

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 “Software”. 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.

Graph & Visualizations

- Bar chart: Research distribution across institution
- Pie chart: Proportion of of different research fields
- History, frequency of research tag

III. Statistical Analysis

We could pick an area we think that will be most trending (AI for example) and test to see if that is true

- Confidence interval for the average number of researcher
- Hypothesis Testing
- Bootstrapping

IV. Predictive modeling (Regression)

Build a regression model to predict number of researcher in a field, institutions

Build a regression model to see if an institution is likely to have to a grant funding

Using cross-validation to validate the 2 models built above

V. Summary

Appendix