

Implementing Interactive Classification Tools in the 2022 Economic Census

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Outline

- Background and motivation
- BEACON overview
- SINCT overview
- Field Test results
- Lessons learned and conclusions

North American Industry Classification System (NAICS)

- Business establishments are classified by NAICS code based on primary business activity
- There are prelisted descriptions, but the respondent also has the option of writing in a business description

ITEM 17: PRINCIPAL BUSINESS OR ACTIVITY

Which ONE of the following best describes this establishment's principal kind of business or activity in 2017?
If none of the provided selections seem appropriate, provide a specific description of the primary business activity.
Select only ONE.

Pipelines

- 486110 001 ☐ Crude petroleum
- 486910 001 ☐ Refined petroleum, including liquefied petroleum gas
- 486210 001 ☐ Pipeline transportation of natural gas and storage of natural gas
- 211111 102 ☐ Petroleum and natural gas field gathering lines
- 486990 001 ☐ Other pipelines - Describe

Describe

Other principal business or activity

- 221210 001 ☐ Natural gas distribution, including marketers and brokers
- 774000 001 ☐ Other principal business or activity - Describe

Describe

Source: 2017 Economic Census

North American Product Classification System (NAPCS)

- Businesses classify their revenue into NAPCS codes based on specific products and services
- Similar to NAICS, respondents choose from a prelist or provide a write-in

ITEM 22: DETAIL OF SALES, SHIPMENTS, RECEIPTS, OR REVENUE

Of the \$,000.00 of Sales, Shipments, Receipts, or Revenue reported in **Item 5**, what was the value for each product or service?

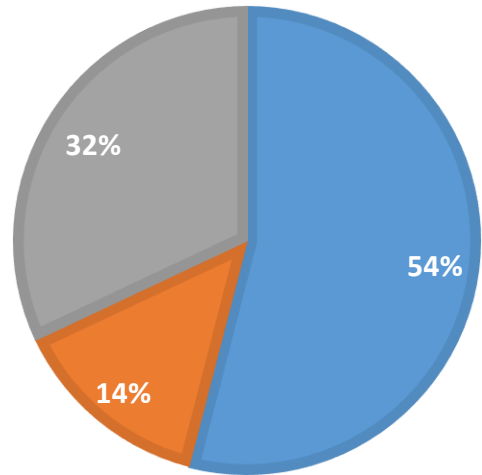
Description	Value	Product Code
1. Warehousing and storage services	\$ <input type="text"/> ,000.00	7011900000
2. Handling services for goods	\$ <input type="text"/> ,000.00	7011975000
3. Packing services for goods	\$ <input type="text"/> ,000.00	7012000000
4. Freight transportation arrangement and customs brokering services	\$ <input type="text"/> ,000.00	7011925000
5. Operations and supply chain management consulting and implementation services	\$ <input type="text"/> ,000.00	7014650000
6. All other products and services, not elsewhere classified		
a. All other products and services, not elsewhere classified - write-in #1		
<input type="text"/> Pick one <input type="button" value="▼"/> <input type="text"/> Describe	\$ <input type="text"/> ,000.00	9000000003
b. All other products and services, not elsewhere classified - write-in #2		
<input type="text"/> Pick one <input type="button" value="▼"/> <input type="text"/> Describe	\$ <input type="text"/> ,000.00	9000000006
c. All other products and services, not elsewhere classified - write-in #3		
<input type="text"/> Pick one <input type="button" value="▼"/> <input type="text"/> Describe	\$ <input type="text"/> ,000.00	9000000009

