

Group 13

Team Members

- Javeria Malik (UIN: 659109741)
 - Mmesoma Udensi (UIN: 671334868)
 - Drew Levitt (UIN: 670159474)
 - Hritika Bhavsar (UIN: 672735146)
 - Reshma DhilipThaneswar (UIN: 655564258)
 - Rahul Panakkal (UIN: 677821608)
-

Question

What has been the impact of electric vehicle (EV) adoption on the automobile industry? How have stock prices of major automakers responded to significant EV-related developments?

Sources of Curated Data

- Mathematica

```
In[*]:= { Finnhub Stock API DATA SOURCE , Nasdaq Data Link DATA SOURCE }  
Out[*]= { Finnhub Stock API , Nasdaq Data Link }  
  
In[*]:= Table[Interpreter["Financial"] [company],  
           {company, {"Tesla", "Rivian", "Ford", "Ferrari", "Toyota", "Honda"}}]  
Out[*]= { Tesla Motors , Rivian Automotive , Ford , Ferrari , Toyota , Honda }  
  
In[*]:= EntityClass["Financial", "NASDAQ"]  
Out[*]= NASDAQ
```

```
In[*]:= EntityClass["Financial", "NASDAQ"] ["Properties"]
Out[*]= { adjusted closing price , adjusted high price , adjusted low price , adjusted opening price , ask price ,
ask size , 200-day average , 50-day average , 3-month average volume , bid price , bid size ,
change , 200-day change , 50-day change , change from 52-week high , change from 52-week low ,
CIK , closing price , company , cumulative fractional change , cumulative return ,
market quote currency , dividend , dividend per share , dividend yield , earnings per share ,
earnings yield , EBITDA , entity classes , entity type list , exchange , shares outstanding ,
foreign listing , fractional change , 200-day fractional change , 50-day fractional change ,
fractional change from 52-week high , fractional change from 52-week low , financial statement currency ,
mutual fund family , mutual fund investment style , high price , 52-week high , company logo ,
initial public offering date , issue , last price , last trade size , latest trade , low price , 52-week low ,
market capitalization , name , official name , opening price , original (split adjusted) closing price ,
price , P/E ratio , 52-week range , raw closing price , raw high price , raw low price ,
raw opening price , raw volume , return , sector , share class description , short symbol ,
symbol , type , 20-day volatility , 250-day volatility , 50-day volatility , volume , website }
```

Data Visualization

We considered a cluster of six automaker companies in our analysis:

- Tesla
- Rivian
- Lincoln
- Ferrari
- Toyota
- Honda

To assess the performances and reactions of these companies, we will be using the cumulative fractional changes in their stock prices, benchmarking them to the NASDAQ Composite Index.

Initialization Cell

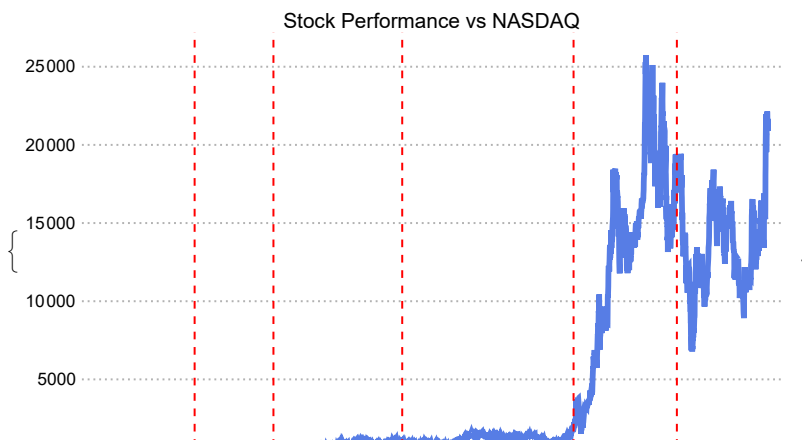
```
names = {"Tesla", "Rivian", "Ford", "Ferrari", "Toyota", "Honda"};
symbol = {"TSLA", "RIVN", "F", "RACE", "TM", "HMC"};
stocks = Interpreter["Financial"][names];
companies = Interpreter["Company"][names];
benchmark = Interpreter["Financial"][FinancialData[{"^COMP"}, "StandardName"]];
stocksAndBenchmark = Append[stocks, benchmark];
```

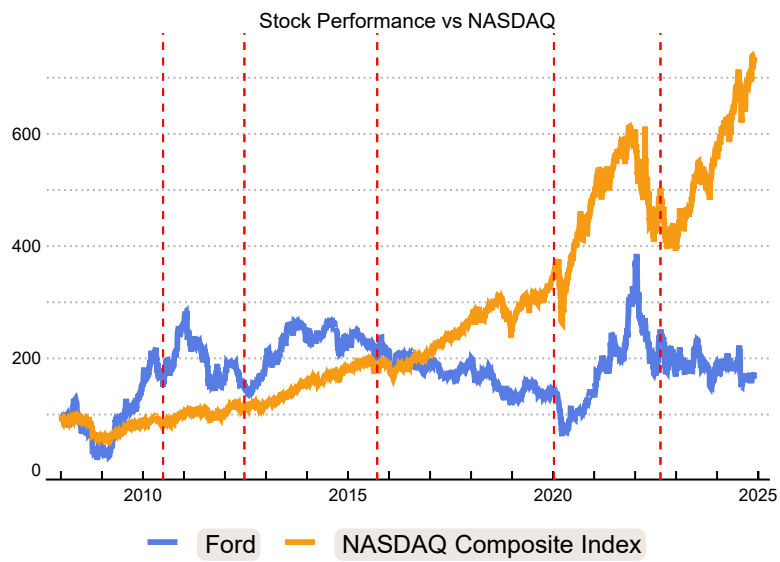
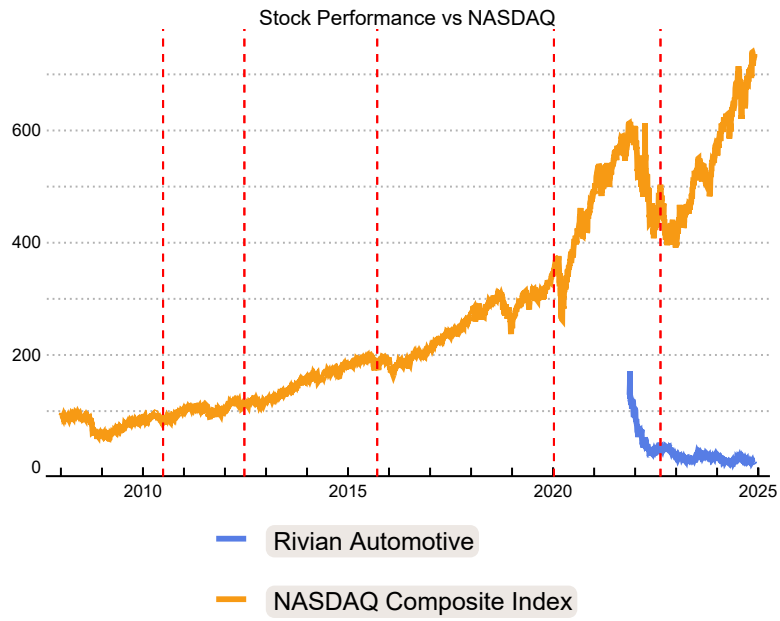
The Automobile Industry

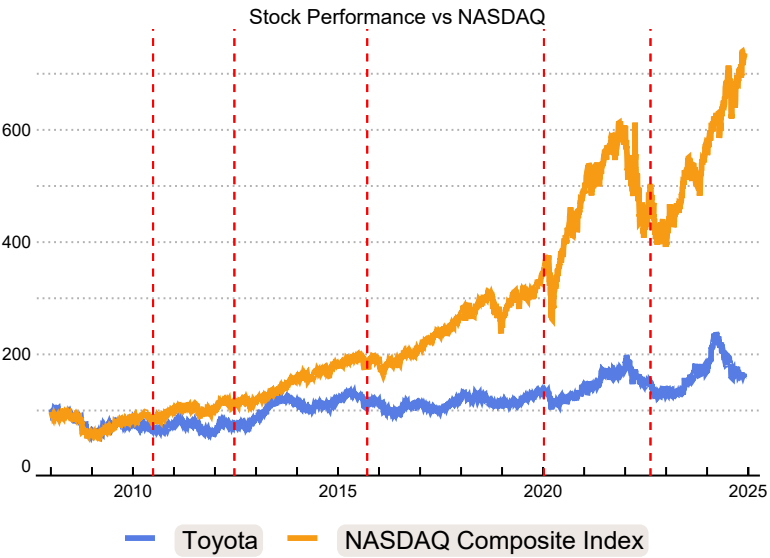
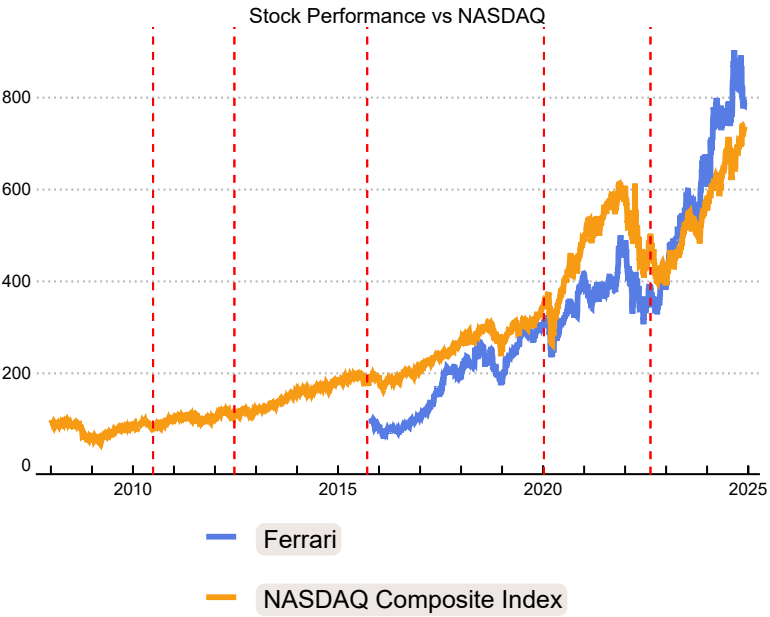
```
(*Plot the cumulative fractional return of
automobile stocks against NASDAQ from 2008 to 2024*)

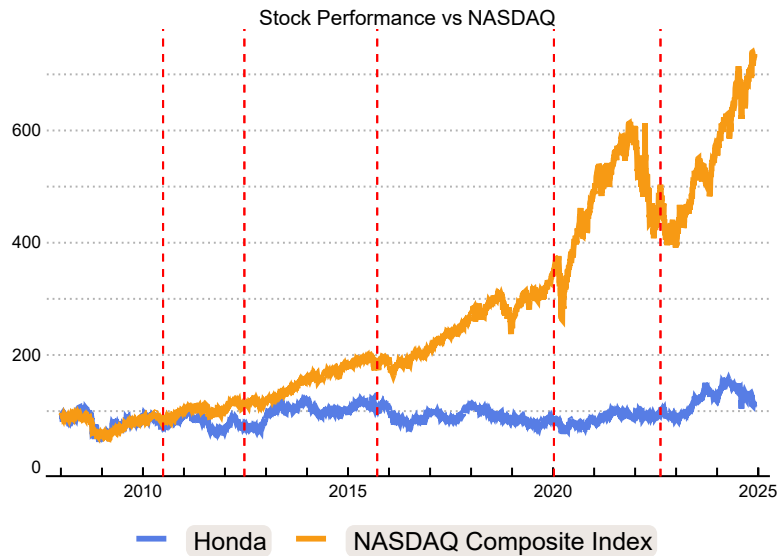
startDate = DateObject[{2008, 1, 1}];
endDate = DateObject[{2024, 12, 1}];
stockTS = Table[FinancialData[i, "CumulativeFractionalChange", {startDate, endDate}],
  {i, stocksAndBenchmark}];
Table[
  DateListPlot[{stockTS[[i]], stockTS[[7]]},
    PlotLabel → "Stock Performance vs NASDAQ",
    PlotRange → Full, ImageSize → 400, PlotTheme → "Business",
    Epilog → {
      Red, Dashed,
      Line[{DateObject["2010/06/29", "Day"], -300},
        {DateObject["2010/06/29", "Day"], 30 000}], (*Tesla IPO*)
      Line[{DateObject["2012/06/22", "Day"], -300},
        {DateObject["2012/06/22", "Day"], 30 000}], (*Tesla Model S Launch*)
      Line[{DateObject["2015/09/18", "Day"], -300},
        {DateObject["2015/09/18", "Day"], 30 000}], (*Volkswagen Dieselgate Scandal*)
      Line[{DateObject["2020/01/09", "Day"], -300},
        {DateObject["2020/01/09", "Day"], 30 000}], (*COVID-19*)
      Line[{DateObject["2022/08/15", "Day"], -300},
        {DateObject["2022/08/15", "Day"], 30 000}], (*Inflation Reduction Act*)
    },
    PlotLegends → Placed[{stocks[[i]], benchmark}, Below]],
  {i, Range@Length@stocks}]
```

Out[]=









Tesla IPO

Tesla was founded in 2003. On June 29th, 2010, Tesla became the first automaker to go public in the U.S. since Ford in 1956.

