

STAA57 Group Project

What are the dominant research areas in Ontario's automotive sector, and how do institutions specialize in different fields?

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I. Introduction

Research Goal

With the growing popularity of electric vehicles (EVs) and the rapid advancements in artificial intelligence (AI), particularly in the development of autonomous vehicles like Tesla, it is crucial for automotive research facilities in Ontario to focus their efforts and resources on the right areas. This will ensure a significant contribution to the academia world while assisting the government in implementing effective policies and educational institutions better educate, prepare the next generation of labors.

This report aims to examine the automotive research areas prioritizing by Ontario's research facilities and identify specialized facilities in trending fields. It will also explore which areas are attracting the most researchers and which institutions are specializing in particular research domains.

Dataset description

Data source

Our dataset was collected by researchers from the Ministry of Economic Development, Job creation and Trade and was published on the Government of Ontario's public database in 2018.

Table 1: Data set Variables

| | |
|--|--|
| ## Rows: 545 | |
| ## Columns: 37 | |
| ## \$ Institution | <chr> "Brock University", "Carleton Univers~ |
| ## \$ Researcher.Name | <chr> "Ahmed, Syed Ejaz", "Ahmadi, Mojtaba"~ |
| ## \$ Associated.Facilities | <chr> "Centre for Statistical Consulting", ~ |
| ## \$ Research.Areas | <chr> "Traffic and road injury prevention."~ |
| ## \$ Research.Chairs.Grant.Funding | <chr> "", "", "", "", "Canada Research Chai~ |
| ## \$ Tag.1 | <chr> "Injury Prevention", "Mechatronics", ~ |
| ## \$ Tag.2 | <chr> "", "Control", "Autonomy and AI", "Ne~ |
| ## \$ Tag.3 | <chr> "", "", "Sensors", "", "", "", "", ""~ |
| ## \$ Tag.4 | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Tag.5 | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Alternative.Fuels | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Autonomy.and.AI | <chr> "", "", "x", "", "", "", "x", "", "",~ |
| ## \$ Batteries.and.Fuel.Cells | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Biocomposites | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Coatings.and.Corrosion | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Connected.Vehicles | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Control | <chr> "", "x", "x", "", "", "", "", "", ""~ |
| ## \$ Crashworthiness | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Electronics | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Forming.and.Joining | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ High.Strength.Steel | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Hybrid.and.Electric.Vehicles | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Industrial.Processes | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Injury.Prevention | <chr> "x", "", "", "", "", "", "", "", ""~ |
| ## \$ Internal.Combustion.Engines | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Lightweight.Metals | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Mechatronics | <chr> "", "x", "", "", "", "", "", "", ""~ |
| ## \$ Nanotechnology | <chr> "", "", "", "", "", "", "", "", ""~ |
| ## \$ Networks.and.Security | <chr> "", "", "", "x", "", "x", "", "x", "x~ |
| ## \$ Noise..Vibration.and.Harshness | <chr> "Err:507", "Err:507", "Err:507", "Err~ |
| ## \$ Polymers.and.Composite.Materials | <chr> "", "", "", "", "", "", "", "", ""~ |

```
## $ Powertrain          <chr> "", "", "", "", "", "", "", "", "", ""~
## $ Sensors             <chr> "", "", "x", "", "x", "", "x", "", ""~
## $ Software            <chr> "", "", "", "x", "", "", "", "", "", ~
## $ Stress.and.Fracture <chr> "", "", "", "", "", "", "", "", "", ""~
## $ Transportation.and.Charging <chr> "", "", "", "", "", "", "", "", "", ""~
## $ Vehicle.Design      <chr> "", "", "", "", "", "", "", "", "", ""~
```

Based on a summary of the data set, the `Noise..Vibration.and.Harshness` variable was corrupted during the process of uploading or collecting the data and therefore will not be used in our report

```
# Remove variable with errors
```

```
researchers = researchers %>% select(!Noise..Vibration.and.Harshness )
```

```
# We removed Brock University, Lakehead University, Royal Military College, and Laurentian University f
```

```
researchers <- researchers %>% filter(!Institution %in% c("Brock University", "Lakehead University", "L
```

Some of the main categorical variables that can help categorizing the data include

- **Researcher.Name**
- **Institution:** Name of university or research center that the researcher works at
- **Research.Areas:** Researcher general field of research
- **Tag:** Researcher’s specialized field of research

