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Data Visualization and Analysis of Vehicle Component Level for Heavy Trucks and Trailers

By: Jiayu Li

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Introduction

• In the United States, vehicles such as trucks are federally mandated to undergo safety and maintenance inspections. The truck inspection rate is affected by multiple factors.

• Purposes:

- Explore the impact of the vehicle make, vehicle driving area, vehicle age, and vehicle mileage on the overall inspection rate and vehicle component level inspection rate of heavy trucks and trailers.
- Design a graphical user interface for humanmachine interaction to help truck fleet managers and truck drivers make better decisions through data analysis results in the dashboard.



Figure1: Flow Chart of Research Purpose

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Data

- Data Source: Compuspections
- All data used for subsequent visualization are **heavy trucks and trailers**. And the following three categories of all data are included in the types in the table below.

Columns in the dataset	Types
Vehicle Type	TRUCK, TRAILER
Vehicle Body	ТК
Vehicle Class	TRUCK DELIVERY, TRUCK TRACTOR

• Datasets Creation:

- Scheme1: Randomly selected 1,000 vehicle data, and then formed a simulated fleet.
- Scheme2: Randomly selected the same number of vehicle data for each vehicle make type, vehicle mileage type, and vehicle region type, formed three datasets of vehicle make, mileage, and region separately. Carnegie

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Research Strategy



Data Visualization

Dashboard Design

Power BI





Advantages

Easy to compare multiple influencing factors

Highlight the visual results of a factor category

Specialized software display



Data Visualization

Dashboard Design

• Python Dash Module







Vehicle Make

• Overall Inspection





Vehicle Make

• Results of each vehicle make type

Vehicle Make	Inspection Results	
INTERNATIONAL	If fleet managers choose this type, they should pay attention to the aspects of brake system, steering, exhaust system, lighting, and <u>others</u>.	
PETERBILT	If fleet managers choose this type, they should pay attention to the aspects of brake system, steering, lighting, and others.	
KENWORTH	If fleet managers choose this type, they should pay attention to the aspects of brake system, steering, and lighting.	
FREIGHTLINER	The overall pass or failed inspection result needs to be improved. If fleet managers choose this type, they should pay attention to the aspects of brake system, lighting, and others.	
FORD	If fleet managers choose this type, they should pay attention to the aspects of brake system, steering, exhaust system, lighting, and others.	Com
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Vehicle Make

• Results of each vehicle make type

Vehicle Make	Inspection Results
	The overall pass or failed inspection result needs to be improved.
VOLVO	If fleet managers choose this type, they should pay attention to the aspects of
	brake system, tire, steering, door, fuel, exhaust system, glazing, lighting, and others.
МАСК	If fleet managers choose this type, they should pay attention to the aspects of
MACK	brake system, steering, exhaust system, and lighting.
STERI ING	If fleet managers choose this type, they should pay attention to the aspects of
STERLING	brake system, steering, lighting, and others.
WESTEDN STAD TD	If fleet managers choose this type, they should pay attention to the aspects of
WESTERN STAR IR	brake system, steering, lighting, and others.
GMC	The inspection results of all component levels and overall level are good.

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Urvanization	level	County
		ALLEGHENY
		PHILADELPHIA
1	Large central metro	
	_	BULTLER
		BUCKS
		WASHINGTON
		WESTMORELAND
		MONTGOMERY
		CHESTER
		DELAWARE
2	Large fringe metro	
		DAUPHIN
		BERKS
		LANCASTER
		CUMBERLAND
		PERRY
		LEHIGH
		YORK
		NORTHAMPTON
		LACKAWANNA
		LUZERNE
3	Medium metro	
		CAMBRIA
		MONTOUR
		LYCOMING
		CENTRE
		LEBANON
		FRANKLIN
4	Small metro	
		NORTHUMBERLAND
		CLEARFIELD
		SOMERSET
		SCHUYLKILL
		SNYDER
		UNION
		HUNTINGDON
		MCKEAN
		VENANGO
5	Micropolitan	
		GREENE
		BEDFORD
		CLARION
		JUNIATA
		POTTER
		HOGA
6	Noncore	

• NCHS urban-rural classification scheme (2013) divides counties into six categories, with 1, 2, 3, 4 being metropolitan counties and 5, 6 being nonmetropolitan counties.