(*Generate two interactive trading charts
(pre- and post-event) for each company around the date of Tesla's IPO*)

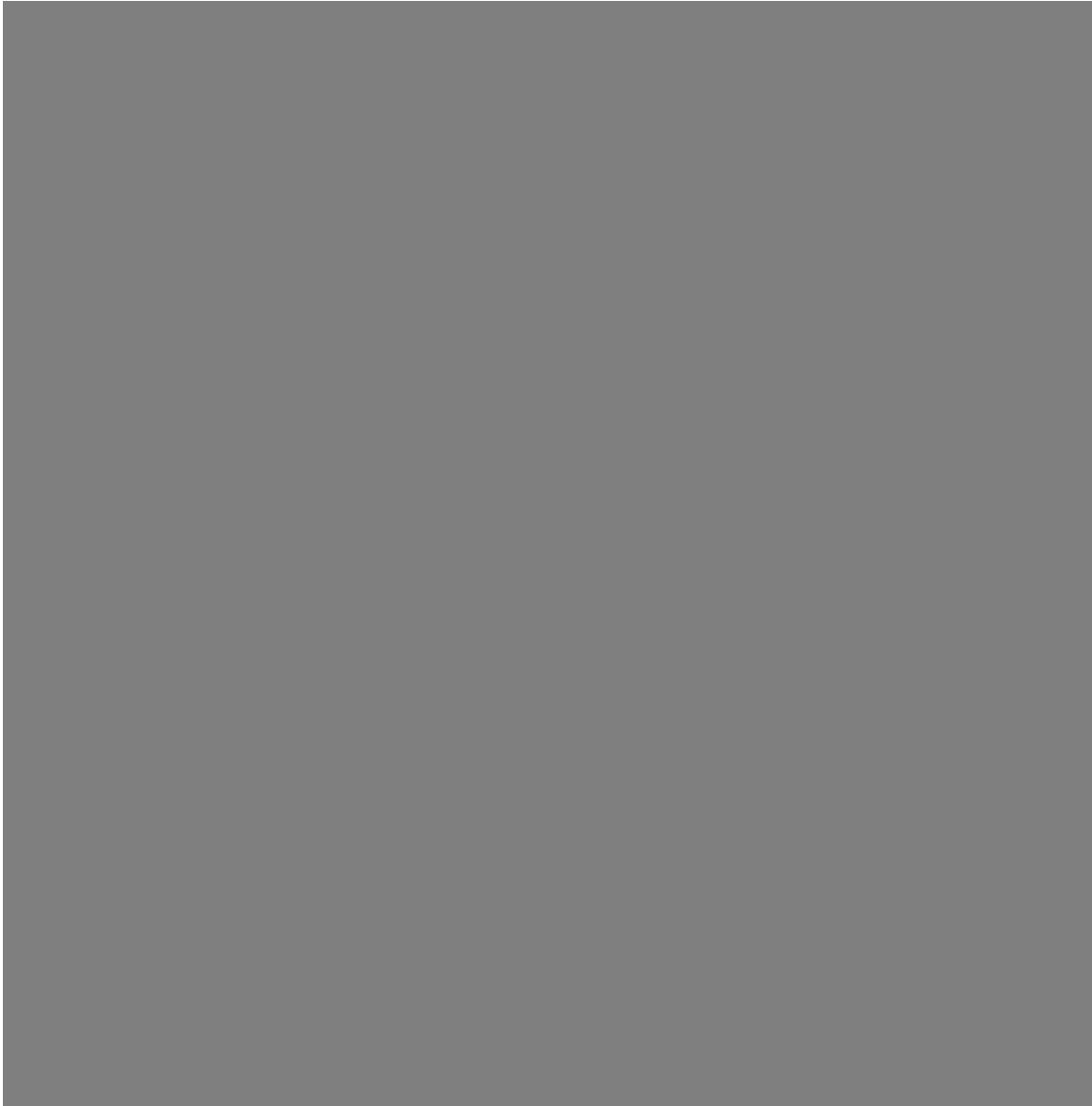
```
In[ ]:= date = DateObject["06/29/2010", "Day"]
helperYesterday[x_] := PreviousDate[x, "Day"]
helperTomorrow[x_] := NextDate[x, "Day"]
Table[{"Pre-IPO", Interpreter["Financial"][i], InteractiveTradingChart[
  FinancialData[i, "OHLCV", {Nest[helperYesterday, date, 7], date}],
  Appearance -> "Line", PlotTheme -> "Business", ImageSize -> 400}], {i, symbol[{"3", "5", "6"}]}]
(*Rivian and Ferrari were not publicly traded at this time*)
Table[{"Post-IPO", Interpreter["Financial"][i], InteractiveTradingChart[
  FinancialData[i, "OHLCV", {date, Nest[helperTomorrow, date, 7]}],
  Appearance -> "Line", PlotTheme -> "Business"}], {i, symbol[{"1", "3", "5", "6"}]}]
```