In addition, the data set also contains research fields as variable (e.g. Alternative Fuels, Autonomy and AI, Vehicle Design) to indicate whether or not a researcher work fall into that field of research

II. Data Overview Analysis

Descriptive Statistic

From our dataset, we are able to extract the disparity of researchers across fields of research. This would include research fields such as “Network and Security”, “Autonomy and AI”, “Nanotechnology”, and other vehicle-related fields.

```
## # A tibble: 13 x 29
##   Institution          Networks and securit~1 `Autonomy and AI` Software
##   <chr>                <int>                <int>    <int>
## 1 "Carleton University"          37             23      21
## 2 "University of Waterloo"        22             16       7
## 3 "McMaster University"          1              4       7
## 4 "University of Toronto"         6             11       1
## 5 "Ryerson University"           6              6       2
## 6 "University of Windsor"         5              5       0
## 7 "Queen's University"           2              1       2
## 8 "University of Guelph"          0              4       0
## 9 "University of Ontario Ins~    7              2       6
## 10 "University of Ottawa"         4              4       1
## 11 "York University"             0              2       0
## 12 "University of Western Ont~    2              0       0
## 13 "Ryerson University"          0              0       0
## # i abbreviated name: 1: `Networks and security`
## # i 25 more variables: `Connected vehicles` <int>, Nanotechnology <int>,
## # `Polymers and composite materials` <int>,
```

```
## # `Hybrid and electric vehicles` <int>, Powertrain <int>,
## # `Batteries and fuel cells` <int>, Sensors <int>,
## # `Transportation and charging` <int>, `Forming and joining` <int>,
## # `Injury Prevention` <int>, Electronics <int>, ...
```

Upon reviewing the table, the three leading researching fields are “Networks and Security”, “Autonomy and AI”, and “Polymers and Composite Materials”. The universities have reported 50+ researchers working in these areas which would indicate there is significant progress being made. On the contrast, “Crashworthiness” and “Mechatronics” are among the least studied fields with less than 10 researchers total.

We now check for the dominating research field for each university. The table below is generated by finding the max researchers in an institution across a research field.

```
## # A tibble: 12 x 2
## # Groups:   Institution [12]
##   Institution                                Research_Area
##   <chr>                                       <chr>
## 1 Carleton University                      Networks and security
## 2 McMaster University                     Powertrain
## 3 Queen's University                      Lightweight metals
## 4 Ryerson University                      Transportation and char~
## 5 University Of Guelph                    Batteries and fuel cells
## 6 University Of Ontario Institute Of Technology (Uoit) Networks and security
## 7 University Of Ottawa                    Sensors
## 8 University Of Toronto                    Polymers and composite ~
## 9 University Of Waterloo                  Networks and security
## 10 University Of Western Ontario           Forming and joining
## 11 University Of Windsor                  Lightweight metals
## 12 York University                       Transportation and char~
```

From the table, the universities are associated with their highest producing research field. Several universities are mostly researching “Networks and Security” like Carleton University, University of Waterloo, University of Ontario Institute of Technology.

This information can also be crucial to understand how the fields with low researchers from the previous table are not being targeted enough by the universities.