Source: 2017 Economic Census

Motivation for Machine Learning Applications

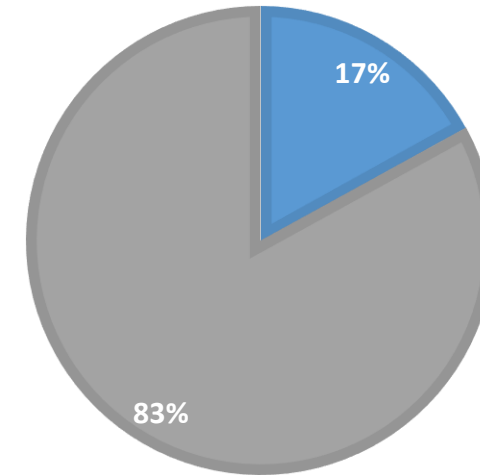
2017 NAICS WRITE-INS
500,000 TOTAL

■ Manually coded ■ Autocoded ■ Not coded



2017 NAPCS WRITE-INS
1,000,000 TOTAL

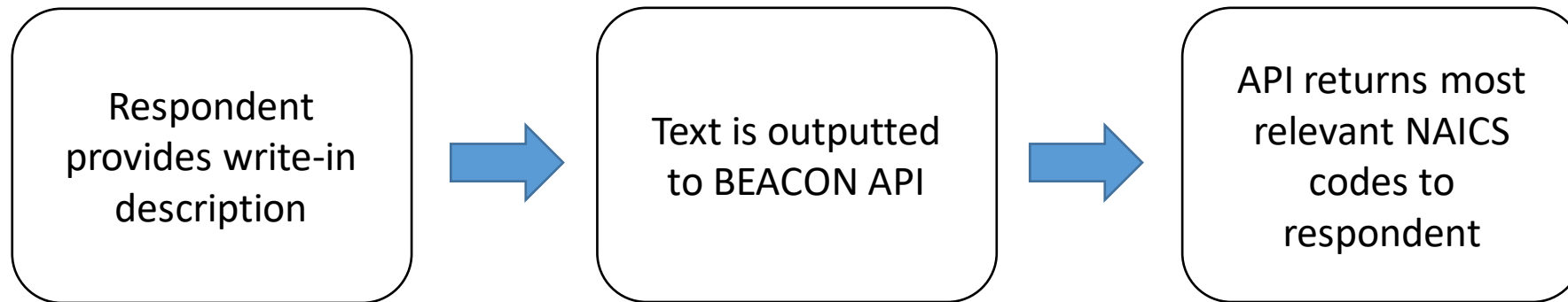
■ Manually coded ■ Not coded



- Goal: develop ML applications and integrate them into the electronic reporting instrument for the 2022 Economic Census

What is BEACON?

- Business Establishment Automated Classification of NAICS
- A machine learning tool developed by the Economic Statistical Methods Division (U.S. Census Bureau) to classify NAICS for establishments based on a write-in business description



BEACON: Goals

- Assist respondents in self-designating their NAICS codes
- Improve accuracy of self-designated NAICS codes
- Reduce manual coding of write-ins

Other primary business or activity

☐ Other primary business or activity
(Describe and click the "Save and Continue" button to search.)

Select Sector ▼

Describe primary business or activity

If applicable, you selected:

- 9-character Code:
- 6-digit NAICS:

Back

Save and Continue

BEACON: Training Data

- Historic write-in responses to the Economic Census (EC)
- Frequent write-in text that was autocoded during 2017 EC
- Business descriptions from IRS SS-4 forms
- Classification Analytical Processing System (CAPS) items
- Harmonized System commodity description

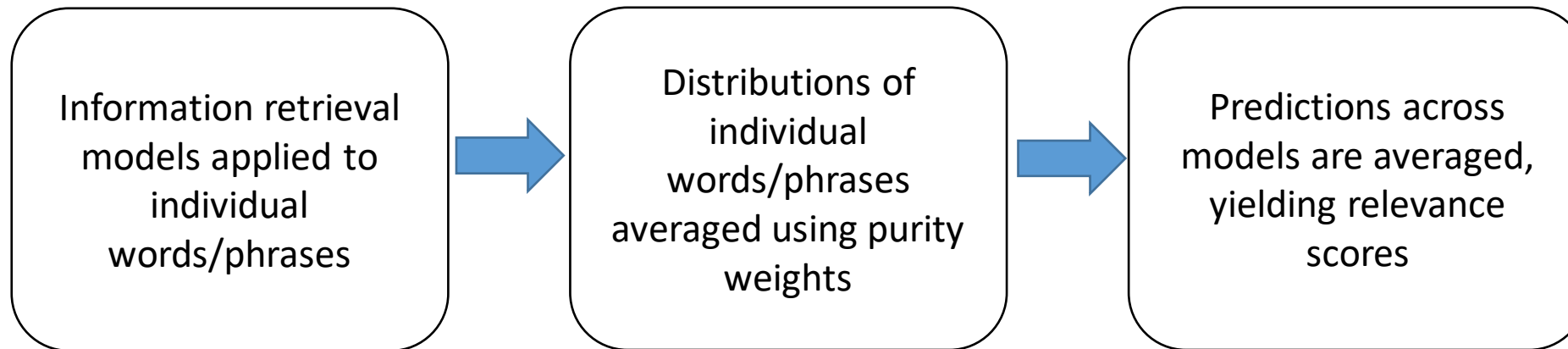
Business Description Text	NAICS
This is a car dealership.	441110
R&D lab – medical/health	541715
we mainly repair furniture, some sales	811420

BEACON: Methodology

- Text cleaning
 - Remove common words and phrases (e.g., “the”, “has”, “for instance”)
 - Correct common misspellings
- Dictionary
 - Words and word combinations that BEACON recognizes
 - Words are cleaned, stemmed, and meet minimum frequency requirements
 - Associations between words and NAICS codes in the training data
 - “tutor” is highly associated with NAICS 611691 – Exam Preparation and Tutoring
 - “retail” occurs in many NAICS codes and is therefore less predictive