Category code	Category name	Category description
Metropolitan categories		
1 2 3 4	Large central metro large fringe metro Medium metro Small metro	NCHS-defined "central" countries of MSAs of 1 million or more population NCHS-defined "fringe" countries of MSAs of 1 million or more population Countries within MSAs of 250,000–999,999 population Countries within MSAs of 50,000–249,999 population
Nonmetropolitan categories		
5 6	Micropolitan Noncore	Countries in micropolitan statistical areas Countries not within micropolitan statistical areas



Vehicle Region

• Vehicle Region Distribution



All the vehicles in the simulated fleet are from within Pennsylvania, mostly in **medium metropolitan counties**, followed by large fringe metro counties and micropolitan counties .

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Vehicle Region

• Which inspection rates are below 95%?



Brake System: micropolitan(77%), medium metro(84%), large central metro(86%), small metro(91%)
Lighting: micropolitan(83%), small metro(85%), large central metro(87%), noncore(93%), medium metro(94%)

Steering: micropolitan(92%)

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Vehicle Age

Percentage of Vehicle Age

• Vehicle Age Distribution



The vehicle ages of the simulated fleet mainly distribute from 0 to 24 years old.



• Overall pass or failed inspection results from two different simulated fleets:

• Simulated Fleet 1:



• Simulated Fleet 2:

Vehicle Age



The overall failed inspection rates in the vehicle ages of **9**, **14** and **16** are higher than other vehicle ages both in the two simulated fleets.

Vehicle Age

- **Brake System Inspection:**
- **Simulated Fleet 1:** Ο \bigcirc **Brake System Inspection Brake System Inspection IPBrakeSys...** ● A ● F ● N ● R ● Y **IPBrakeSys...** ● A ● F ● N ● R ● Y -1 0 26 35 33 36 37
- **Simulated Fleet 2:**

The vehicle age with low pass brake system inspection rate is concentrated around 10 - 16 years old.



Vehicle Age

• Lighting Inspection:



The vehicle age with low pass lighting inspection rate is concentrated around 14 - 17 years old.



Vehicle Age

100%

- Steering Inspection:
- **Simulated Fleet 1: Simulated Fleet 2:** Ο \bigcirc **Steering Inspection Steering Inspection IPSteering** ● F ● N ● R ● Y **IPSteering** ● A ● F ● N ● R ● Y 0 3 7 11 13 14 20 21 23 24 23 24 28 31 29 32 30 33 34 32 35 33 36 34 37 35 39 40% 60% 80% 100% 0% 20% 40% 60%

The vehicle age with low pass steering inspection rate is concentrated around 14 years old.



Vehicle Mileage

• Summary:

Odometer Type	Mileage Range (mile)
1	0 ~ 5,000
2	5,000 ~ 10,000
3	10,000 ~ 15,000
4	15,000 ~ 20,000
5	20,000 ~ 25,000
6	25,000 ~ 30,000
7	30,000 ~ 35,000
8	35,000 ~ 40,000



The mileage distribution of the simulated fleet ranges from 0 to 40,000 miles.



Vehicle Mileage

• Which inspection rates are no more than 90%?



Brake System: 2(83%), 3(84%), 7(89%), 8(90%) Lighting: 2(83%), 3(87%), 5(86%) Steering: 8(90%)



Vehicle Make

Different vehicle makes have different inspection results in both overall and vehicle component levels. The inspection **s** pass rates of these vehicle makes such as **Freightliner**, **Western Star TR**, and **Volvo** need to be improved.