Out[]:=

Tue 29 Jun 2010

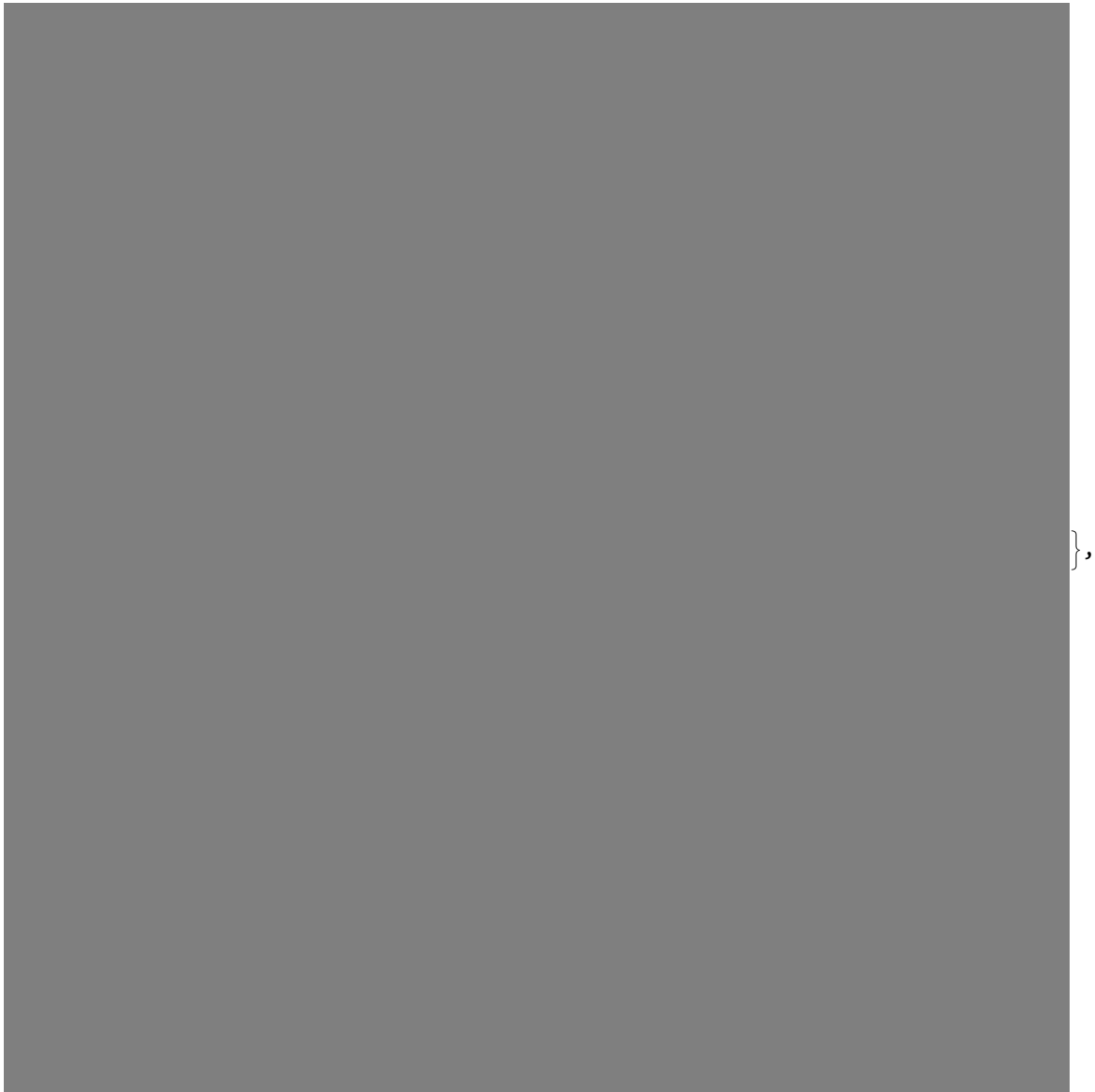
Out[]:=

{Pre-IPO, Ford,



}

{Pre-IPO, Toyota, }



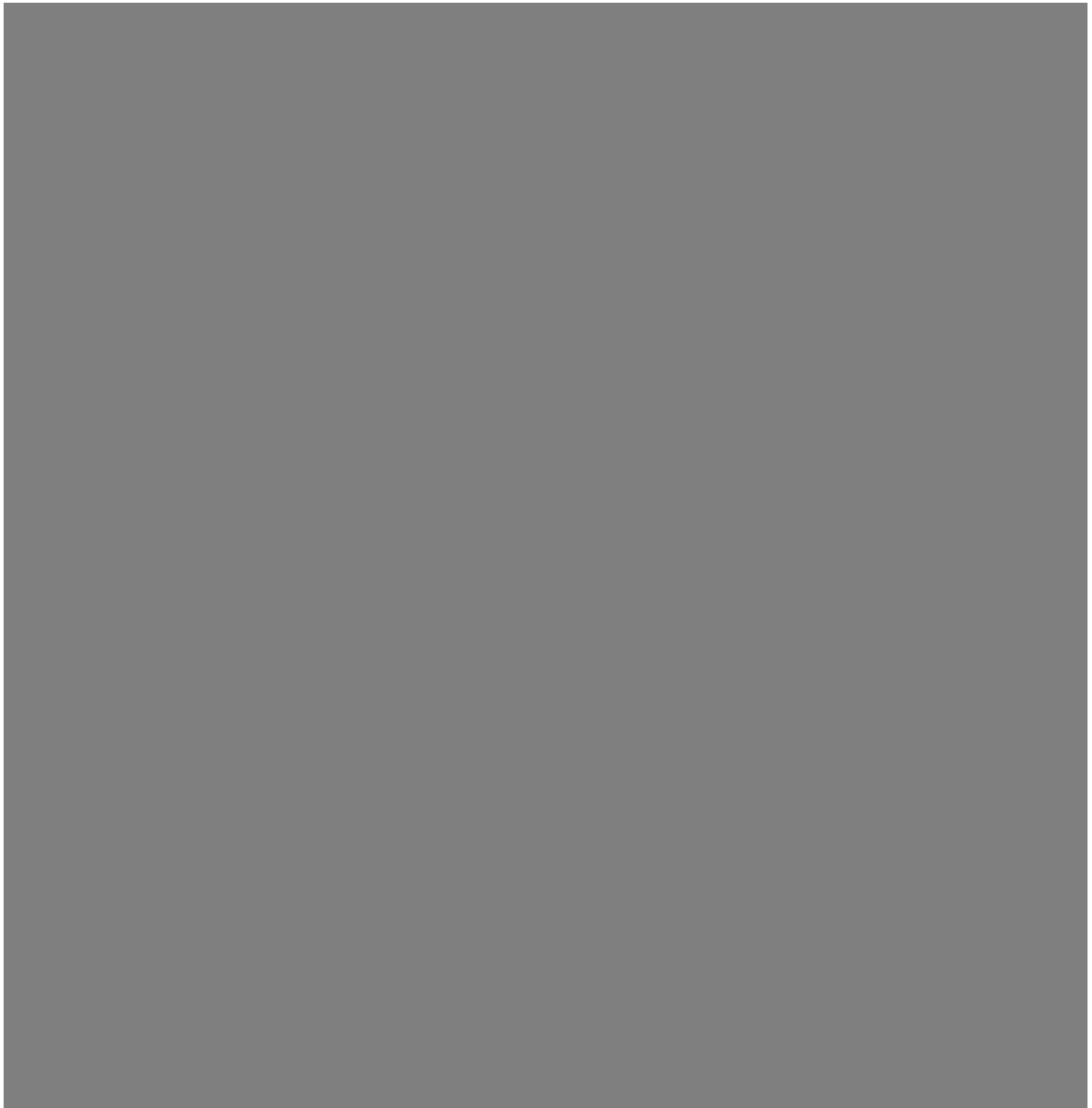
{Pre-IPO, Honda},



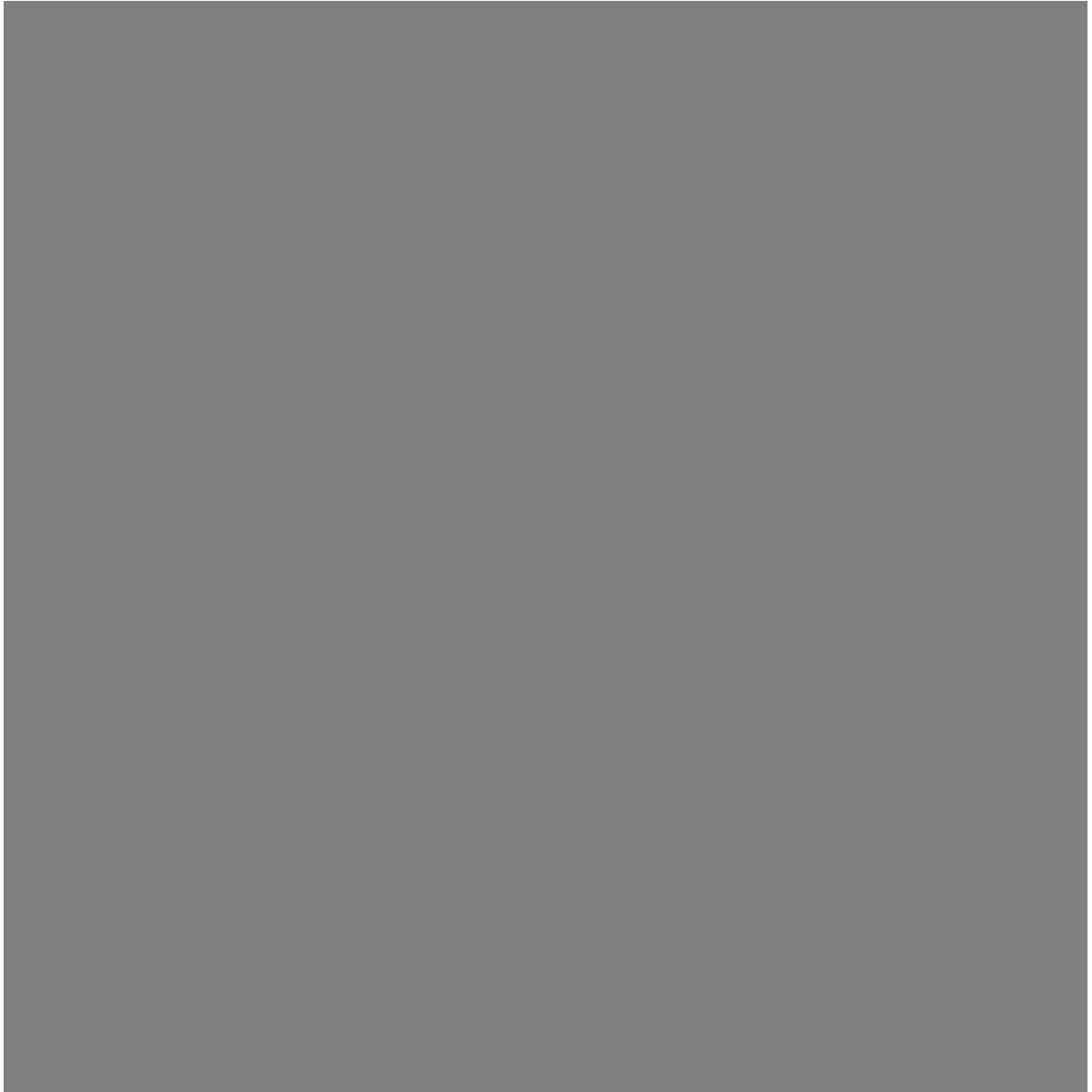
}}

Out[*]=

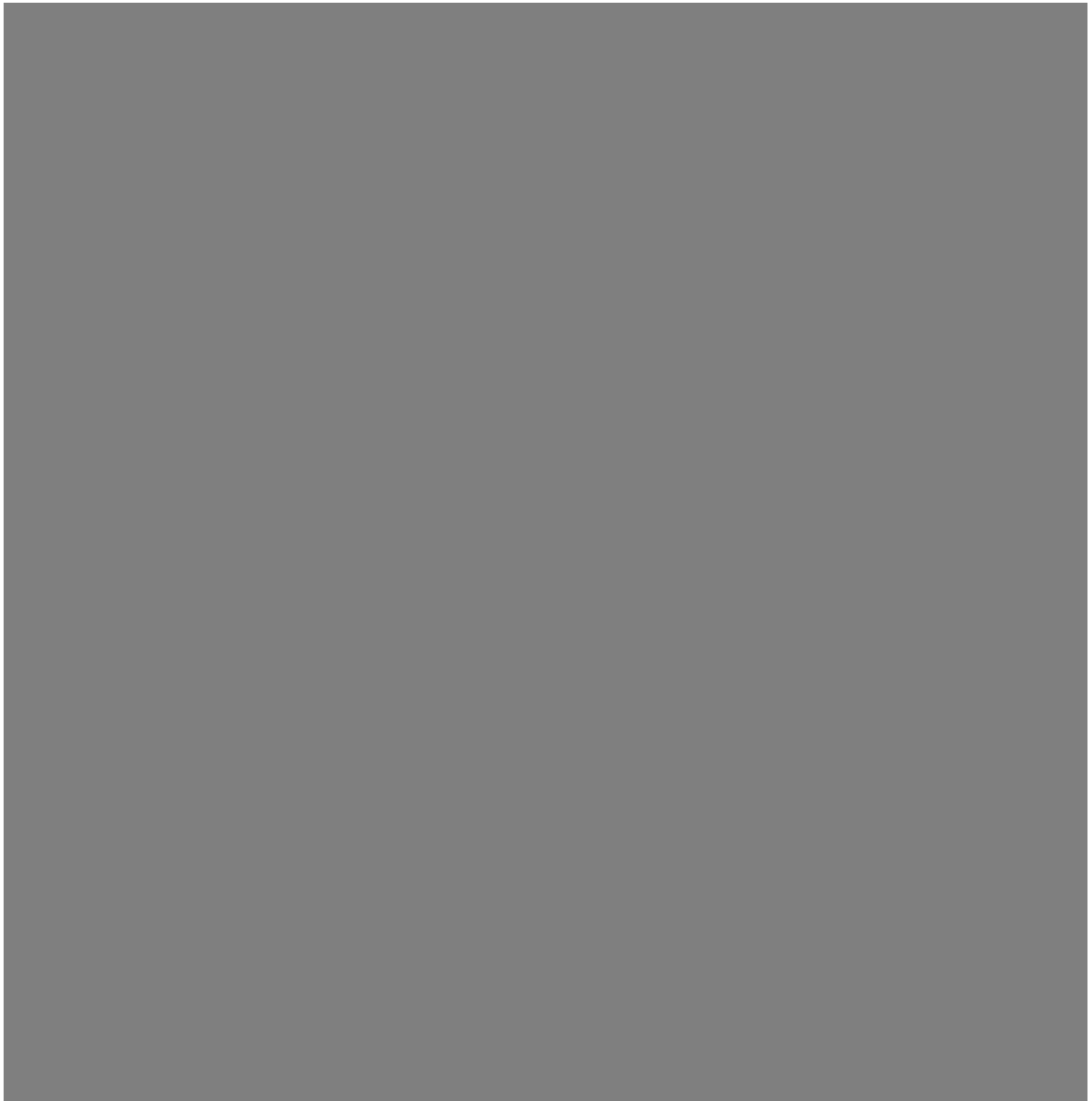
 $\left\{ \left\{ \text{Post-IPO}, \text{Tesla Motors} \right\}, \right.$



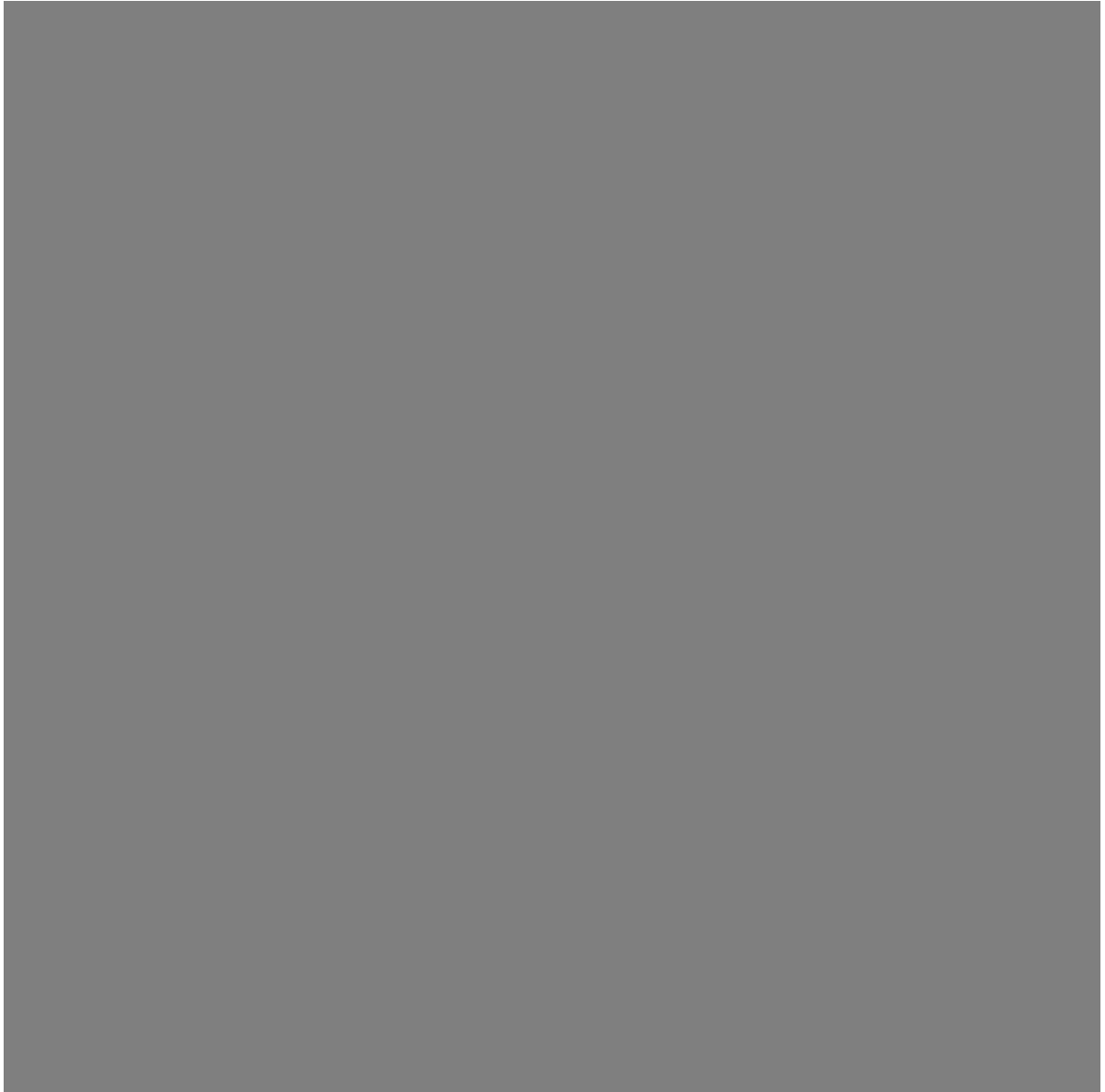
}, {Post-IPO, Ford, }



}, {Post-IPO, Toyota},



}, {Post-IPO, Honda},



}}

Tesla Model S

In June 22, 2012, Tesla released the Model S, revolutionizing the EV market.

