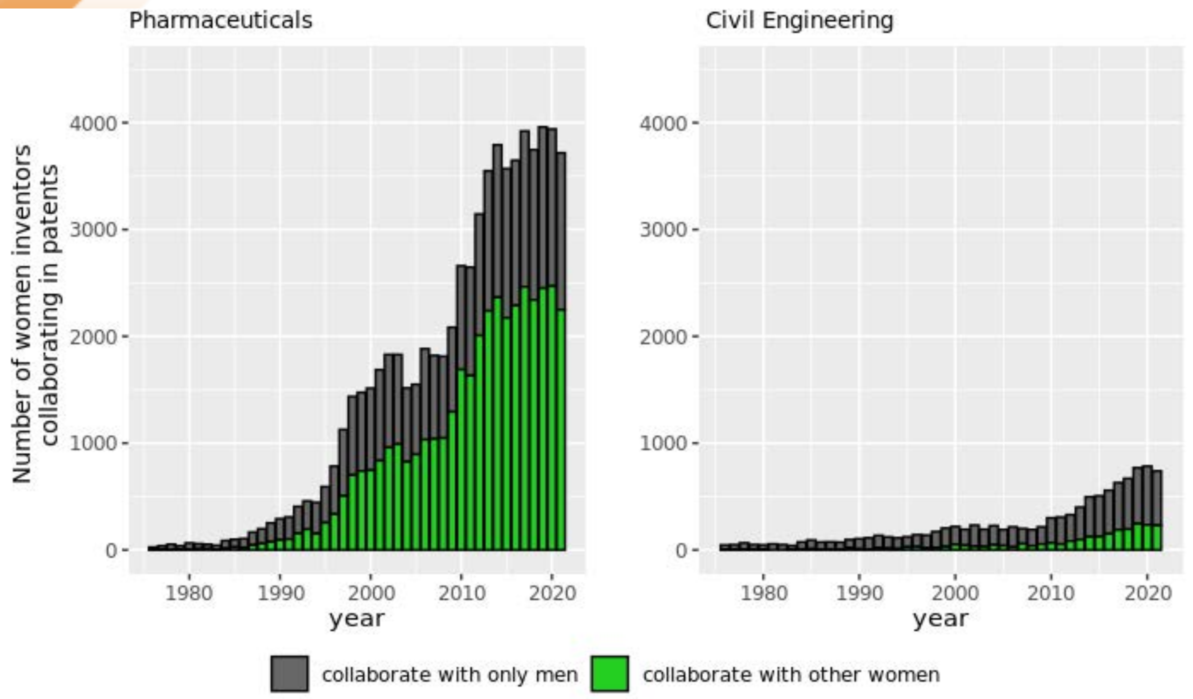
Table: Distribution of new and senior women inventors by collaboration type

Field	Period	Average number of patents per year for women inventors	Percentage of new women inventors (%)		Percentage of senior women inventors (%)	
			Solo patenting	Collaborating patents	Solo patenting	Collaborating patents
civil engineering	1976-1990	4.70	49.45	50.55	50.25	49.75
civil engineering	1990-2000	3.89	34.27	65.73	39.20	60.80
civil engineering	2000-2010	9.42	25.30	74.70	22.92	77.08
civil engineering	2010-2021	15.81	17.90	82.10	14.76	85.24
pharmaceuticals	1976-1990	8.36	18.78	81.22	21.00	79.00
pharmaceuticals	1990-2000	15.81	8.21	91.79	8.52	91.48
pharmaceuticals	2000-2010	24.42	5.70	94.30	4.79	95.21
pharmaceuticals	2010-2021	15.63	5.47	94.53	3.96	96.04

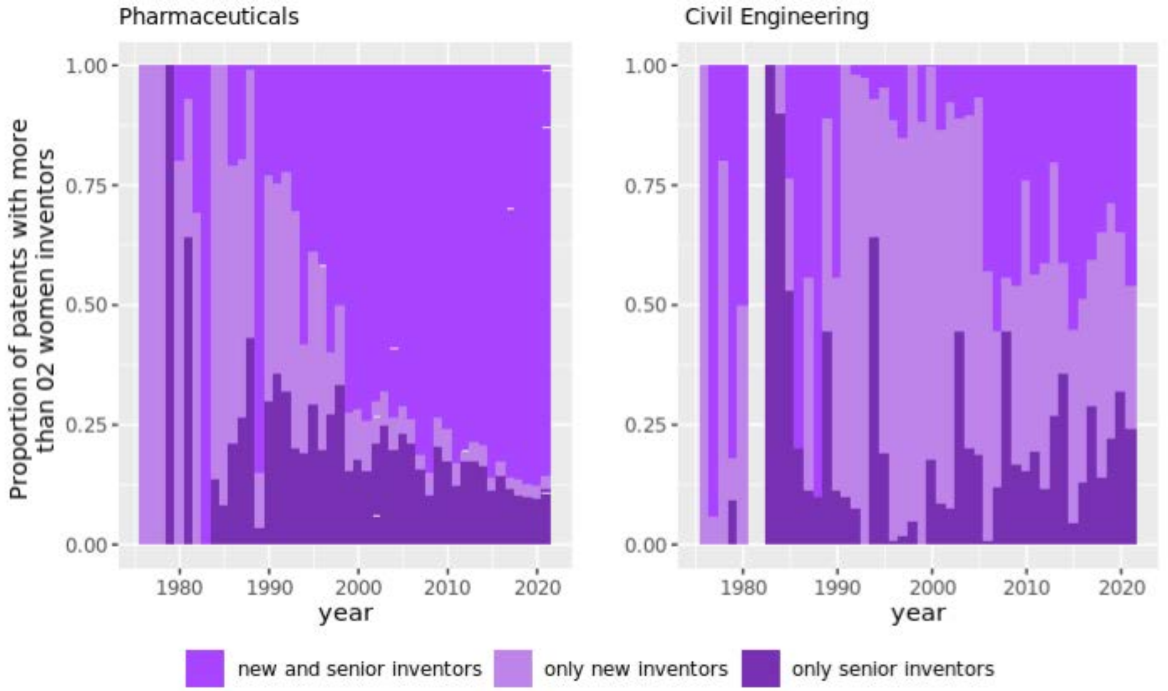
- The percentage of women on solo and collaborative patents is about the same for new and senior inventors.

Source: USPTO PatentsView, 1976-2021

Mentorship in collaborative patents



- Since 2000, women's collaboration on pharmaceutical patents primarily involves senior and new inventors (**women-to-women mentorship**)
- Since 2010, collaboration has been distributed across the three types of mentorship/relationships on civil engineering patents.



- More women inventors collaborate with other women on pharmaceutical patents than on civil engineering patents.
- For civil engineering, there were no patent with two or more women in 1981 (white bar).

Source: USPTO PatentsView, 1976-2021

Percentage of women by occupation and doctorates (PhDs) in Pharmaceuticals and Civil Engineering