BEACON: Methodology

- Three separate information retrieval models
- Models are applied hierarchically
 - First: 2-digit (sector level)
 - Then: 6-digit (industry level)



BEACON: Methodology

- Purity Weights
 - The NAICS distributions of the various words/combs are averaged using “purity weights” that give more weight to the NAICS distributions of words/combs that are more pure/predictive
 - The purity weight is a function of the maximum proportion
- Relevance scores
 - Range in value between 0 and 100
 - Reflect how confident BEACON is that the NAICS code is correct

BEACON: Results

- From these scores, BEACON returns a ranked list of NAICS codes at the 6-digit level

ITEM 4/4A: PRIMARY BUSINESS OR ACTIVITY - SEARCH AND SELECT

Please select the **primary** business or activity from the results below. You can also try a New Search.

Note: After you make a selection on this screen, you will further refine your **primary** business or activity with a more detailed selection on the next screen, if applicable.

Retail Trade	car dealer	New Search
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Description	NAICS	Sector
<input type="radio"/> Used car dealers More	441120	Retail Trade
<input type="radio"/> New car dealers More	441110	Retail Trade
<input type="radio"/> Automotive parts and accessories stores More	441310	Retail Trade
<input type="radio"/> Tire dealers More	441320	Retail Trade
<input type="radio"/> Electronic shopping (Internet retailing), mail-order, and TV shopping, including retail online auction sites. Excluding establishments also retailing via a physical (walk-in) store. More	454110	Retail Trade
<input type="radio"/> New and used automobiles merchant wholesalers, including trucks, tractors, trailers, motorcycles, all-terrain vehicles (ATVs), snowmobiles, motor scooters, mopeds, buses, recreational vehicles (RVs), motor homes, and campers More	423110	Wholesale Trade
<input type="radio"/> New motor vehicle and truck parts merchant wholesalers, including batteries and automotive glass (excluding tires and tubes) More	423120	Wholesale Trade
<input type="radio"/> Sales financing More	522220	Finance and Insurance
<input type="radio"/> General automotive repair, including general automotive repair shops, and automotive engine repair and replacement shops More	811111	Other Services
<input type="radio"/> Not listed (Note: You can try a New Search above.)		

What is SINCT?

- Smart Instrument NAPCS Classification Tool
- Developed by Economy-Wide Statistics Division
- Two distinct versions
 - SINCT 1.0: TF-IDF
 - SINCT 2.0: Doc2Vec



Source: istockphoto.com

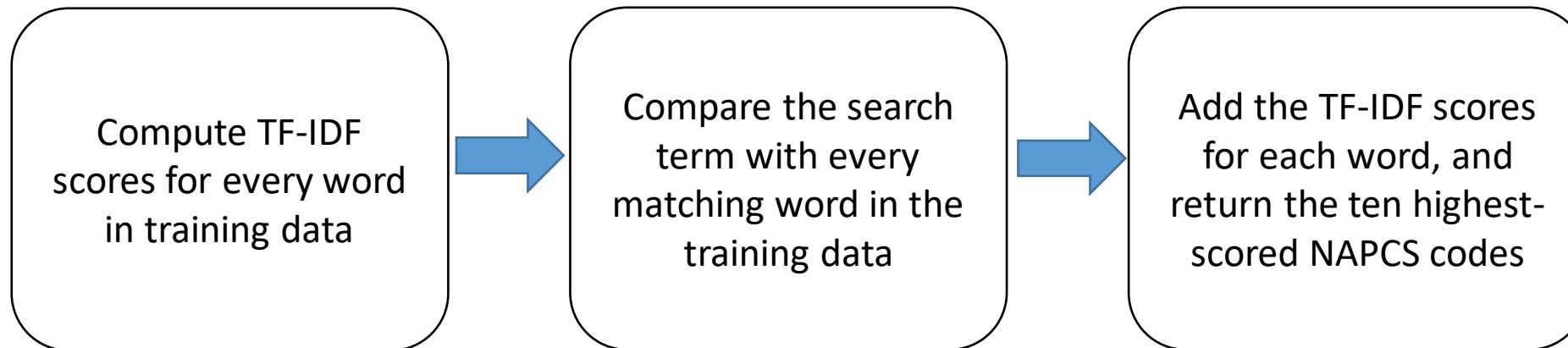
SINCT: Training Data

- Reclassified write-ins from the 2012 and 2017 Economic Census
- Classification Analytical Processing System (CAPS) items
- Subject matter expert examples
- NAPCS title file