(*Generate two interactive trading charts (pre- and post-event)
for each company around the date of Tesla's Model S release*)

```

In[ ]:= date = DateObject["06/22/2012", "Day"]
helperYesterday[x_] := PreviousDate[x, "Day"]
helperTomorrow[x_] := NextDate[x, "Day"]
Table[{"Pre Model S", Interpreter["Financial"][i], InteractiveTradingChart[
  FinancialData[i, "OHLCV", {Nest[helperYesterday, date, 7], date}],
  Appearance → "Line", PlotTheme → "Business"}], {i, symbol[[{1, 3, 5, 6}]]}]
Table[{"Post Model S", Interpreter["Financial"][i], InteractiveTradingChart[
  FinancialData[i, "OHLCV", {date, Nest[helperTomorrow, date, 7]}],
  Appearance → "Line", PlotTheme → "Business"}], {i, symbol[[{1, 3, 5, 6}]]}]

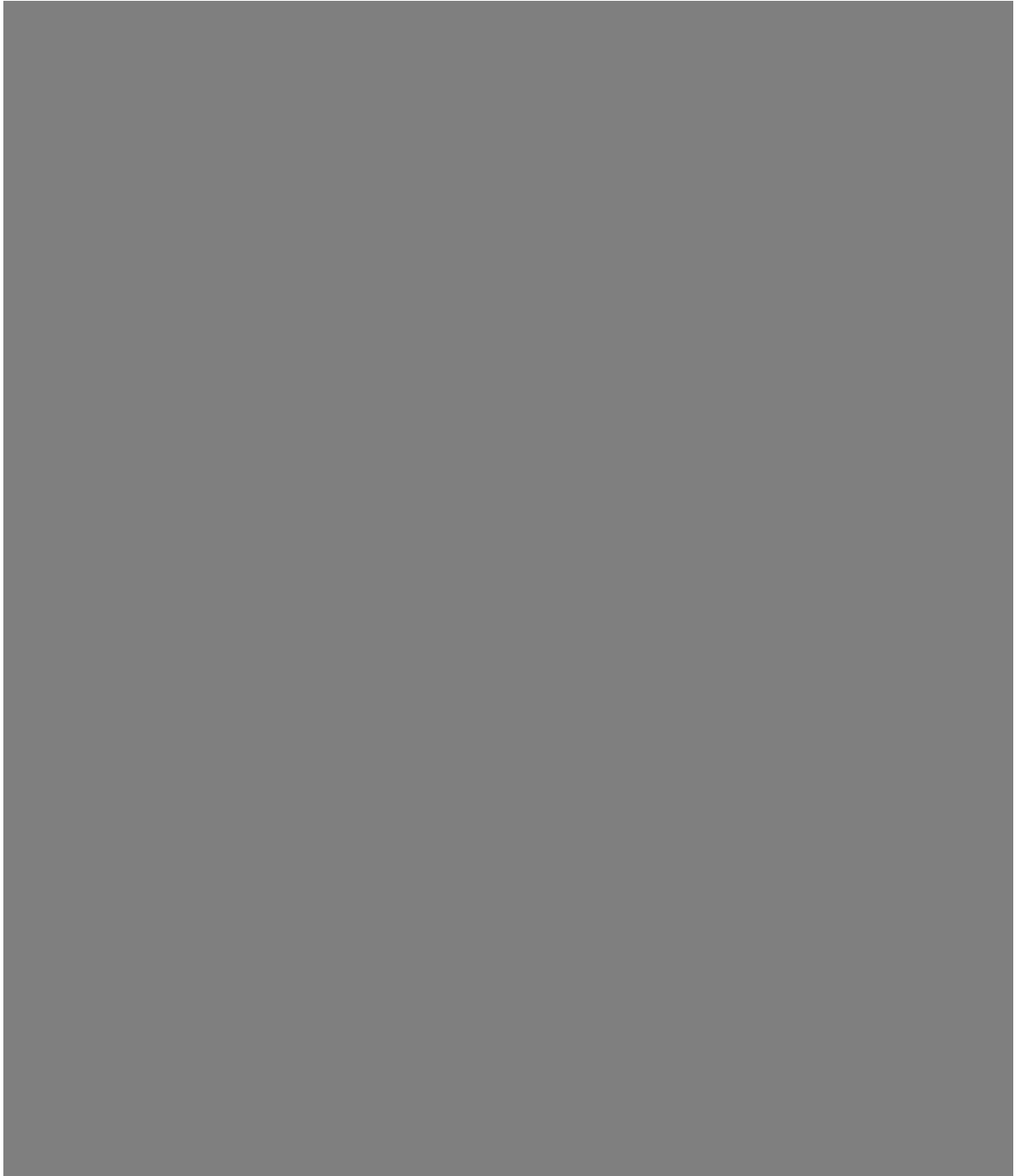
```