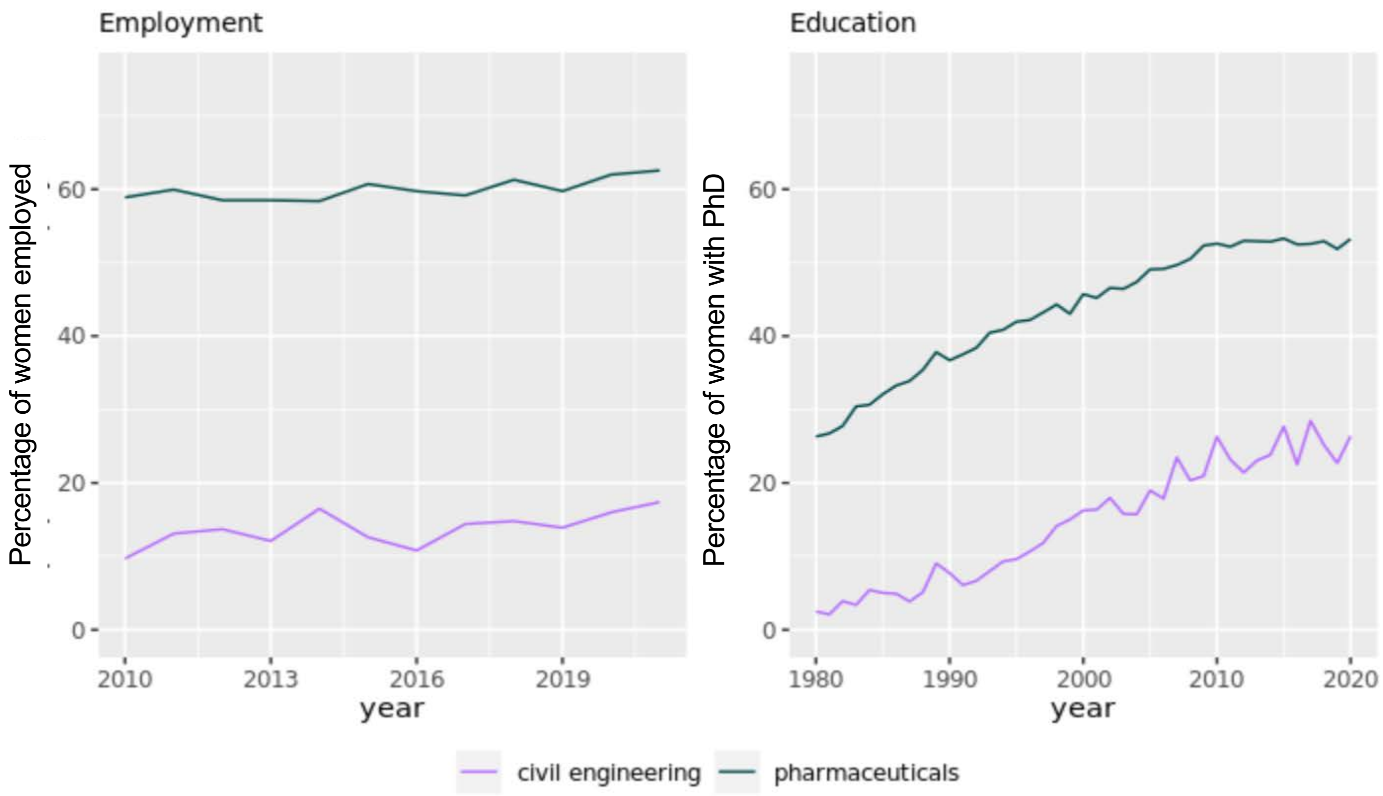


Figure: Percentage of women in occupations and education fields

Source: Bureau of Labor Statistics, Current Population Survey (2010-2021)
NCSES, Survey of Earned doctorates, (1980-2021)

- The percentage of women employed in the pharmaceutical industry is higher than the percentage of women in civil engineering
- The percentage of women with doctorates in pharmaceuticals is higher than the percentage of women in civil engineering.

Key Takeaways

- The number and percentage of women inventors on pharmaceutical patents are higher and growing faster than women inventors in civil engineering.
- Collaborative patents make up the majority of the overall number of patents in both fields over time.
- The number of patents involving women inventors has increased over time.
- More mentorship is observed between women inventors collaborating in pharmaceuticals than civil engineering.

3. Comparing Name Gendering Techniques

Goal: Analyze software packages to compare techniques and outputs using PatentsView as a benchmark within the set of inventors that work in the fields of Civil Engineering and Pharmaceuticals.

Data used: PatentsView public data Inventors dataset

- contains a 'male_flag' column (male=1; female=0)
- We use the indicator to decide whether an Inventor is a man or a woman.

male_flag value is generated using an *analytical method that predicts gender based on the name of the individual and other criteria (e.g., country, time, etc.) and relies on the assumption that frequently, names are gender-specific*

Source: Slide 4 of Assessing approaches for identifying the gender of inventors on patents by Michelle Saksena - https://patentsview.org/events/august26-2022

PatentsView Gendering Process

Analyze and compare PatentsView gendering method to the performance of other open-source or publically accessible methods.

Tier 1: Uses the IBM Global Name Recognition (GNR) database to classify inventors using their first name.

- Names are attributed if the probability associated with their name is equal to or greater than 97%. The threshold is reduced to 95% for popular first names in the GNR library.

Tier 2: Still uses the GNR database, but only for country-name correlations.

- Country of origin is assigned to the country with the highest correlation. Then, a gender is assigned to each inventor, conditional on the gender information provided by the World Gender-Name Dictionary (WGND 1.0).

Tier 3: Uses same GNR process from tier 1, but decreases the thresholds for Asian-origin names (chiefly China, Singapore, Taiwan, Macao, Hong Kong, Korea and India).

Source: From Assessing approaches for identifying the gender of inventors on patents by Michelle Saksena - https://patentsview.org/events/august26-2022

Methods Used

Commonly used methods and datasets for the task of inferring gender from first name.

- WGND 1.0: World Gender Name Dictionary version 1(2016)
- WGND 2.0: World Gender Name Dictionary version 2 (2021) (incorporates country information)
- Gender Guesser in Python https://pypi.org/project/gender-guesser/ (based on a dataset from 2006)
- 'gender' in R https://cran.r-project.org/web/packages/gender/gender.pdf (4 methods in 1)
  1. gender:"ssa" (Better for American names, can be improved by using date of birth)
  2. gender:"ipums" (Uses IPUMS international microdata for names)
  3. gender:"napp" North American countries (better for UK and US and Nordic Countries)
  4. gender:"genderize" (Limit 1000 a day) Most well referenced method, also uses Country https://api.genderize.io?name=peter&country_id=US

Our Analysis

- Take a representative stratified sample (by country) of inventors for Civil Engineering and Pharmaceuticals
  - 2000 inventor names for each industry
- Use each method to assign a gender to the first name of the inventor.
- Compare these gender results to the PatentsView gender value and examine cases of mismatch
- The Confusion Matrix shows the number of correct classifications each method is able to make from our sample.

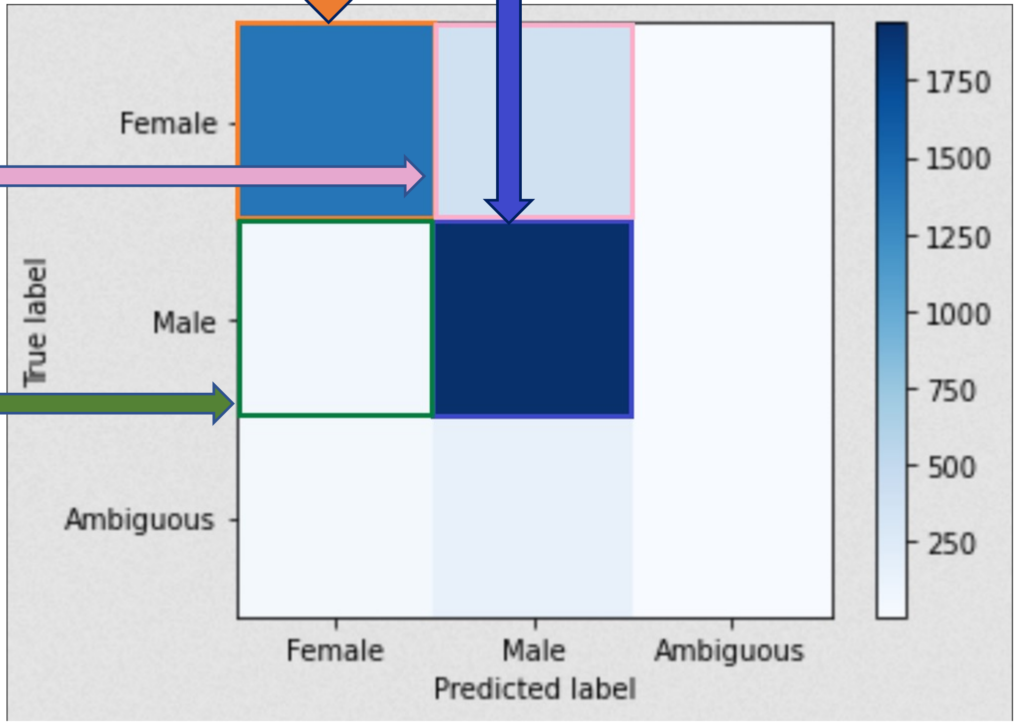
Reading the Confusion Matrix

Number of Male inventors predicted as Male by the Method

Number of Female inventors predicted as Female by the Method

Number of Female inventors predicted as Male by the Method (Type 1 Error)

Number of Male inventors predicted as Female by the Method (Type 2 Error)



Note: We use the USPTO male_flag values for gender assignment, 1 for male and 0 for non male.

Source: Yang et al 2022

This procedure implements a binary gender system to remain consistent with most existing gender studies in science (28, 30), which is not designed to address the important issue of nonbinary gender distinctions in the data.