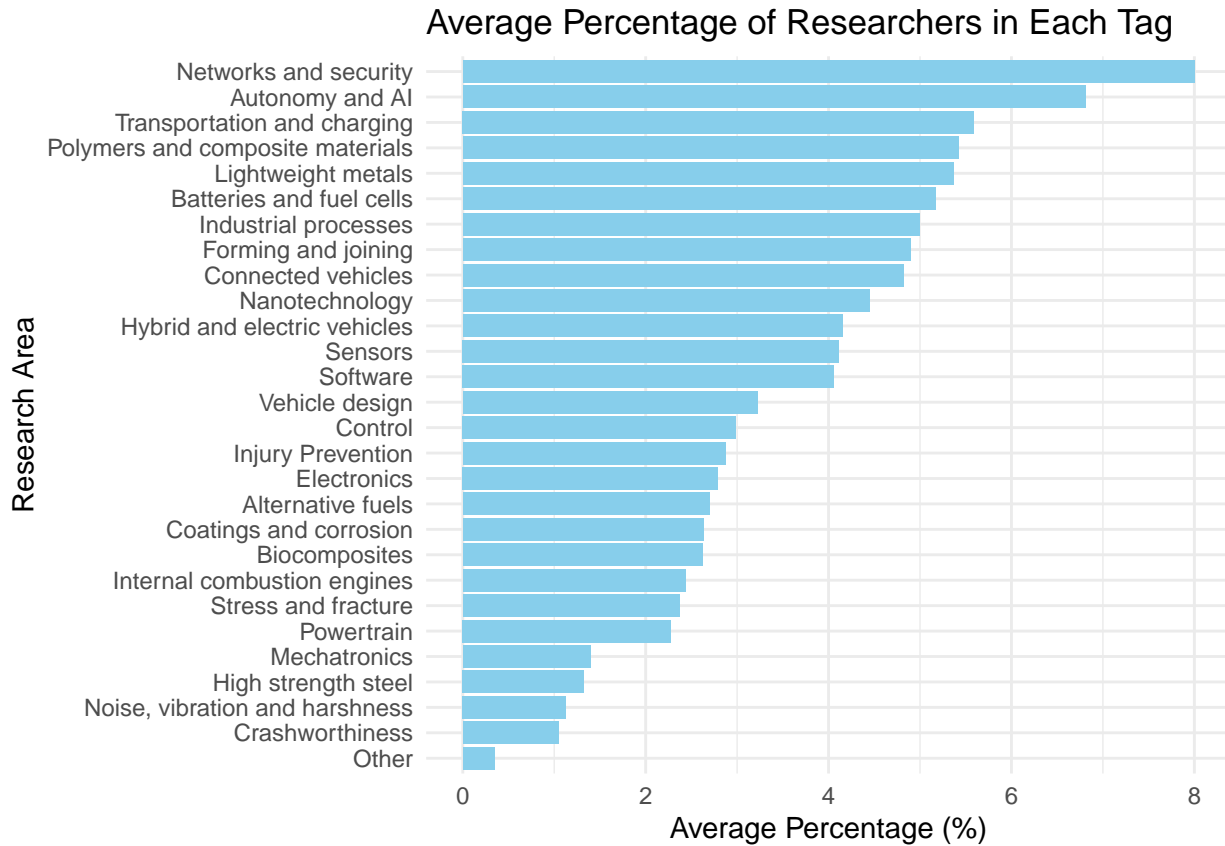
We now check for the percentage breakdown of the university’s dominating research field and their contribution as a whole. This is important to understand the concentration of university’s in specific fields and whether some diversification can be made to the university.

```
## # A tibble: 12 x 4
## # Groups:   Institution [12]
##   Institution                                Research_Area Count Percentage
##   <chr>                                       <chr>         <int>         <dbl>
## 1 Carleton University                      Networks and~    37          24.5
## 2 York University                          Transportati~    6           22.2
## 3 University Of Ottawa                    Sensors         7           21.2
## 4 University Of Western Ontario           Forming and ~    3           17.6
## 5 Ryerson University                      Transportati~   11           17.5
## 6 Queen's University                      Lightweight ~    7           15.2
## 7 University Of Guelph                    Batteries an~    7           12.5
## 8 McMaster University                     Powertrain      16           11.0
## 9 University Of Toronto                    Polymers and~   13           9.92
## 10 University Of Windsor                  Lightweight ~   11           9.65
## 11 University Of Ontario Institute Of Technology~ Networks and~    7           9.21
## 12 University Of Waterloo                  Networks and~   22           7.80
```