Out[]=

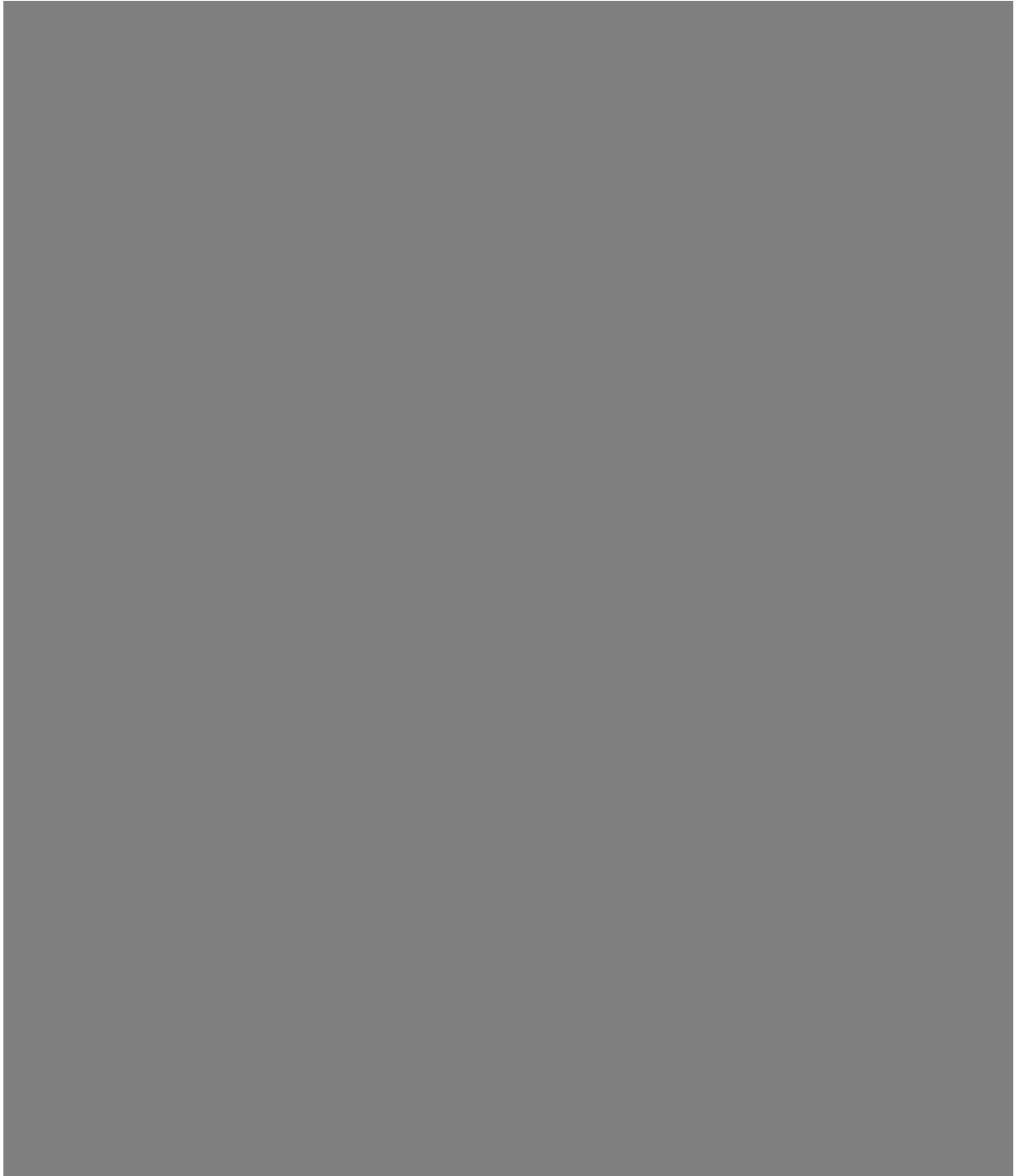
Fri 22 Jun 2012

Out[]=

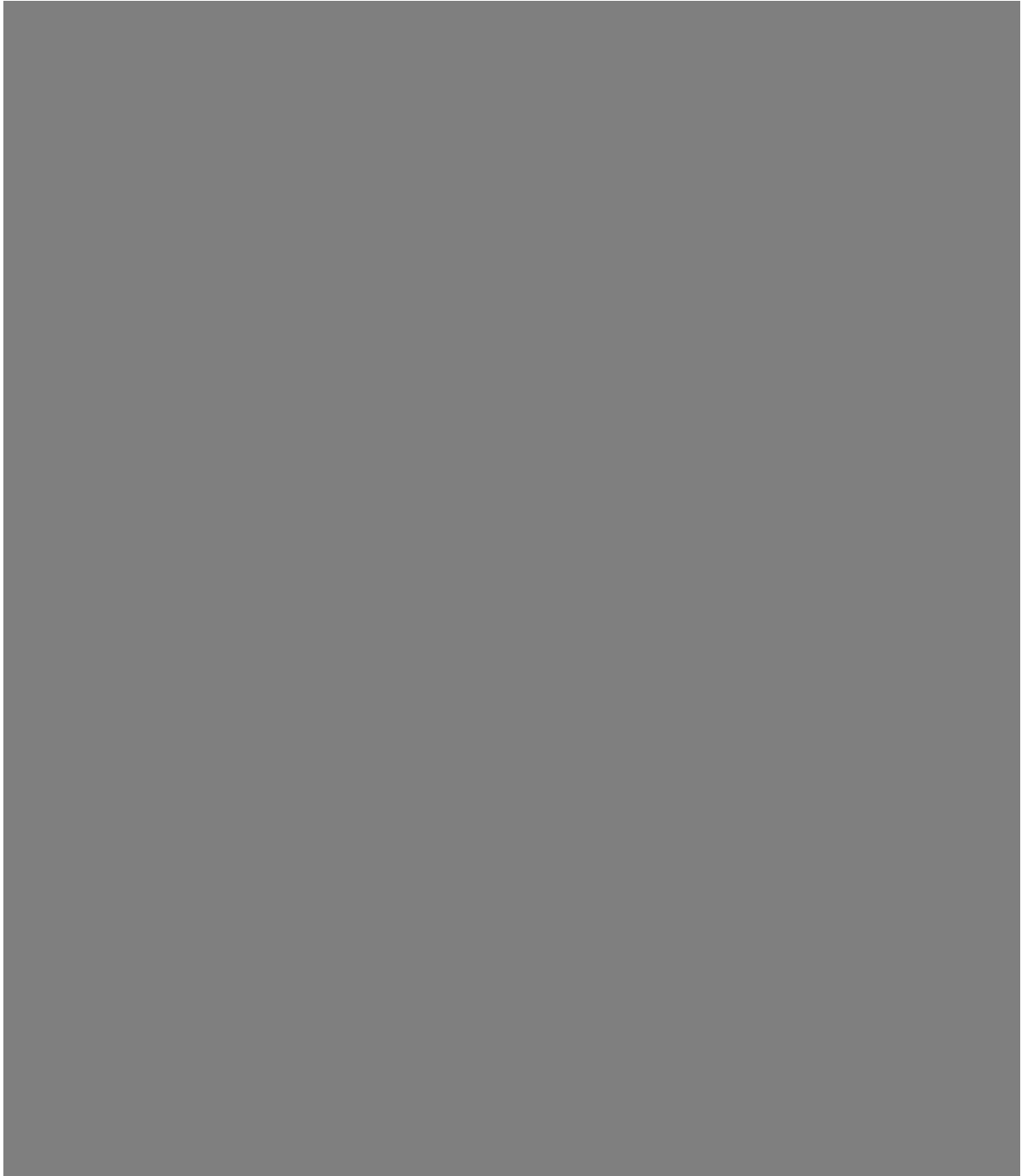
{ {Pre Model S, Tesla Motors, }



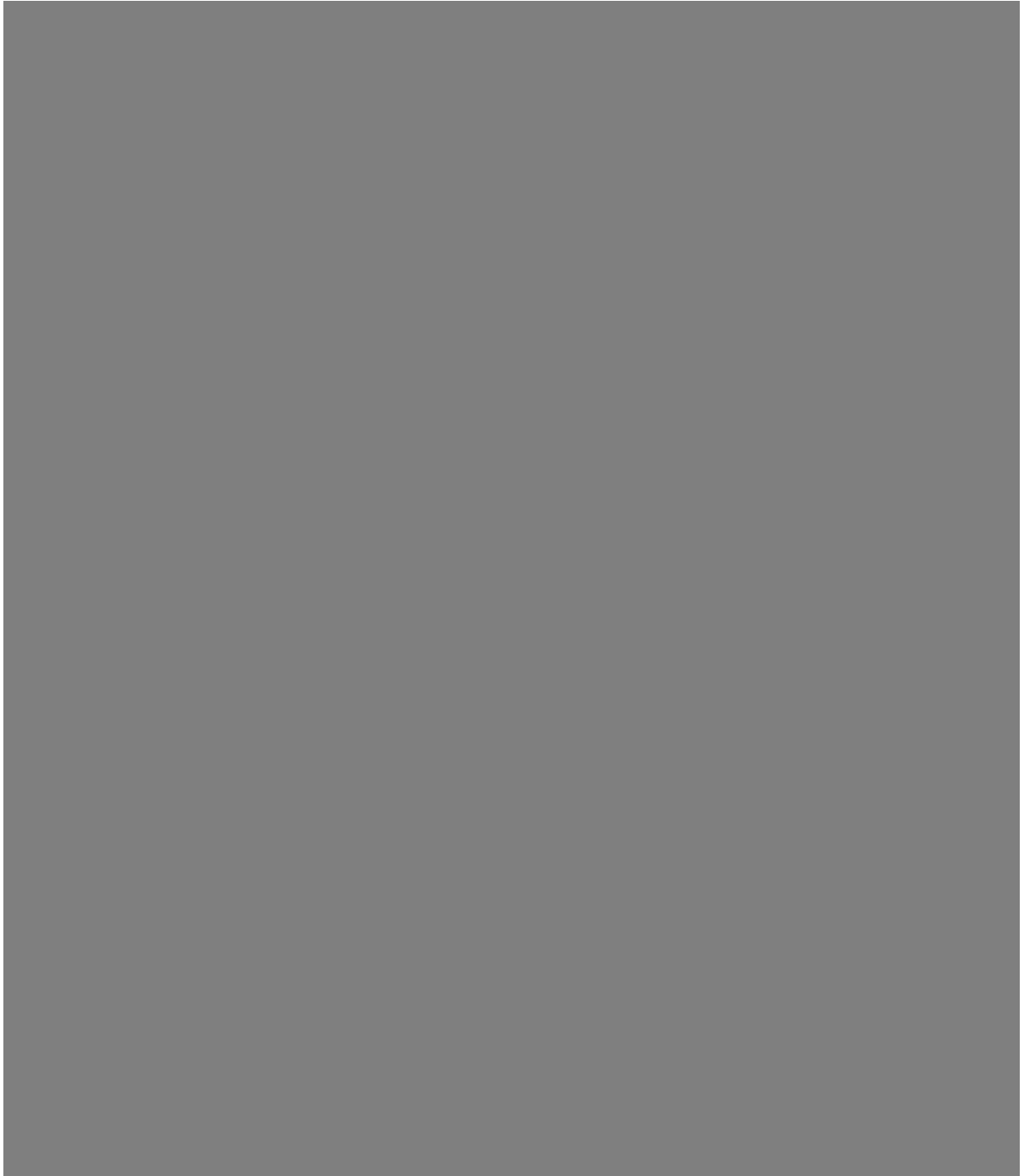
} , { Pre Model S, Ford ,



} , { Pre Model S, Toyota ,



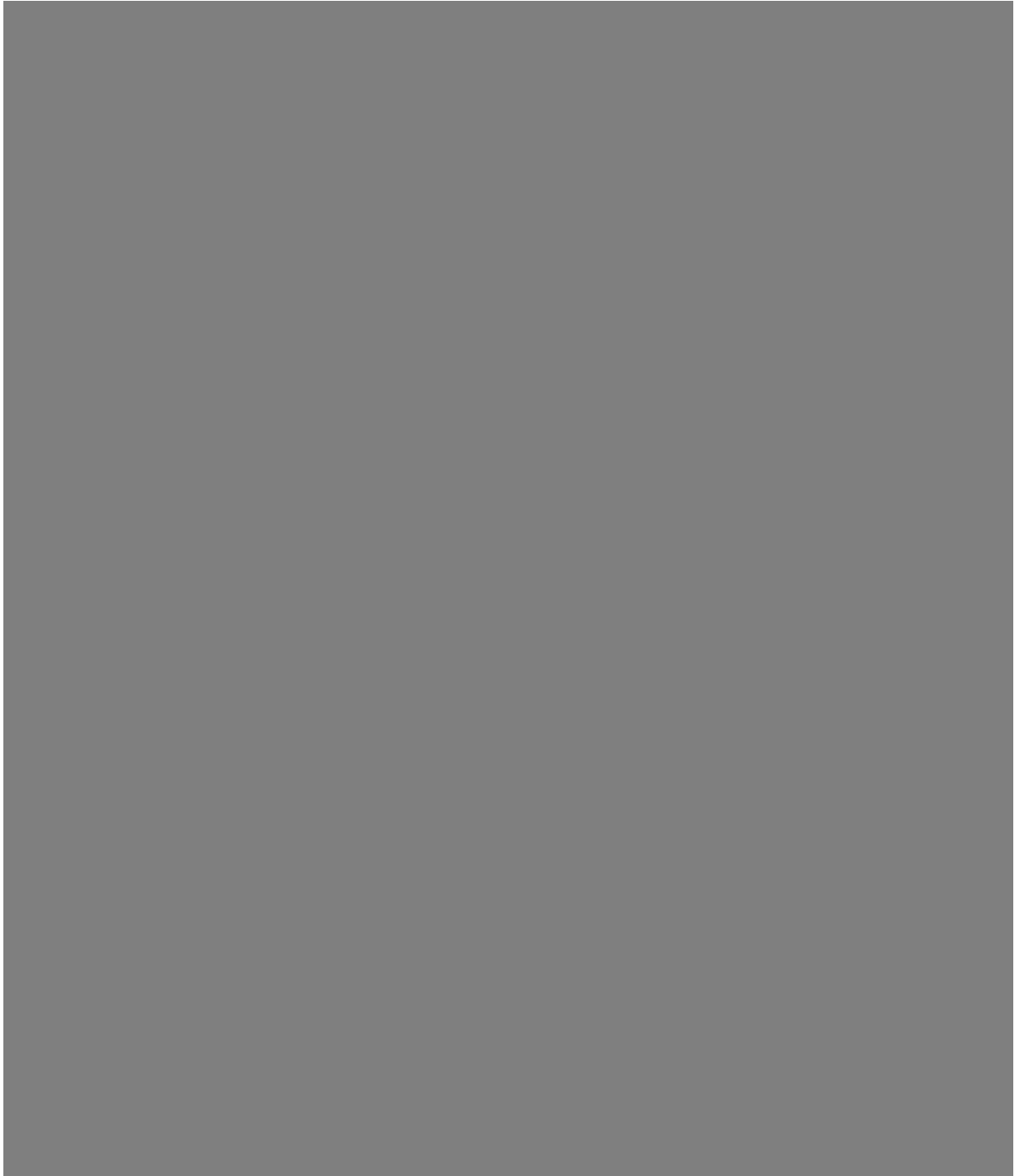
}, {Pre Model S, Honda,



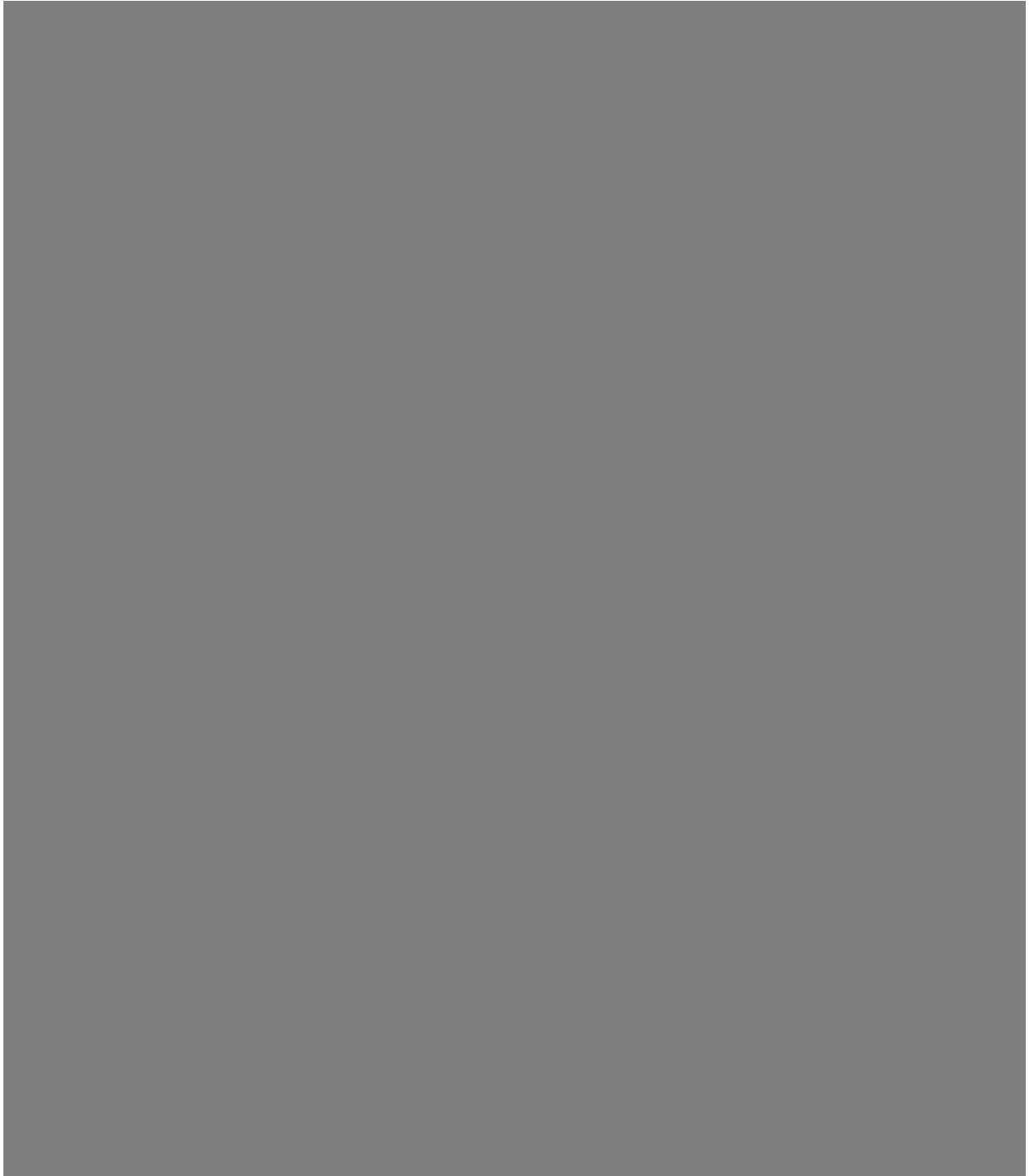
}}

Out[*]=

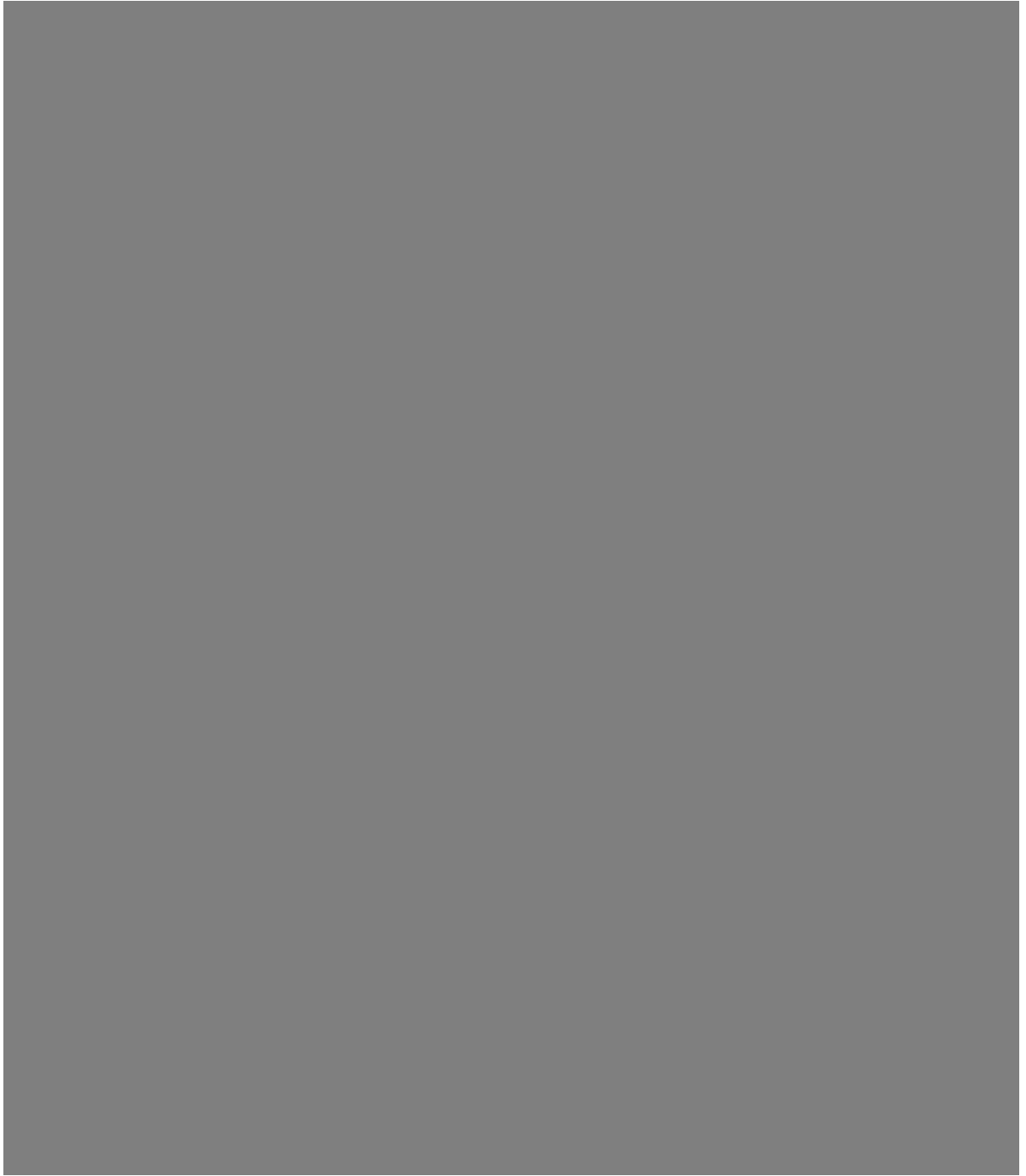
{ {Post Model S, Tesla Motors, }



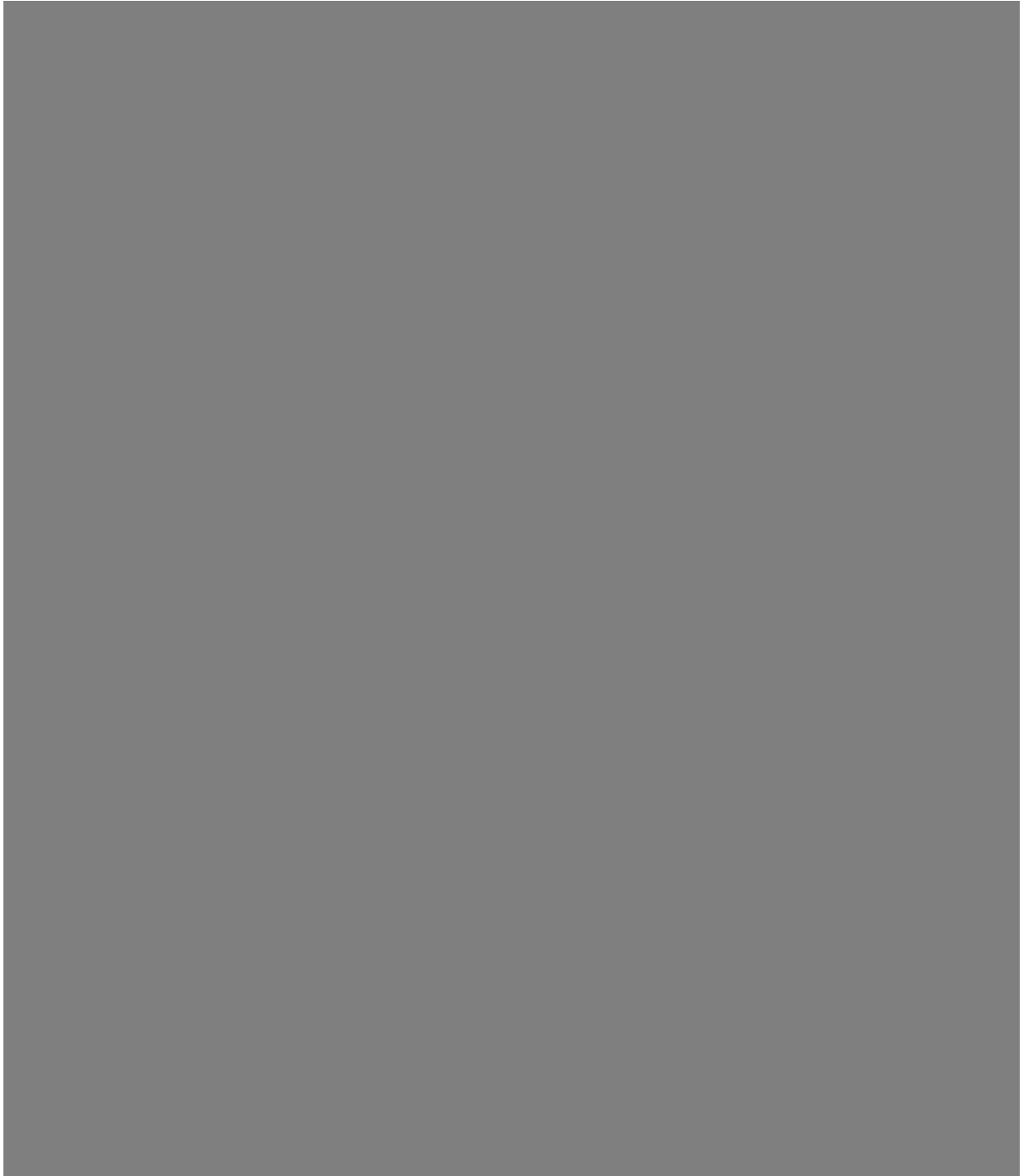
}, {Post Model S, Ford, }



}, {Post Model S, Toyota, }



}, {Post Model S, Honda, }



}}

Volkswagen Dieselgate Scandal

In September 18, 2015, The U.S. EPA issued a Notice of Violation to Volkswagen, exposing its emissions fraud. Volkswagen's emissions scandal accelerated investments in EVs as automakers sought to