Source: [28] link here (Pinho et al. 2020)

Source: [30] link here (Hahn & Bentley 2003)

WGND 1.0 [World Gender Name Dictionary]

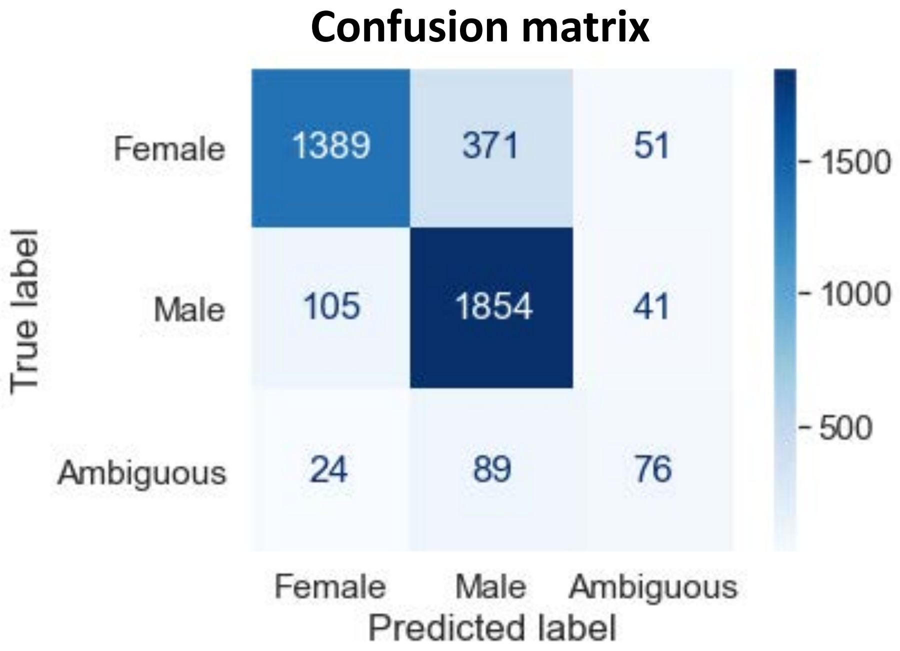
Maintained by Harvard Dataverse

Contains 6.2 million names for 182 different countries. (Last update Nov 2016)

Consolidated by WIPO with the express purpose of identifying the participation of women inventors[ref]

Possible values: M or F

- **The Confusion Matrix shows that this method is best at identifying male names (true & predicted labels match 1854 times)**
- **Erroneous classifications in this method tend to gender females as males (371 times) around 3 times as often as it genders males as female (105 times).**
- **Some Asian names are challenging.**
  - **Nguyen, for example is the most common Vietnamese last name, but in the PatentsView dataset there are cases where it appears as a first name.**



Names the method is not able to gender	Mismatched Names in PatentsView using this method
Name and Frequency	Name and Frequency
casey 5	michael 60
jean-claude 3	robert 52
pengfei 3	john 46
jean-marie 2	james 43
anne-marie 2	david 39
stéphane 2	paul 33
nguyen 2	maria 29
munehiko 1	william 28
sukdeb 1	richard 27
jérôme 1	mark 27

WGND 2.0 World Gender Name Dictionary

Updated version of WGND 1.0

Contains 26 million records for 195 different countries. (Last update 2021)

Consolidated by WIPO with the express purpose of identifying the participation of women inventors[ref]

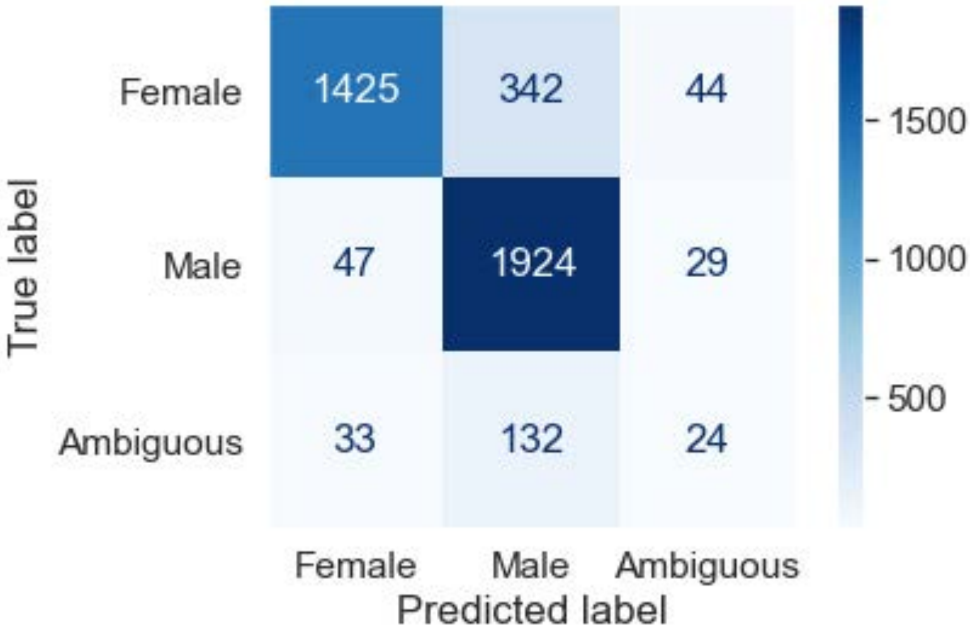
Possible values: M or F or ?

Uses country codes for more effective matching

(Add male names mismatched and female names mismatched)

- **The Confusion Matrix shows that this method is best at identifying male names (true & predicted labels match 1924 times)**
- **Erroneous classifications in this method tend to gender females as males (342 times)** compared to the previous method. There is not much progress when it comes to female names (342 misidentified compared to 371 in WGND 1.0).

Confusion matrix



Names the method is not able to gender	Names that mismatch with PatentsView using this method
Name and Frequency	Name and Frequency
young 10	young 12
hyun 4	james 11
ju 3	michael 9
sung 3	mike 5
seung 2	casey 5
sang 2	mark 5
yun 2	john 5
in 2	dominique 5
you 2	christopher 5
jung 2	samuel 4

Python Gender-Guesser package

Popularly used package in Python, one of the oldest packages developed for guessing the first name from gender.

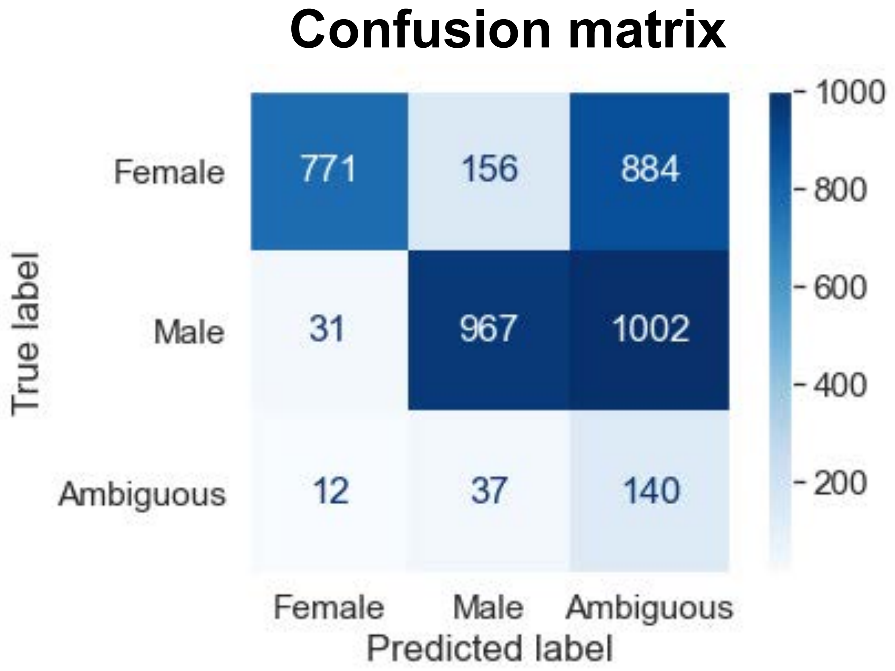
Based on a dataset collected by Jorg Michael, containing 40,000 names (from 2006), which was first collected into a python package in 2013 . This package has been ported to several different languages but there is not much documentation on the method.