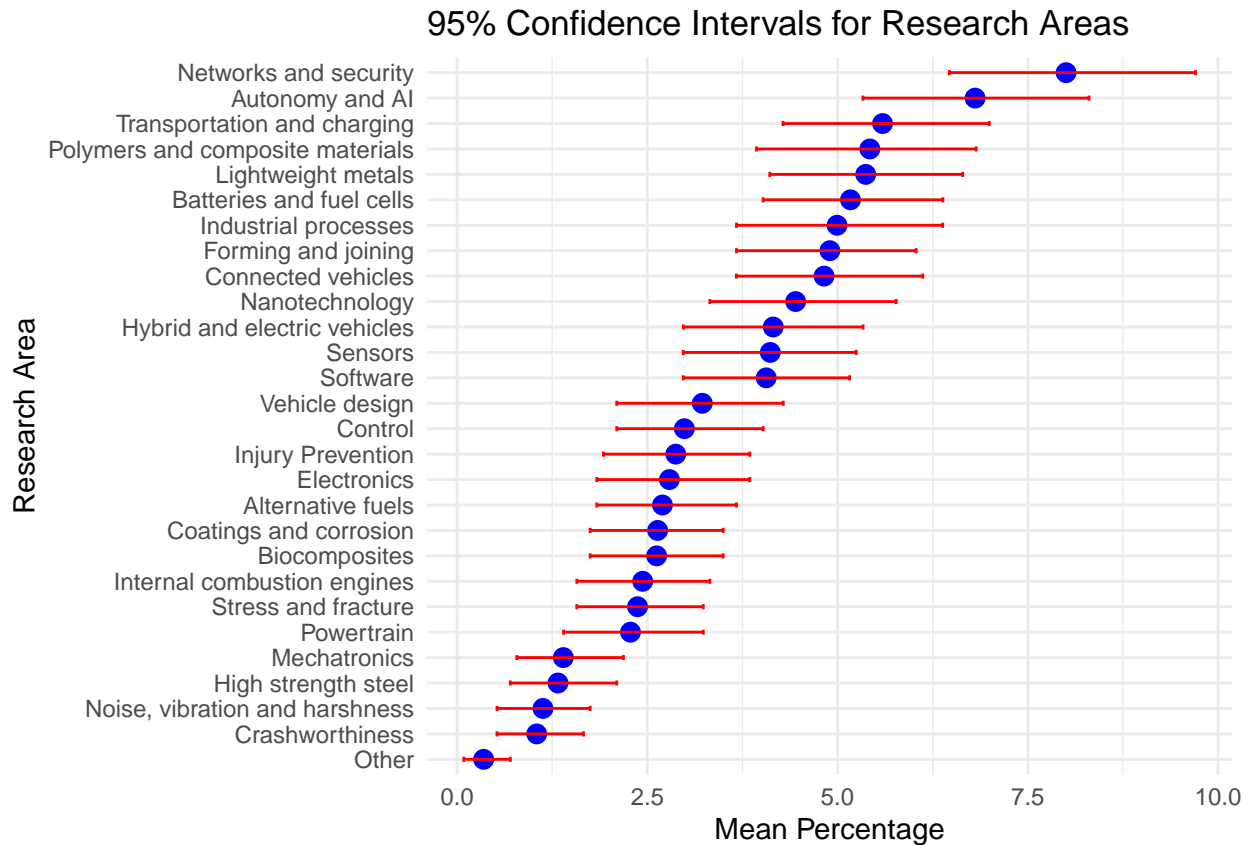
From the table, we see that Carleton University, York University, and University of Ottawa have 20%+ of their research contributions among their highest fields. Waterloo University and University Of Ontario Institute Of Technology have the most diversification as well as high amounts of researchers across several fields.

III. Statistical Analysis

Let's pick our highest leading tag and see how it performs in bootstrapped data. We want to observe how it does compared to other tags and if it's the leading tag in all the samples by taking an average.



In this graph, the data of the institutions and their tags have been replicated 1000 times. We take the average percentage to see how they perform over the 1000 trials and gain a graph of each tags performance. By inspection, “Networks and Security” and “Autonomy and AI” lead from our 1000 samples.



By taking confidence intervals for each research tag, we gain data regarding the ranges of each tag within the 1000 trials. While “Networks and Security” leads the dataset by inspection, the CI interval overlaps with “Autonomy and AI”. It is necessary to verify if in any of the 1000 trials if “Networks and Security” loses even once to “Autonomy and AI” to conclude it always leads in our dataset.

Let’s examine how “Networks and Security” performs when compared to the 2nd highest tag (Autonomy and AI) in the bootstrapped data to see if it leads in the hypothesis test. Let’s choose the hypothesis test to include an H_0 where “Networks and Security” always leads, giving significant difference compared to other tags. H_1 is represented by “Autonomy and AI” winning even once, leading to no significant difference of “Networks and Security” in the dataset.

```
## Independent t-test: Networks and Security vs. Autonomy and AI
## Mean % Network and Security: 8.001923
## Mean % ( Autonomy and AI ): 6.806818
## T-statistic: 33.42531
## P-value: 3.359765e-195
## Reject H0. Networks and Security is significantly higher than the other tags. (p < 0.05).
```

Based off our t-test, we get a “Networks and Security” mean of 8.001923 and an “Autonomy and AI” mean of 6.806818. Since the averages are distant, we can expect a large t- statistic and a small p value.

We observe a t statistic value of 33.42531 and a extremely small p value 3.359765e-195 ($p < 0.05$), rejecting the null hypothesis and observing “Networks and Security” is significantly higher than the other tags. We conclude that “Networks and Security” always wins in comparison to other research tags.