improve their environmental image.

(*Generate two interactive trading charts (pre- and post-event)
for each company around the date of the Dieselgate Scandal*)

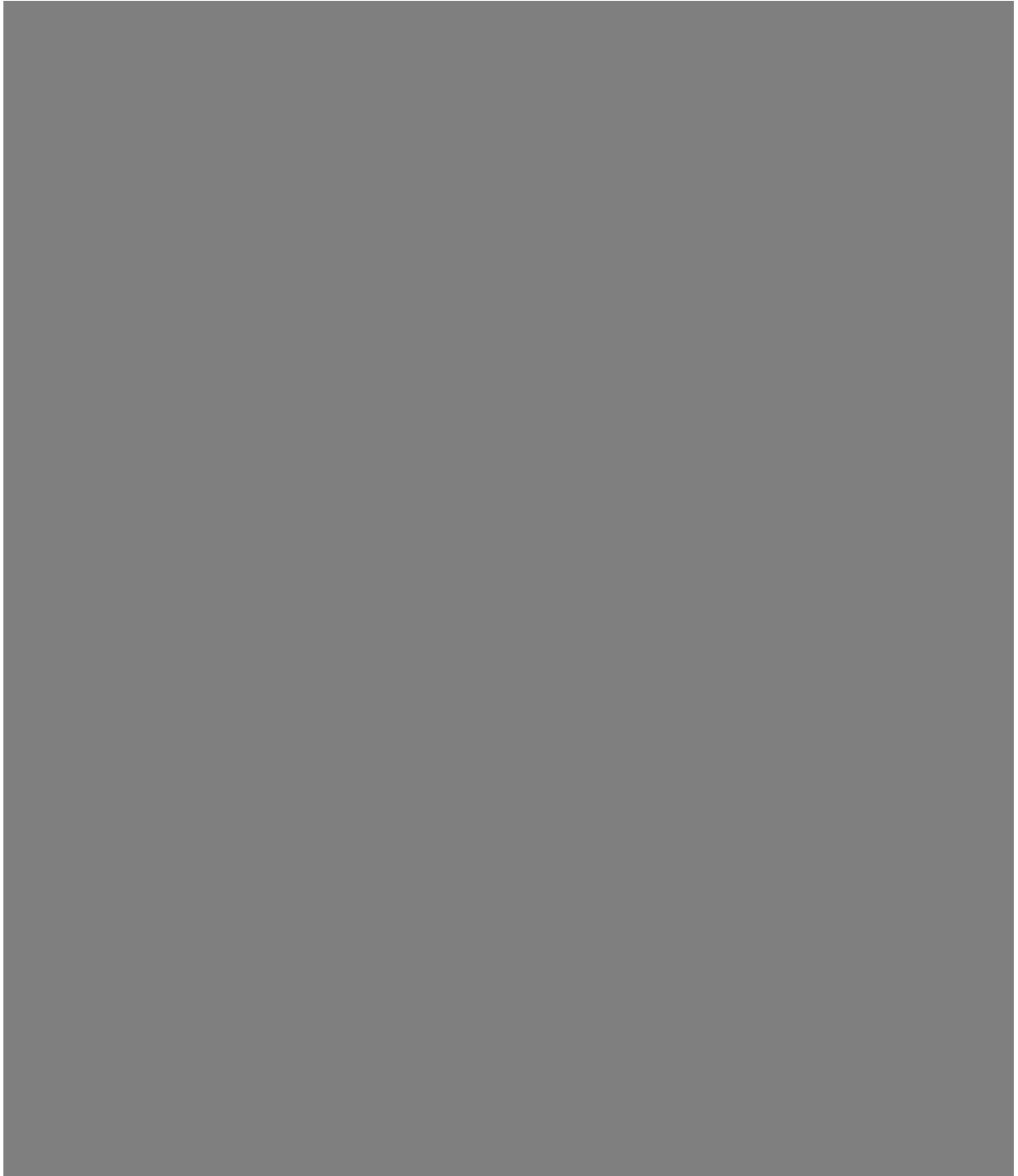
```
In[ ]:= date = DateObject["09/18/2015", "Day"]
helperYesterday[x_] := PreviousDate[x, "Day"]
helperTomorrow[x_] := NextDate[x, "Day"]
Table[{"Pre-Dieselgate", Interpreter["Financial"][i], InteractiveTradingChart[
  FinancialData[i, "OHLCV", {Nest[helperYesterday, date, 7], date}],
  Appearance → "Line", PlotTheme → "Business"}], {i, symbol[1, 3, 5, 6]}]
Table[{"Post-Dieselgate", Interpreter["Financial"][i], InteractiveTradingChart[
  FinancialData[i, "OHLCV", {date, Nest[helperTomorrow, date, 7]}],
  Appearance → "Line", PlotTheme → "Business"}], {i, symbol[1, 3, 5, 6]}]
```