Focus is on European names

Source:[ref][https://github.com/cstuder/genderReader/blob/master/gender.c/gender.c]
This list should be able to cover the vast majority of first names in all European countries and in some overseas countries (e.g. China, India, Japan, U.S.A.) as well

Possible values: male, female, unknown (not found in the dataset) or andy (androgynous)

- **The Confusion matrix shows that the method frequently misclassifies names as ambiguous (884 female and 1002 male).**
- **This is indicative of the relatively small dataset that powers this method, and the fact that this is one of the oldest implementations of a gendering system using first names.**



Names the method is not able to gender	Names that mismatch with PatentsView using this method
Name and Frequency	Name and Frequency
john 39	john 39
robert 38	michael 36
michael 36	robert 36
james 33	james 36
david 24	david 25
william 24	william 24
maria 21	mark 23
paul 20	maria 22
mark 20	paul 21
daniel 18	daniel 18

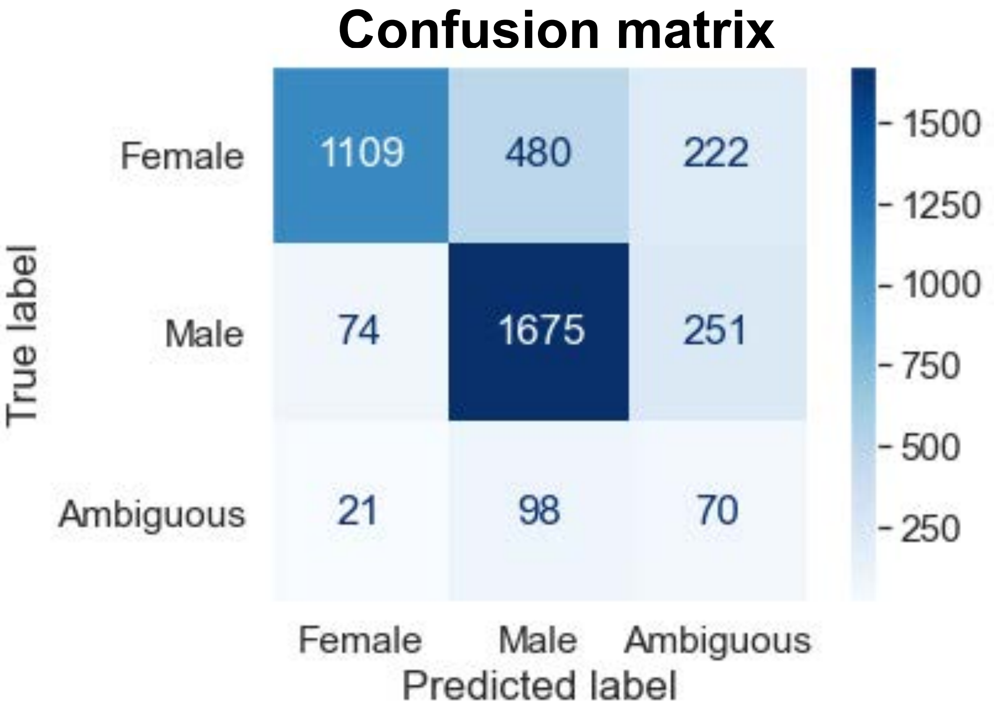
IPUMS Method

One of the methods in the R ‘gender’ package

Possible values – [‘male’, ’female’, ’unknown’, ‘either’]

IPUMS originally stood for Integrated Public Use Microdata Series. Since then, the datasets assembled have expanded and not all these projects are microdata and some have access conditions that limit their usage. It became inaccurate to describe IPUMS as a "public use” microdata series, So now, IPUMS continues as the data series name though it is no longer an acronym

- **The Confusion Matrix shows a relatively high classification as ambiguous (but not as high as the Python Gender-Guesser package)**
- **The table shows the difficulty of this method to gender Asian names.**



Names the method is not able to gender	Names that mismatch with PatentsView using this method
Name and Frequency	Name and Frequency
thierry 6	young 12
yusuke 3	james 11
hirofumi 3	kelly 10
hartmut 3	michael 9
svetlana 3	leslie 8
pengfei 3	nicole 6
chantal 3	thierry 6
jean-claude 3	john 5
nguyen 2	mike 5
hyoung 2	mark 5

SSA Gender Method (Social Security)

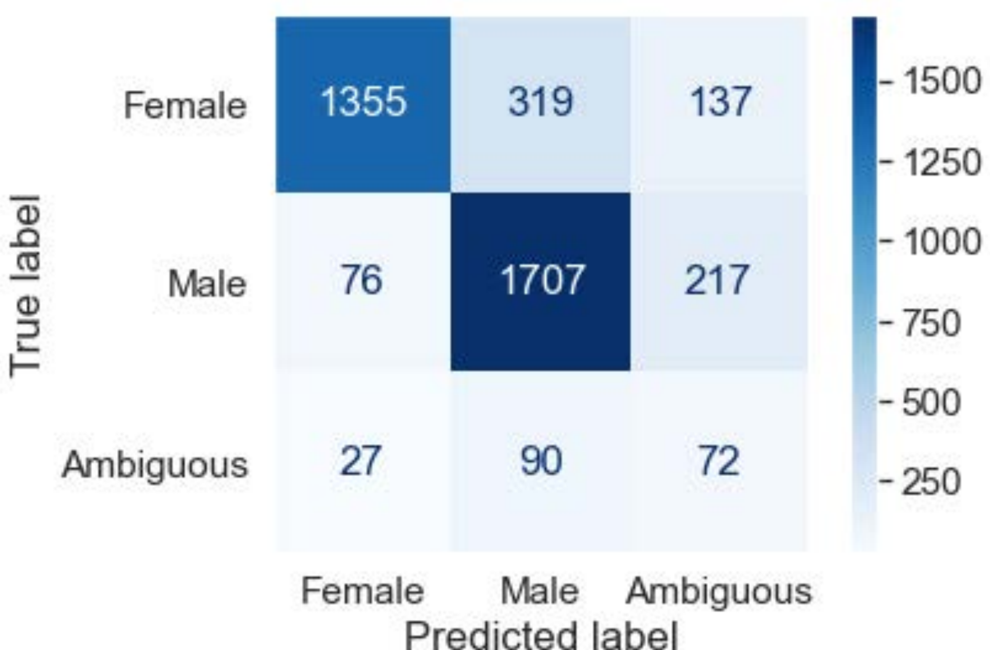
One of the methods in the R ‘gender’ package

The "ssa" method looks up names based from the U.S. Social Security Administration baby name data. (This method is based on an implementation by Blevins & Mullen 2015.

Possible values – [‘male’, ’female’, ’unknown’]

- **The Confusion Matrix shows higher accuracy for male names and less for female names.**
- **From the names that the method can't gender, this method has difficulty with Asian and French names, likely because the Social Security datasets are from the US and are several decades old.**

Confusion matrix



Names the method is not able to gender	Names that mismatch with PatentsView using this method
Name and Frequency	Name and Frequency
jean-claude 3	young 12
pengfei 3	james 11
hartmut 3	michael 9
yoshitaka 3	mark 5
albrecht 3	casey 5
hirofumi 3	christopher 5
shigeki 2	john 5
toshihiko 2	mike 5
fumio 2	merle 4
wilhelmus 2	kevin 4

NAPP Gender Method

One of the methods in the R ‘gender’ package

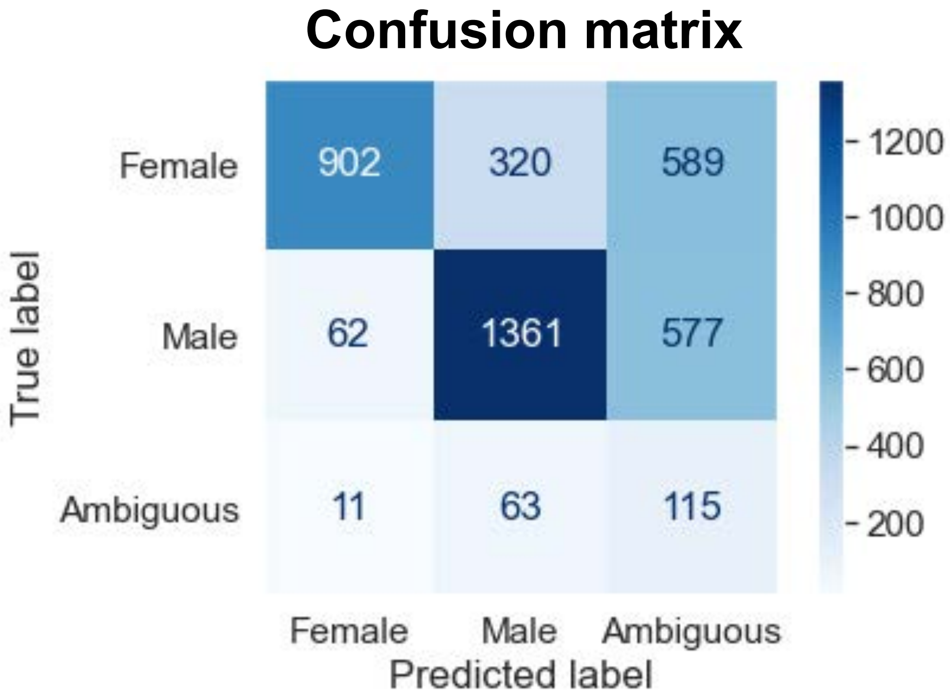
Uses name: gender dictionaries sourced from the North Atlantic Population Project