Vehicle Make	Inspection Results
INTERNATIONAL	If fleet managers choose this type, they should pay attention to the aspects of brake system, steering, exhaust system, lighting, and others .
PETERBILT	If fleet managers choose this type, they should pay attention to the aspects of brake system, steering, lighting, and others.
KENWORTH	If fleet managers choose this type, they should pay attention to the aspects of brake system, steering, and lighting.
FREIGHTLINER	The overall pass or failed inspection result needs to be improved. If fleet managers choose this type, they should pay attention to the aspects of brake system, lighting, and others.
FORD	If fleet managers choose this type, they should pay attention to the aspects of brake system, steering, exhaust system, lighting, and others.

Vehicle Make	Inspection Results
VOLVO	The overall pass or failed inspection result needs to be improved. If fleet managers choose this type, they should pay attention to the aspects of brake system , tire, steering, door, fuel, exhaust system, glazing, lighting, and <u>others</u> .
MACK	If fleet managers choose this type, they should pay attention to the aspects of brake system , steering, exhaust system, and lighting.
STERLING	If fleet managers choose this type, they should pay attention to the aspects of brake system, steering, lighting, and others.
WESTERN STAR TR	If fleet managers choose this type, they should pay attention to the aspects of brake system, steering, lighting, and others.
GMC	The inspection results of all component levels and overall level are good.



Key Findings

Vehicle Age

The vehicle age with low pass **brake system** inspection rate is concentrated around 10 - 16 years old. The vehicle age with low pass **lighting** inspection rate is concentrated around 14 - 17 years old. The vehicle age with low pass **steering** inspection rate is concentrated around 14 years old.

Vehicle Age	Answers
3	Steering and other inspection.
4	Brake system, exhaust system, lighting and other inspection.
6	Brake system, steering, lighting and other inspection.
7	Glazing and lighting inspection.
8	Brake system, steering, exhaust system, lighting and other inspection.
9	Brake system inspection.
10	Brake system and lighting inspection.
11	Brake system, lighting and other inspection.
12	Brake system, exhaust system, lighting, and other inspection.
13	Brake system, steering, lighting, and other inspection.
14	Brake system, tire, steering, exhaust system, lighting, and other inspection.
15	Brake system, lighting, and other inspection.
16	Brake system, door, exhaust system, glazing, lighting, and other inspection.
17	Brake system, steering, door, exhaust system, and lighting inspection.
18	Steering and lighting inspection.
19	Brake system, tire, steering, lighting, and other inspection.
20	Brake system, steering, and lighting inspection.
21	Brake system, steering, exhaust system, and lighting inspection.
24	Brake system, lighting, and other inspection.
25	Brake system inspection.
28	Brake system, exhaust system, and lighting inspection.
29	Brake system, steering, and lighting inspection.
30	Brake system and lighting inspection.



Key Findings

Vehicle Region

Vehicles driven in **micropolitan** counties have the lowest inspection rates of the components such as **braking system, steering and lighting.**

Category code	Category name	Category description
Metropolitan categories		
1	Large central metro	Counties in MSAs of 1 million or more population
2	large fringe metro	Counties in MSAs of 1 million or more population that did not qualify as large central metro counties
3	Medium metro	Counties in MSAs of populations of 250,000- 999,999
4	Small metro	Counties in MSAs of populations less than 250,000
Nonmetropolitan categories		
5	Micropolitan	Counties in micropolitan statistical areas
6	Noncore	Nonmetropolitan counties that did not qualify as micropolitan

Category Code	Inspection Results
1	Brake system and lighting inspection.
2	None.
3	Brake system, lighting, and other inspection.
4	Brake system, and lighting inspection.
5	Brake system, exhaust system, lighting and other inspection.
6	Lighting inspection.



Key Findings

Vehicle Mileage

Vehicles whose mileages are from **5,000** ~ **15,000** miles have the lowest inspection rates of brake system and lighting, while vehicles whose mileages are from **35,000** ~ **40,000** miles have the lowest inspection rates of steering.







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Thank you for your listening!

By: Jiayu Li