NAICS	Search Term	NAPCS
423860	Airplane	4002000003
481111	Airplane	7003075000

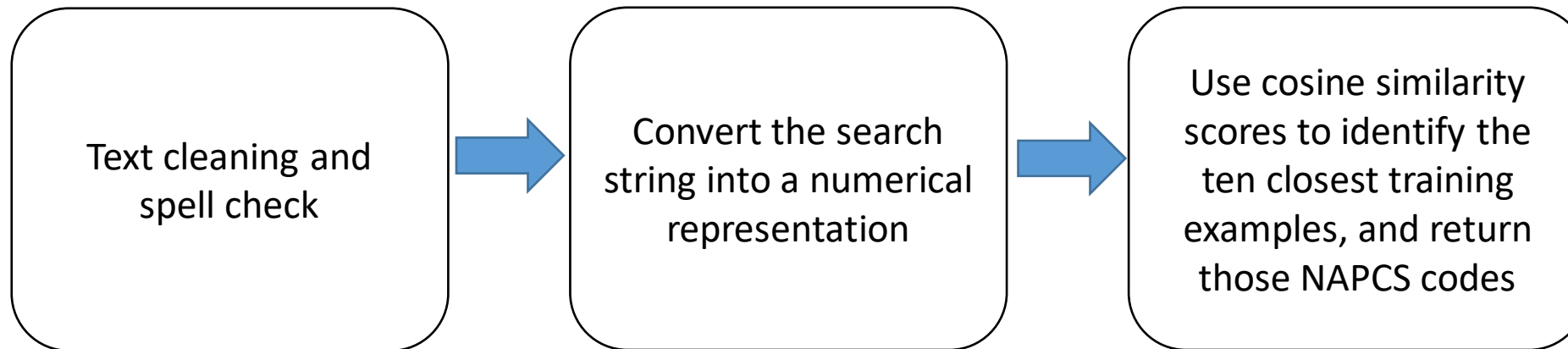
SINCT 1.0: Methodology

- Term frequency-inverse document frequency (TF-IDF)
 - Compute the frequency of a word or phrase within a document, and then adjust that calculation to account for common words



SINCT 2.0: Methodology

- Doc2Vec machine learning model
 - Neural network model
 - Represent words, phrases, sentences, or paragraphs as a vector



SINCT: Results

- SINCT returns the ten highest-scored NAPCS codes to respondents
- Respondents can select from those results, perform a new search, or leave their search term as a write-in

Search for product/service not listed

X

Use the search bar below to find additional products or services. Then select the result(s) that best match(es).

If none of the results apply, please try a new Search, or select "Not listed" and click the "Add Selected Products/Services" button.

Specify additional product or service:

car wash

Search

Select ALL that apply from the results below.

Select	Description	Product Code
<input type="checkbox"/>	Automatic washing and waxing services for automobiles and light-duty trucks	7002650006
<input type="checkbox"/>	Self-service washing and waxing for automobiles and light-duty trucks	7002650012
<input type="checkbox"/>	Self-service vacuuming services for automobiles and light-duty trucks	7002650015
<input type="checkbox"/>	Regulatory safety inspections and emissions testing services for automobiles and light-duty trucks	7002675000
<input type="checkbox"/>	Hand washing, with or without waxing services, for automobiles and light-duty trucks	7002650009
<input type="checkbox"/>	Detailing services for automobiles and light-duty trucks	7002650003
<input type="checkbox"/>	Washing and cleaning services for heavy trucks and buses	7009375042

2021 Industry Classification Report Field Test

- The 2021 Economic Census Industry Classification Report (Refile) was repurposed as a field test for BEACON and SINCT
- Approximately 37,000 establishments
 - 12,000 truth deck
 - 25,000 non-truth deck

Field Test: Results

- BEACON
 - Returned correct NAICS code 90% of the time
 - Respondents selected it 83% of the time
- SINCT
 - Returned correct NAPCS code 74% of the time
 - Respondents only selected it 50% of the time

Lessons Learned

- BEACON performed as expected
 - Speed and concurrent request requirements were met
 - 90% accuracy rate
- SINCT performance was lower than expected
 - 6% timeout rate
 - 74% accuracy rate
 - Solution: overhaul the model, improving speed and accuracy

Lessons Learned

- Respondents often select “none of these”, even if the correct result is presented
 - Solution: update wording and instructions for main mailing
- Additional training data
 - Added 7,000 examples each to BEACON and SINCT’s training data

Conclusions

BEACON and SINCT should significantly reduce the number of unclassified write-ins in the 2022 Economic Census



Analysts will spend less time and will code a higher percentage of write-ins



Data quality will be improved

Thank You!

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