Focuses on the following countries: "United States", "Canada", "United Kingdom", "Denmark", "Iceland", "Norway", "Sweden“

Uses census microdata from Canada, Great Britain, Denmark, Iceland, Norway, and Sweden from 1801 to 1910

Possible values – [‘male’, ’female’, ’unknown’, ‘either’]

- **The Confusion Matrix shows frequent classification as ambiguous (589 female and 577 male), reflective of the dataset being sourced primarily from European and North American countries.**



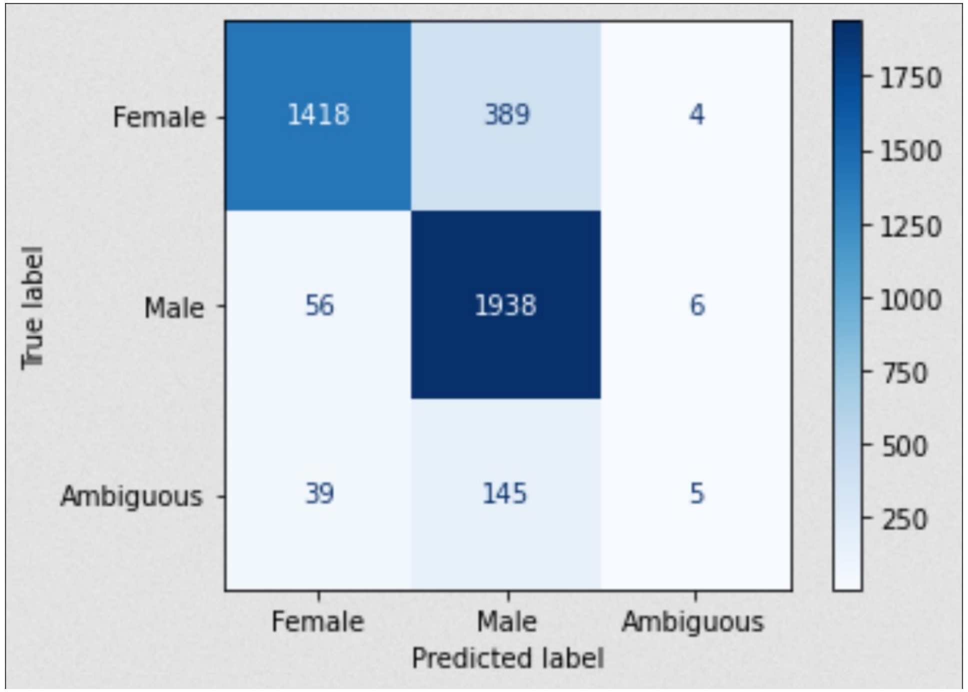
Names the method is not able to gender	Names that mismatch with PatentsView using this method
Name and Frequency	Name and Frequency
jennifer 13	jennifer 13
hiroshi 7	young 12
thierry 6	james 11
casey 5	michelle 11
dawn 5	michael 9
hong 5	leslie 8
wei 5	hiroshi 7
hyun 4	jean 6
akiko 4	thierry 6
brad 4	mike 5

Genderize.io

One of the most commonly used methods in recent times
Uses social media data to build name-gender dictionaries, which makes it the best representation of real-world data.
Possible values – [‘male’, ’female’]
Very few cases where this method is not able to gender a name, reflective of the large dataset it works with.

- **The Confusion Matrix shows high accuracy (1938 male names and 1418 female names)**
- **The tendency when the method makes errors is to predict females as males (389 times).**

Confusion matrix



Names the method is not able to gender	Names that mismatch with PatentsView using this method
Name and Frequency	Name and Frequency
sangmeshwer 1	young 12
avadhesha 1	james 11
jing-shan 1	michael 9
vedala 1	mike 5
annebärbel 1	casey 5
claes-inge 1	dominique 5
a. 1	john 5
yu-qing 1	mark 5
sabbana 1	christopher 5
hong-da 1	stephen 4

Prediction Results

Key Observations:

- WGND 2.0 and Genderize.io have the highest **accuracy**
- **Precision** is lower for males, i.e., When errors occur, its usually a female name incorrectly classified as male (**Type 1 error is higher than Type 2**)
- **Precision** is high for female names, which means that when these methods classify names as female they tend to be correct.
- **Recall** is high for male names, which means a **large proportion of male names are actually captured by the methods.** **Recall** for female names tends to be lower, meaning that fewer female names are captured out of the total set.
- **F1 score** is the harmonic mean of precision and recall. Practically it acts as a score for model performance, and in this case, it can be used to decide which method is best at classifying male names and female names.

Comparing name-to-gender predictions

Gender Attribution Approaches:	PatentsView Male Flag	WGND 1.0	WGND 2.0	Python Gender.Guesser	IPUMS	SSA	NAPP	Genderize.io
Total predictions:	3,985	3,243	3,903	1,974	3,457	3,574	2,719	3,356
Out of:	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Prediction rate:	0.996	0.811	0.976	0.494	0.864	0.894	0.680	0.839
Accuracy		0.830	**0.843**	0.470	0.714	0.784	0.595	**0.840**
Male								
Precision		0.801	0.802	0.834	0.743	0.807	0.780	0.784
Recall		0.927	0.962	0.484	0.838	0.854	0.681	0.969
F1 score		0.860	0.875	0.612	0.788	0.829	0.727	0.867
Female								
Precision		0.915	0.947	0.947	0.921	0.929	0.925	0.937
Recall		0.767	0.787	0.426	0.612	0.748	0.498	0.783
F1 score		0.834	0.859	0.587	0.736	0.829	0.648	0.853
Ambiguous								
Precision		0.452	0.247	0.069	0.129	0.169	0.090	0.333
Recall		0.402	0.127	0.741	0.370	0.381	0.608	0.026
F1 score		0.426	0.168	0.126	0.191	0.234	0.156	0.049

- WGND 2.0 and Genderize.io are consistently the best methods for those tasks (But not necessarily the best at handling ambiguous names)

Consistent Mismatches

- The tables show examples where all gendering methods predict one value but USPTO male_flag disagrees.
- In our sample set, there are 12 cases where females are assigned as male_flag 1 (male), and 81 cases of males assigned as male_flag=0. (female)
- Pattern might imply an overcounting of women inventors – *would need to examine larger sample to confirm*

name_first	name_last	male_flag
Caroline	Martin	1
Audrey	Brown	1
Linda	Parker	1
Esther	Schmitt	1
Claire	Wilson	1
Adriana	Katz	1
Marie	Andersson	1
Jenny	Viklund	1
Diana	Thompson	1
Melinda	Sanders	1
Julie	Hughes	1
Maria	Castaneda	1

name_first	name_last	male_flag
Christian	Neumann	0
Adam	Baker	0
Donat	Pelletier	0
Andrew	Wright	0
Martin	Joly	0
Rob	Walker	0
Caleb	Curtis	0
Scott	Kirk	0
Martin	Kowalski	0
Yong	Luo	0
Andreas	Schroeder	0
Klaus	Voigt	0

Civil Subset vs Pharmaceutical Subset

Are their differences in assigning male/non-male flags in Civil Engineering compared to Pharmaceuticals?

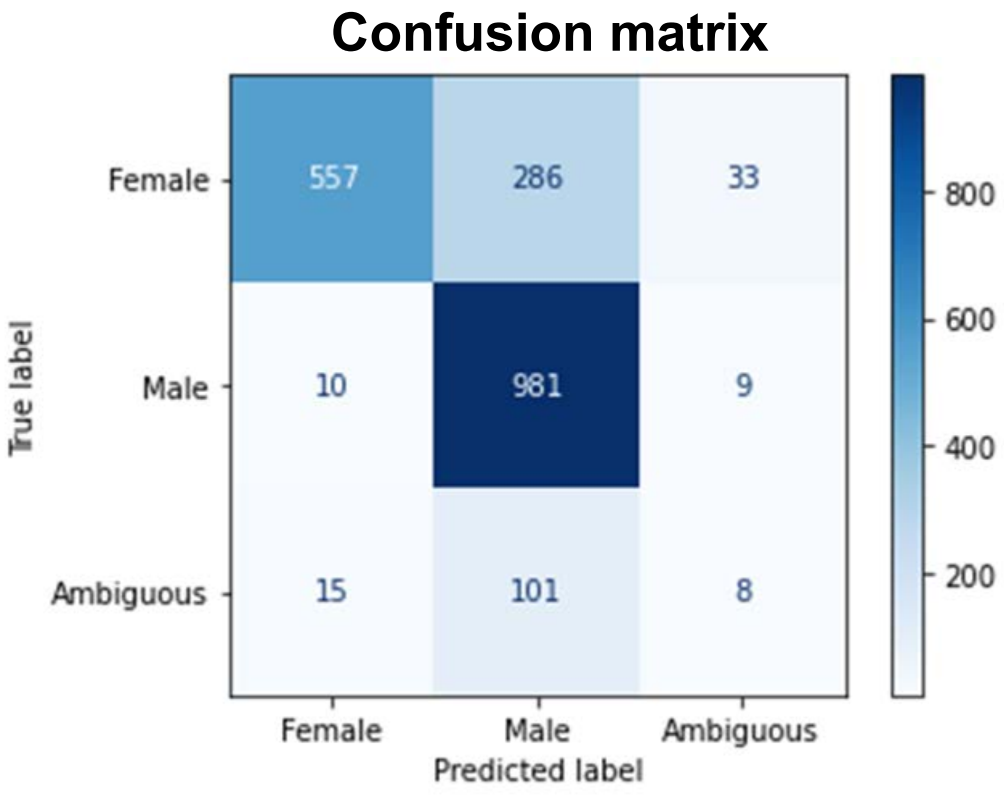
Used the two high performing packages:

- WGND 2.0
- Genderize.io

- We split the dataset by field (Civil and Pharma) and also by gender as assigned by male_flag (1 or not 1)
- This results in 4 sets. civil_nonmale, civil_male, pharma_nonmale, pharma_male,
- Comparing accuracy measures, using male_flag as ground truth and WGND 2.0 as our method gives us
  - ['accuracy_score', 0.565, 0.981, 0.884, 0.943]
- Comparing accuracy measures using male_flag as ground truth and genderize.io as our method gives us
  - ['accuracy_score', 0.558, 0.984, 0.865, 0.954]
- **Key Takeaway:** The male_flag assigned gender is incorrect more frequently when gendering civil inventors who are not male. Pharma inventors who are not male get correctly identified significantly more often than civil inventors who are not male.

Civil Subset Analysis: WGND 2.0

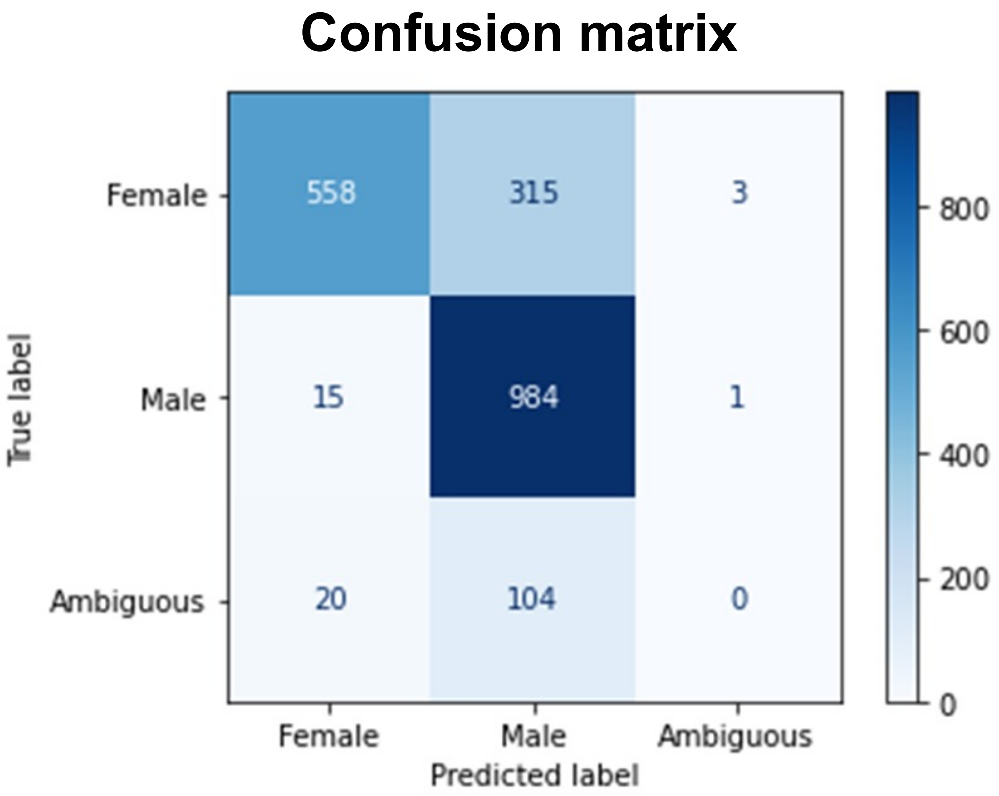
- Confusion matrix: female names are more often misclassified as males. Results are similar to Genderize.io
- Because the ground truth we are using for comparison is the PatentsView male_flag, some of these mismatches may be incorrectly assigned. These mismatches may also be the result of country-specific naming conventions which often allows certain names to be used by both males and females.



Male Names Assigned Female	Female Names Assigned Male
Name and Frequency	Name and Frequency
parveen 1	michael 9
krishna 1	james 9
audrey 1	dominique 5
jean 1	john 5
sophia 1	mike 5
sharon 1	andrew 4
maria 1	casey 4
caroline 1	samuel 4
kazumi 1	kerry 4
leslie 1	merle 4

Civil Subset Analysis: Genderize.io

- Confusion matrix: female names are more often misclassified as males. Results are similar to WGND 2.0
- Similar to the prior slide, some of these mismatches could be related to the inconsistencies in the male_flag column or country specific naming conventions.

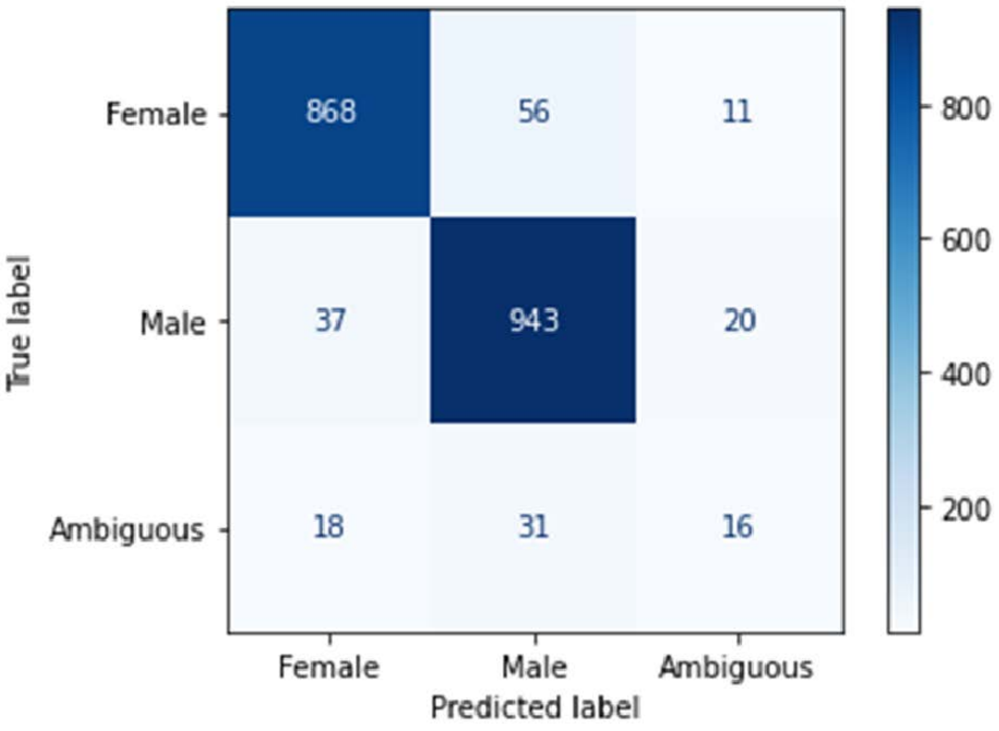


Male Names Assigned Female	Female Names Assigned Male
Name and Frequency	Name and Frequency
maria 1	michael 9
vesa 1	james 9
sharon 1	young 9
sophia 1	mike 5
ira 1	dominique 5
leslie 1	john 5
audrey 1	andrew 4
parveen 1	casey 4
kazumi 1	samuel 4
jean 1	kevin 4

Pharmaceutical Subset Analysis: WGND 2.0

- Confusion matrix: The classification of male and female names appears accurate in the pharmaceutical sector.
- Several of the mismatched names seem to be of Asian origin. Asian names are more challenging for name gendering systems.

Confusion matrix



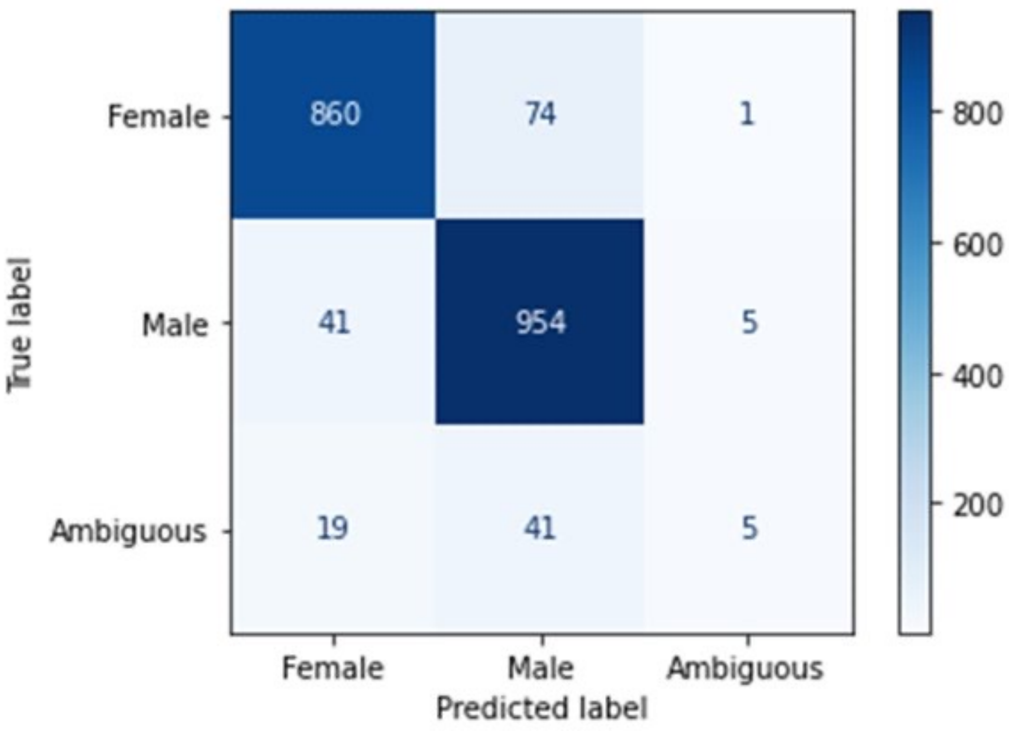
Male Names Assigned Female	Female Names Assigned Male
Name and Frequency	Name and Frequency
tomomi 3	kei 2
morgan 2	stephen 2
andrea 2	christopher 2
karen 1	mark 2
linda 1	young 2
maureen 1	james 2
marite 1	mugesh 1
shikha 1	yuichi 1
xiaoli 1	yero 1
rachel 1	jae 1

Pharmaceutical Subset Analysis: Genderize.io

Similar to the WGND 2.0 method,

- Confusion matrix: The classification of male and female names appears accurate in the pharmaceutical sector.
- Several of the mismatched names seem to be of Asian origin. Asian names are more challenging for name gendering systems.

Confusion matrix



Male Names Assigned Female		Female Names Assigned Male	
Name and Frequency		Name and Frequency	
tomomi	3	young	3
jean	3	jin	3
jean-marie	2	hyun	2
andrea	2	stephen	2
esther	1	kei	2
jinny	1	mark	2
maria	1	christopher	2
marie	1	laurence	2
sangeeta	1	james	2
agnes	1	ji	1

Key Takeaways

- Most methods for gendering using first name tend to be better at classifying male names. This may be because *When it comes to naming children, most people are more comfortable giving girls an unusual name.*
  - *Researchers informally call this the "playground effect," in which new parents imagine how the name they choose will play out for their child in the crucible of school recess* (Hahn & Bentley 2003).
- Using WGND 2.0 with its country code field, could be a useful way to help address these mismatches. (This should be relatively easy considering WGND 1.0 is already part of the USPTO method)
- USPTO PatentsView male_flag may have a few mismatches, ~2% (assuming consensus between all other techniques) Mismatch could be higher if we don't use methods like NAPP and Gender.Guesser (that have limited databases)
- This mismatch might result in an overestimation of the number of female inventors.
- Significant number of mismatches originate from the challenges involved in gendering Asian inventor names, e.g., Korean, Japanese and Indian. French names can also be challenging.
- The male_flag assigned gender is incorrect more frequently when gendering civil inventors who are not male. Pharma inventors who are not male get correctly identified significantly more often than civil inventors who are not male.

4. Increasing Women Inventors: Challenges & Benefits (Literature Review)

Challenges

Underrepresentation of women in many STEM fields and on patents (Couch et al. 2020, Toole et al. 2021)

Implicit bias in innovation, education, and patent review boards (Stewart, 2017)

Lack of high-quality, affordable childcare (Cutura 2019, Yellen 2017, US Dept of Treasury 2021)

Stagnation in women's labor force participation (Aguirre 2012, BLS 2022)

Benefits

Increasing the female participation rate to that of men would raise our Gross Domestic Product by 5 percent (Aguirre et al. 2012)

Increasing women inventors would increase the breadth and novelty of patents applicable to all (Reardon 2021, Yang et al. 2022)

Ambitious USPTO Policy Idea

<u>USPTO - NSF</u>

Create innovative K-16 Educational Programs through grants programs, **e.g., fund grantees to develop and implement educational patent programs**

- Fund through
    - **Engineering Education and Centers (EEC)**
    - **Research** on **Learning in Formal and Informal Settings (DRL)**
- Develop patent programs in girls-focused programs for K-12, e.g., Girls Excelling in Math and Science (GEMS), Girls Who Code, etc.
- Work with NSF to include patenting ideas in Broader Impacts criteria

NSF National Science Foundation
WHERE DISCOVERIES BEGIN

Ambitious USPTO Policy Idea

<u>USPTO-Treasury Dept Partnership</u>

Create *Increasing Women Inventors program*

- High profile program supported by Janet Yellen, USDT, and Kathi Vidal, USPTO
- Co-fund out of the Treasury's Equity Hub and USPTO Office of Innovation Outreach (OIO)

Kathi Vidal, Undersecretary of Commerce, USPTO

Janet Yellen, Secretary, Treasury Department

- Increase visibility of economic benefits & challenges for women inventors
- Conduct focus groups to develop policy ideas to support women inventors
- Expand existing mentorship programs across organizations, e.g., the Society for Women Engineers

Ambitious USPTO Policy Idea

Test anonymizing patent review process. Why?

- Blind auditions increase women in orchestras (Goldin & Rouse 1997)
- Harvard Business Review, To Reduce Gender Bias, Anonymize Job Applications (Johnson & Kirk 2020)
- NSF's Big Pitch experiment focused on novel ideas (Bhattacharjee 2012)
- NASA Science Mission Directorate, motivated by Hubble Space Telescope study, is adopting dual-anonymous peer review (DAPR) (Evans 2021)

What's in a name?

Taylor (*left*) and Mydlarz (*right*) are among a handful of researchers who won NSF grants based on anonymous, two-page proposals describing the big idea behind their projects. CREDIT: COURTESY OF LAURA MYDLARZ; RICHARD MORAN

Approach

- Hire experts and offer training to increase awareness of and to reduce implicit biases (Gino & Coffman 2022)
- Test experimentation and adoption of anonymous reviews (NSF 2012, NIH 2017, NAS 2021)

Other Ideas – See Appendix 4

Evaluate USPTO Outreach Programs

Who do they reach? Do they inspire innovation? What are outputs and outcomes? What is working/not working? How do results compare to nonprofit and private-sector initiatives?

- Women's Entrepreneurship Symposium
- Inventor and entrepreneur resources
- Inclusive Innovation hub
- Startup resources
- Many other programs

Partner with existing organizations (SWE, Lemelson-MIT InvenTeam, dozens of other programs)

- Branding – USPTO logo as a supporter
- Work with organizations to increase awareness and knowledge of patenting process, e.g., Patent law organizations

Appendix: Background Literature

Increasing Women Inventors: Challenges and Benefits

Challenges

- Underrepresentation of women in many STEM fields and on patents (Couch et al. 2020, Toole et al. 2021)
- Implicit bias in innovation, education, and patent review boards (Stewart, 2017)
- Lack of high-quality, affordable childcare (Cutura 2019, US Dept of Treasury 2021)
- Stagnation in women's labor force participation - Since 2000, the participation rate has stagnated in the U.S. – even as it has continued to rise in other advanced economies (Yellen 2022, BLS 2022)

Benefits

- Increase GDP - increasing the female participation rate to that of men would raise our Gross Domestic Product by 5 percent (Aguirre et al. 2012)
- Increase the breadth of patents applicable to all (Reardon 2021)
- Increase novelty of patents (Yang et al. 2022)

Increasing Women Inventors - Challenges

- Underrepresentation of women In STEM
- Implicit Bias
- Lack of high-quality and affordable childcare
- Stagnant women’s labor force participation

Underrepresentation of Women

Women are on 5.5% of commercialized patents (Toole et. al, 2021)

- Mostly in teams

Young men and women are equally STEM capable, but women lack networks and exposure --> less opportunities for women (Couch et al. 2020)

- Both sexes perform equally well on science and math assessments in high school.
- AP enrollment is equal for both sexes
- Women are not exposed or encouraged to enter STEM careers early on nor made aware of women inventors

Childcare responsibilities are one reason that women to leave STEM workforce (Cutura 2019, Yellen 2017, 2022, US Department of Treasury 2021)

- Childcare is affordable for fewer than half of families
- Childcare requires ~13% of family income
- Childcare workers are in the bottom 2% of occupations

Implicit Bias

- Funding bias
  - Funding is necessary to patent due to huge costs (Cutura, 2019)
  - Venture capitalists see innovation as male-dominated (Stewart, 2017)
    - Male-produced innovations are more likely to be funded
- Patent review bias
  - Patent review boards tend to be male-dominated --> approve more male patents (Stewart, 2017)
  - Patenting seen as male field
- Education bias
  - Teachers tend to call on boys more than girls in math class (Stewart, 2017)
  - Parents may encourage daughters to pursue more female-dominated fields

Increasing Women Inventors - Benefits

- Economic growth
- Diversity increases the novelty of inventions
- Spillover effects of affordable and available childcare

Outcomes with More Female Innovators

Economic growth

- Increasing female patenting would lead to 2.7-3.3% GDP growth (Cutura, 2019)
- As more women get patents --> more women have successful startups --> economic growth
- Metropolitan areas have more female inventors (concentration in medicine/chemistry and computer science industries) (Saksena et al. 2022)

Diversity links to novel innovations

- All women patent teams are 35% more likely to focus on women's health than all male or mixed teams (Koning et al. 2021)
- More women patenting will lead to more inventions that benefit women (Koning et al. 2021)
- Gender-diverse teams produce more novel and higher-impact scientific ideas (Yang et al. 2022)
- Female experiences inform and improve quantity and quality of innovation, expands research into new topics (fills technology gaps) (Saksena et al. 2022)

Outcomes with Affordable and Available Childcare

Improve childcare --> healthier, more prosperous labor force

- Children stay in school longer and get higher-paying jobs (Yellen 2021)

Women can stay in workforce (US Department of Treasury 2021)

- 0.5% real GDP growth per year from 1948-1990 due to more female participation in labor force
- Without childcare, women often take care of kids
  - Glass ceiling for women- intense careers demand long, inflexible work weeks
  - Part-time work – lower wages and less opportunity for advancement

- **Improve paid leave policies for caregiving and health responsibilities** (like Europe) (Ricci 2015, Expatica 2018, 2022)
  - Better maternity leave, as well as leave for other child-related issues
  - Companies can also provide more flexible work weeks for women caring for children

Increasing Women Inventors – Policy Ideas

Addressing Underrepresentation of Women Inventors

- Education
- Networking
- Childcare
- Partnering with professional societies

Addressing Implicit Bias

- Patent reviews
- Education
- Funding

Increasing Women Inventors – Policy Ideas

Education policies

- Expose and mentor young girls in innovation (campaigns in schools, programs targeted to girls)
- Dual enrollment programs and inventive education (Couch et al. 2020)
  - Public engagement beyond exposure will solidify interest in inventing (Couch et al. 2018)
- Provide career pathways, not just prerequisite education (Stewart 2017)
- Affluent school districts can implement inventive education campaigns more easily but must watch for socioeconomic gaps (Couch et al, 2020)
- Webinars on the importance of patenting and guidance on how to succeed (Cutura 2019)
- Lemelson-MIT InvenTeam program (Couch et al. 2018)

Addressing Bias

- K-12 education programs will decrease bias in classroom (exposes and encourages young girls)
- WIPO can encourage institutions/companies to examine programs for gender bias (Cutura, 2019)

Increasing Women Inventors – Policy Ideas

Networking policies

- Create networks for women pursuing and already in STEM careers --> better access and connections to pursue patents (Shaw et al. 2018)
- Programs can implement spaces for women to make connections and hear experiences of other women and mentors (Shaw et al. 2018)
- Research Evaluation and Commercialization Hubs (REACH) (NIH 2022)

Childcare and workplace policy

- Flexible work arrangements and affordable childcare for working mothers (Cutura, 2019)
- Seminars and workshops to shed light on issues women face in the workplace and identify policies that will make a difference (Cutura, 2019)
- Improve paid leave policies for caregiving and health responsibilities
  - Better maternity leave, as well as leave for other child-related issues
  - Companies can also provide more flexible work weeks for women caring for children

Increasing Women Inventors – Policy Ideas

Partner with existing organizations, *for example,*

Society of Women Engineers empowers women to achieve their full potential in engineering careers

  - “advocate and catalyst for change for women in engineering and technology.

- Main focus is networking for women to
  - Share practices and raise awareness about issues in engineering education and workplace
  - Mentor young girls, girls pursuing engineering degrees, and professional engineers (SWENext & SWENext Clubs)
  - Patent Recognition Rewards - annually recognizes SWE members who have been awarded a patent within the previous three years from the award application deadline.

Source: Society of Women Engineers, 2022

Increasing Women Inventors – Policy Ideas

Patent Review Bias

- Patent committees should be trained against bias (Cutura, 2019)
- WIPO can examine IP Law for bias against women (Cutura, 2019)

Funding Bias

- Create programs to fund female innovators (Shaw et.al., 2018)
  - Bioscience and Entrepreneurship Inclusion Initiative (BioSTL)
  - SBIR/STTR Phase 0 Assistance Program (U.S. Department of Energy)
- Create remote patent process to alleviate funding concerns/bias (and saves time) (Cutura, 2019)
- Companies can help employees with legal services and filing fees (Couch et.al., 2020)
  - Companies can file on behalf of female employee if they support commercializing the idea (Shaw et.al., 2018)
  - Alleviates funding concerns

Increasing Women Inventors – Policy Ideas

Evaluate the effectiveness of USPTO Innovation Outreach programs compared to private & non-profit sector programs

- Develops awareness and outreach programs and training for inventors, organizations, and universities
- Creates annual programming and works with partners from other federal agencies, organizations, and universities to help everyone better understand, secure, and utilize IP
  - Women's Entrepreneurship Symposium
  - Inventor and entrepreneur resources
  - Inclusive Innovation hub
  - Startup resources
  - Many other programs

Source: https://www.uspto.gov/learning-and-resources/startup-resources

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Project GitHub

GitHub- uva-bi-sdad/us_patents_case_study https://github.com/uva-bi-sdad/us_patents_case_study/upload/main/01_documents/Literature