Out[]=

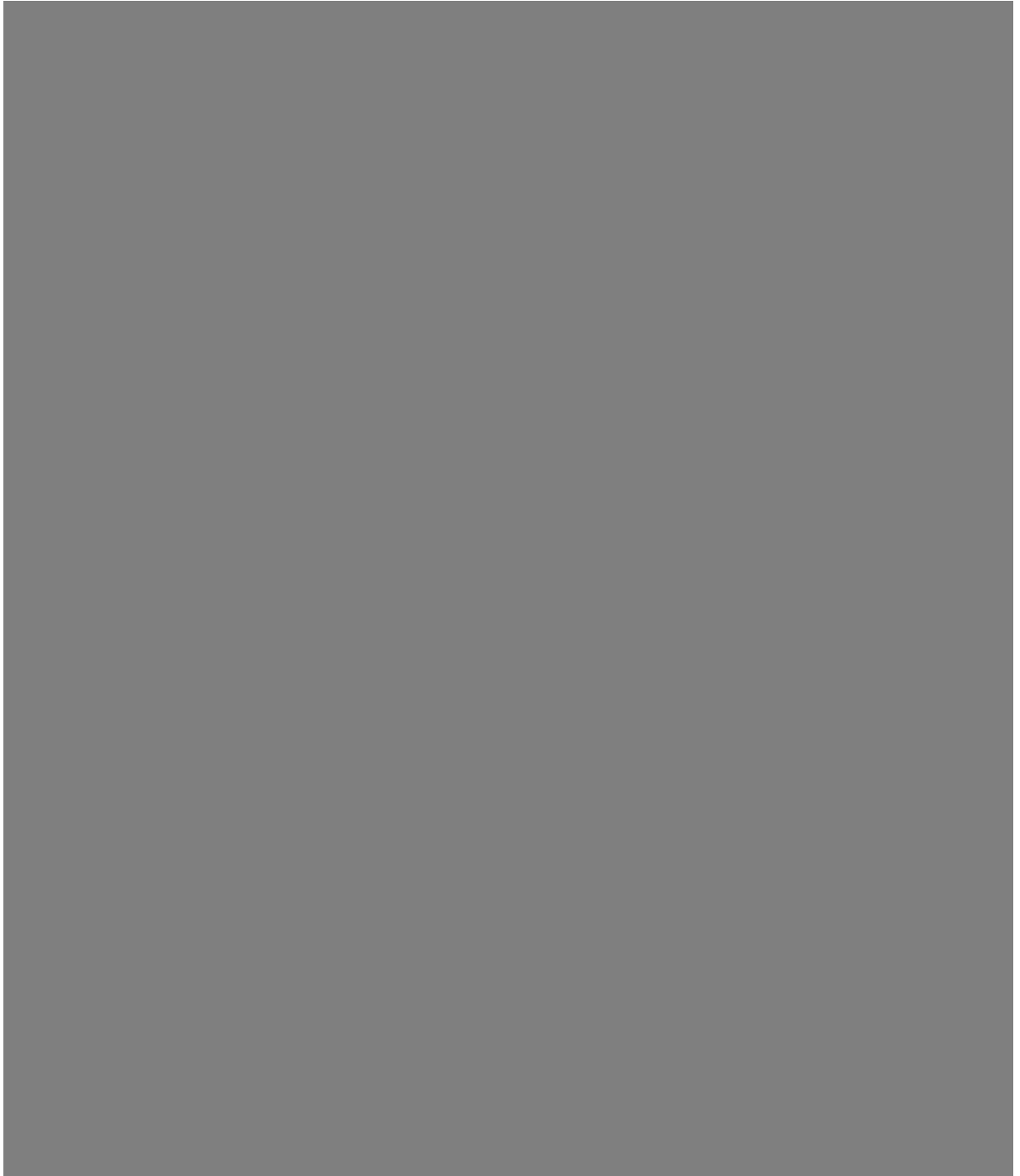
Fri 18 Sep 2015

Out[]=

{ {Pre-Dieselgate, Tesla Motors, }



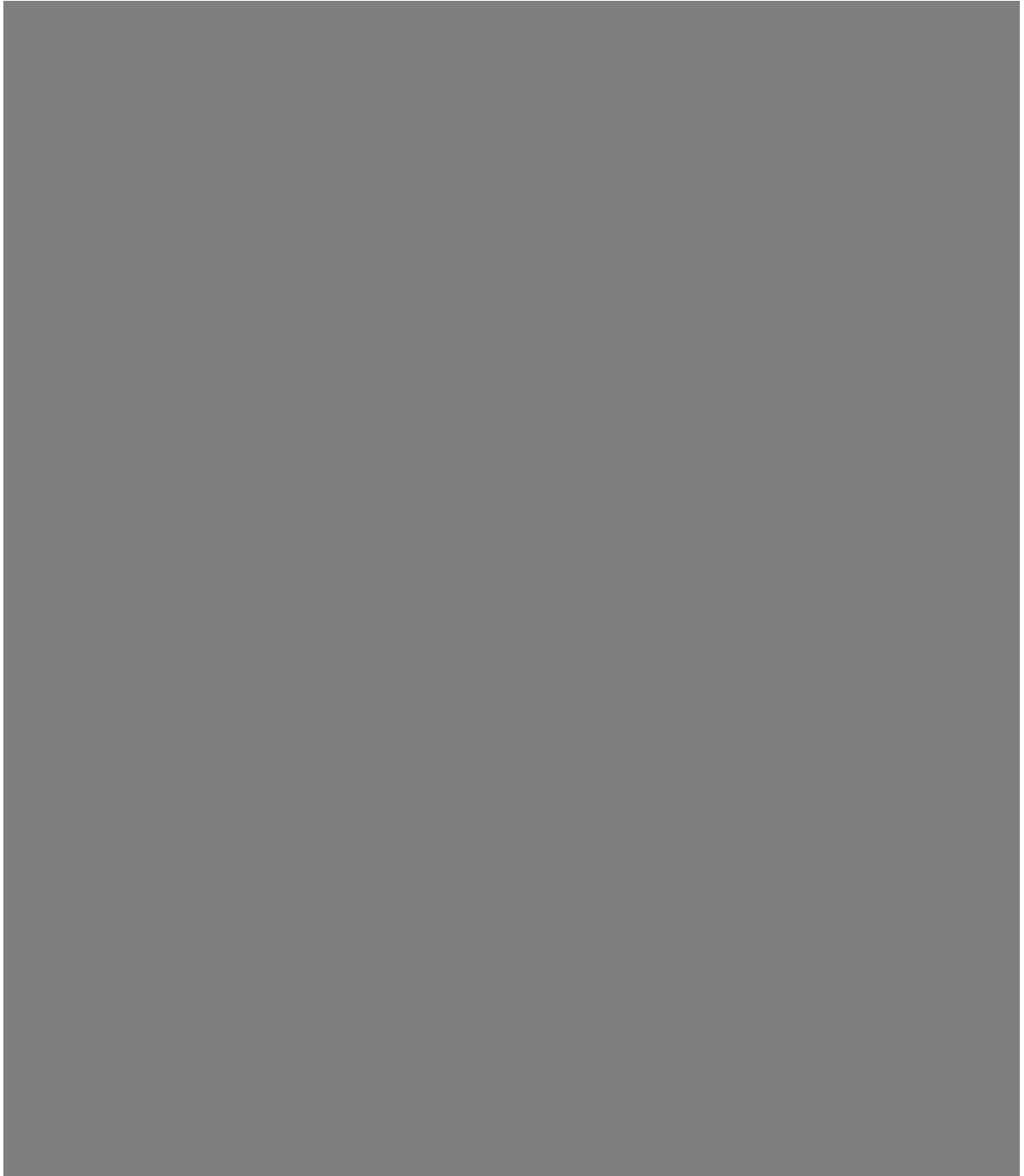
`}, {Pre-Dieselgate, Ford, }`



$\}, \{ \text{Pre-Dieselgate}, \text{Toyota},$



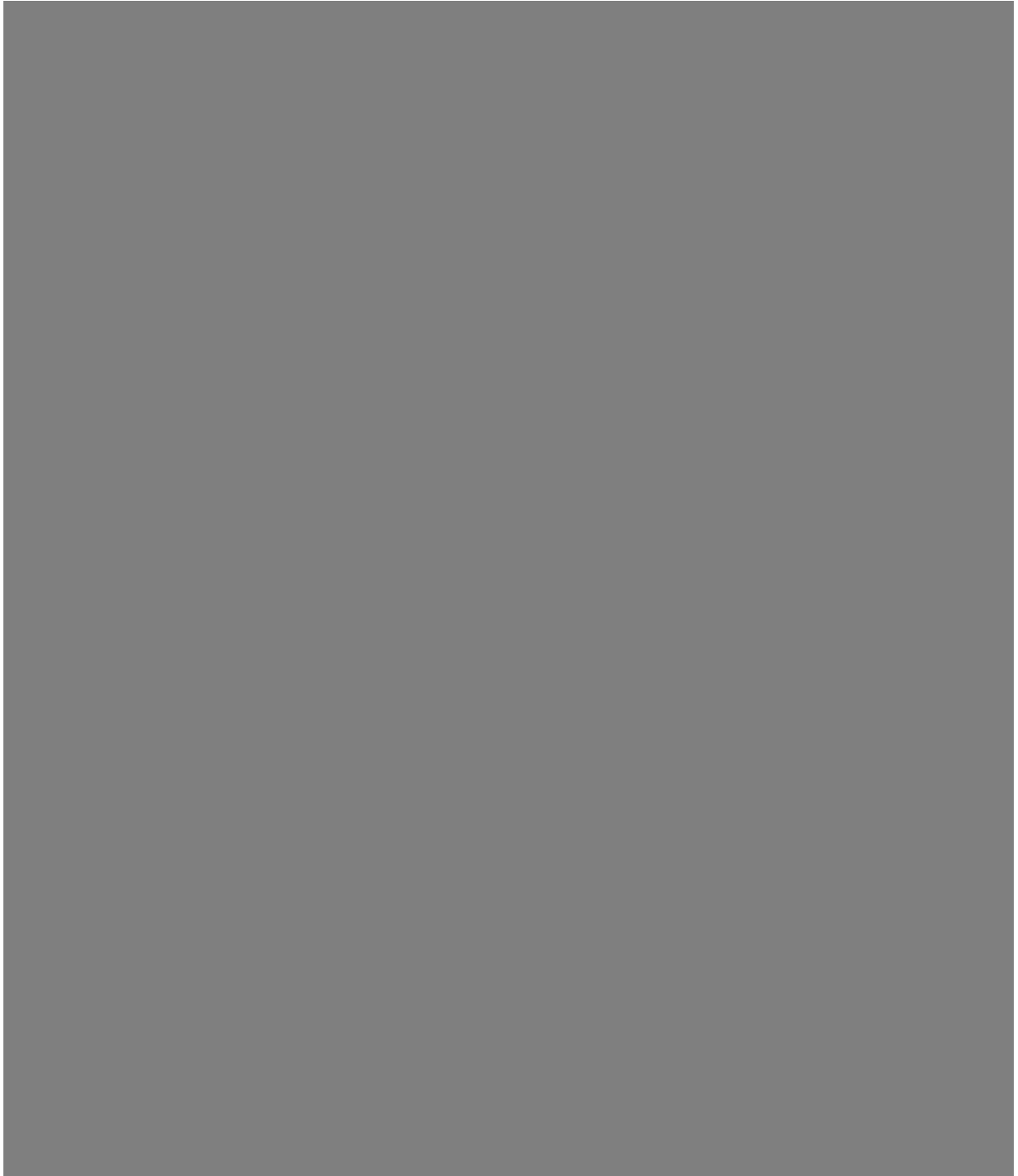
}, {Pre-Dieselgate, Honda,



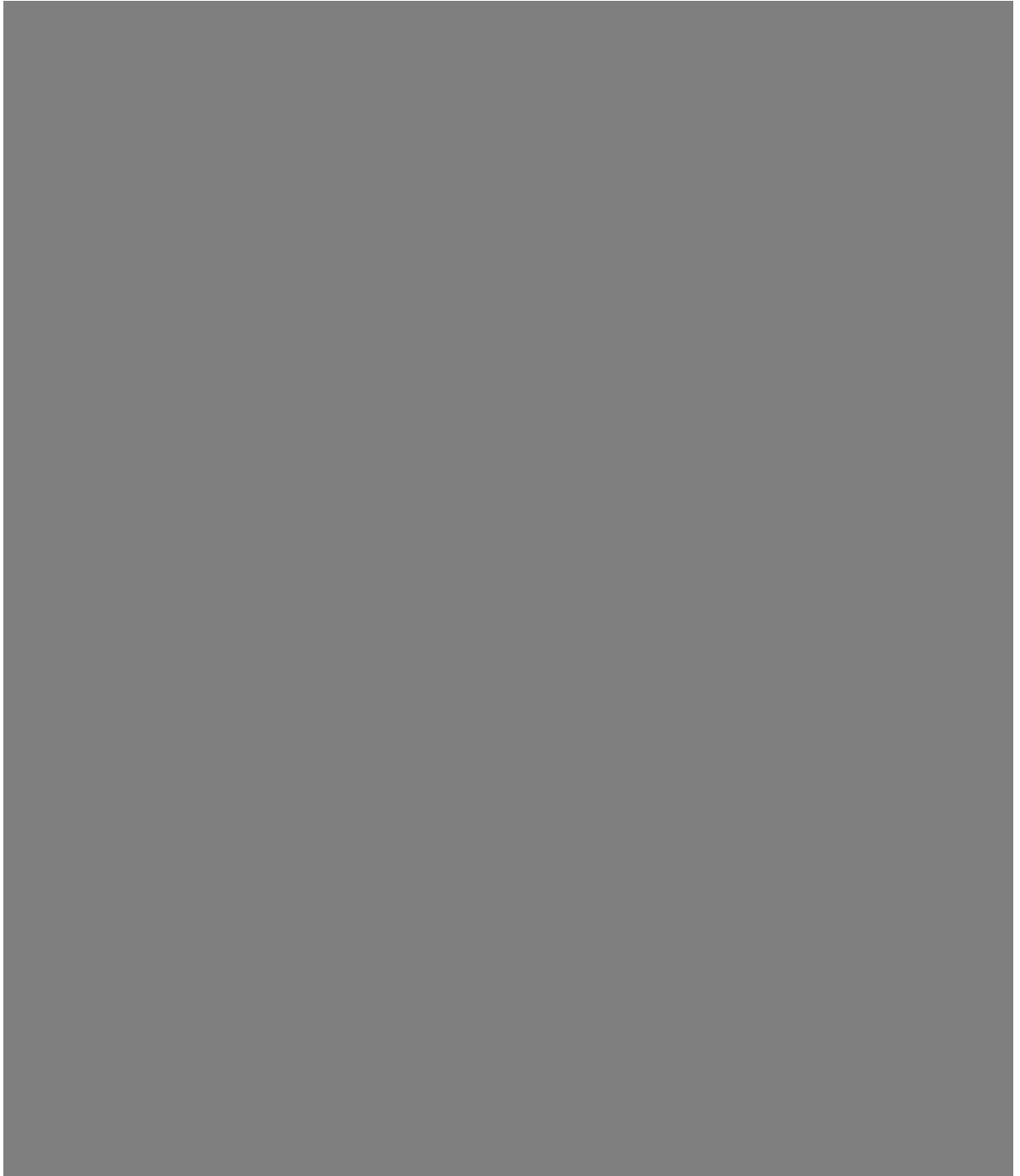
}}

Out[8]=

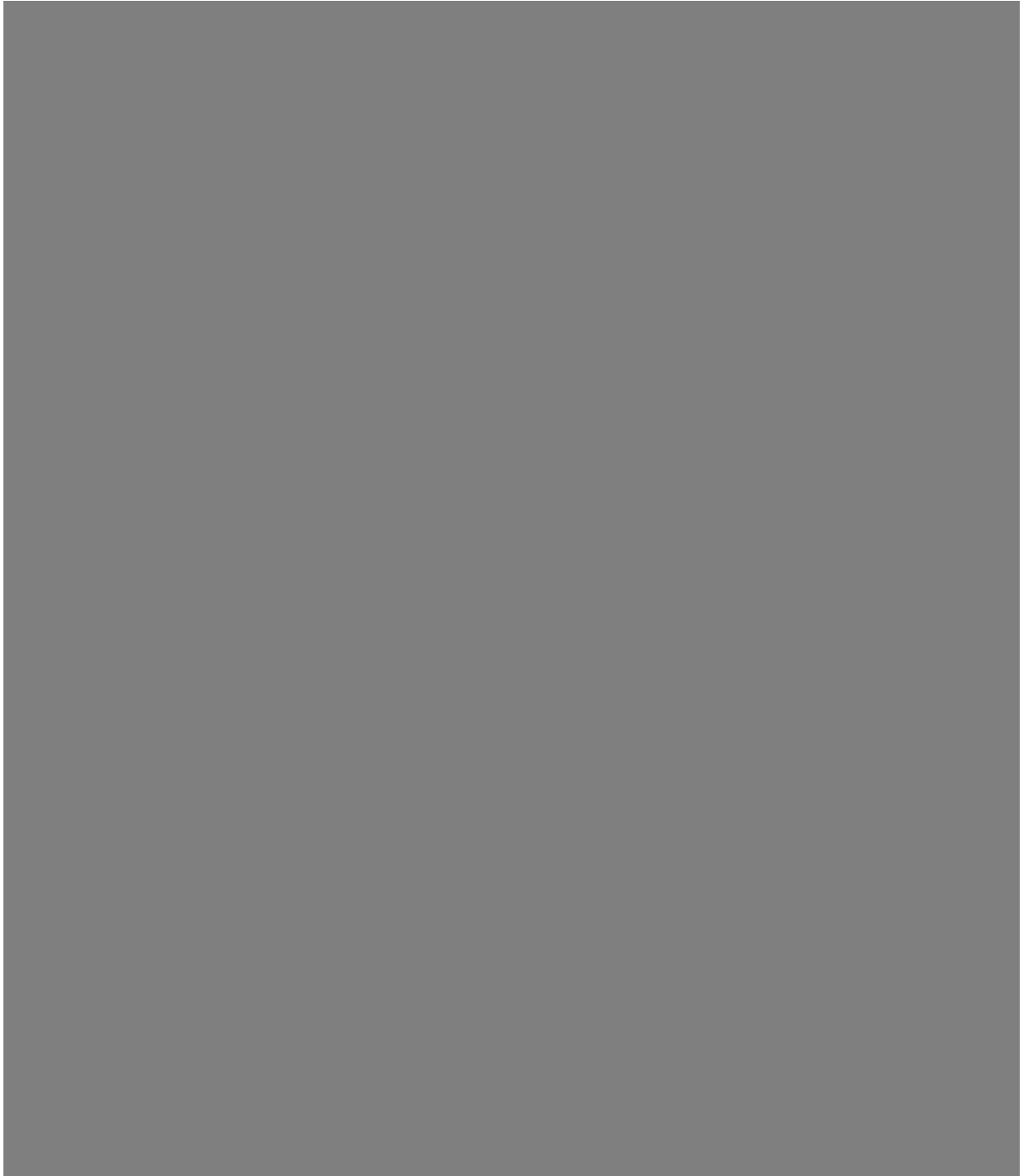
{ {Post-Dieselgate, Tesla Motors},



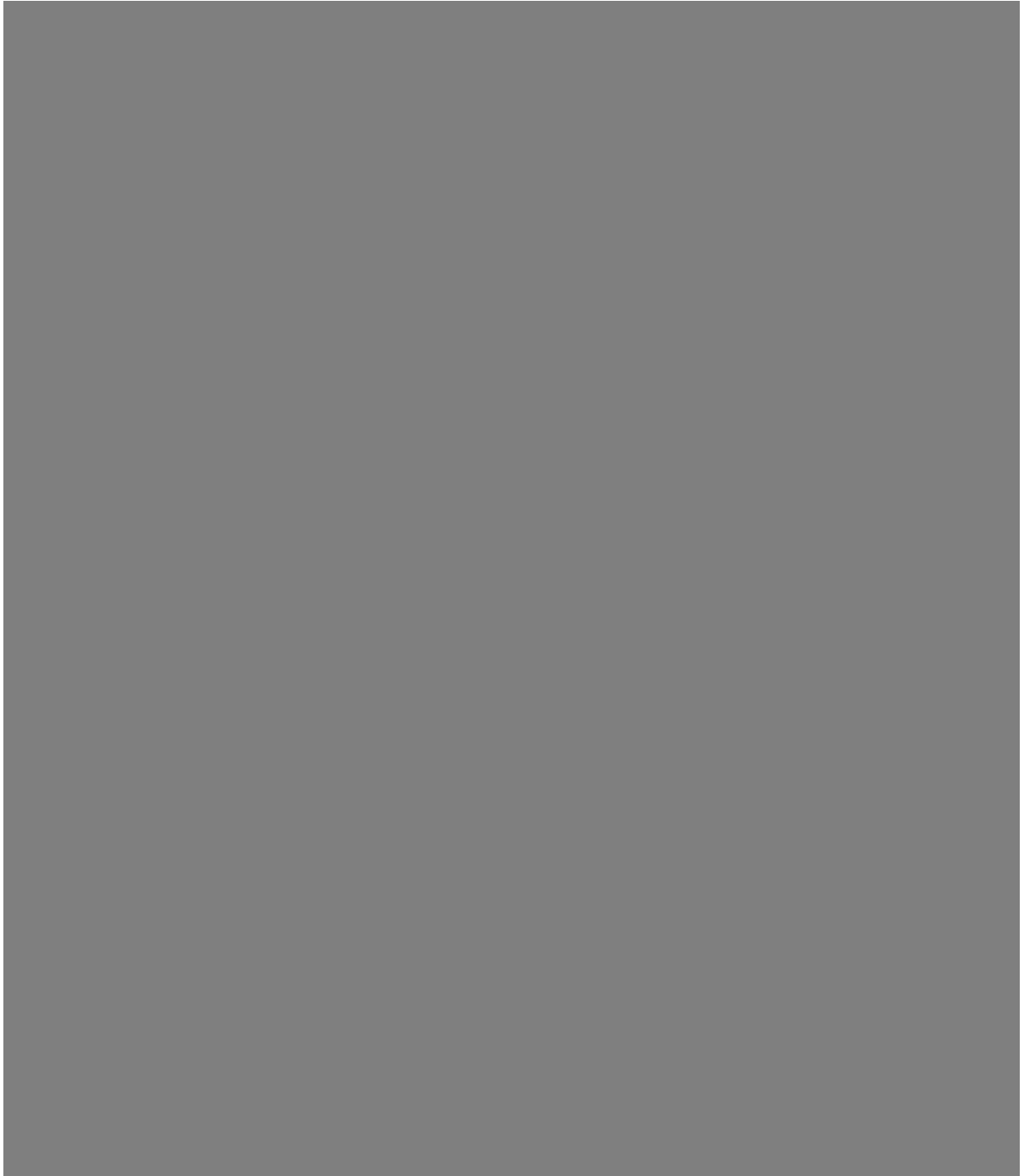
$\}, \{ \text{Post-Dieselgate}, \text{Ford},$



}, {Post-Dieselgate, Toyota},



}, {Post-Dieselgate, Honda ,



}}

Inflation Reduction Act (IRA)

The Inflation Reduction Act (IRA), signed into law on August 16, 2022, significantly supported electric vehicles (EVs) through tax incentives and domestic manufacturing requirements. It provided a tax

credit of up to \$7,500 for new EV purchases and \$4,000 for used EVs, with eligibility tied to the vehicle's final assembly in North America and sourcing of critical minerals from approved trade partners.

(*Generate two interactive trading charts (pre- and post-event)
for each company around the date of the IRA's signing*)

```
In[ ]:= date = DateObject["08/16/2022", "Day"]
helperYesterday[x_] := PreviousDate[x, "Day"]
helperTomorrow[x_] := NextDate[x, "Day"]
Table[{"Pre-IRA", Interpreter["Financial"][i], InteractiveTradingChart[
  FinancialData[i, "OHLCV", {Nest[helperYesterday, date, 7], date}],
  Appearance → "Line", PlotTheme → "Business"]}, {i, symbol}]
Table[{"Post-IRA", Interpreter["Financial"][i], InteractiveTradingChart[
  FinancialData[i, "OHLCV", {date, Nest[helperTomorrow, date, 7]}],
  Appearance → "Line", PlotTheme → "Business"]}, {i, symbol}]
```

Out[]:=

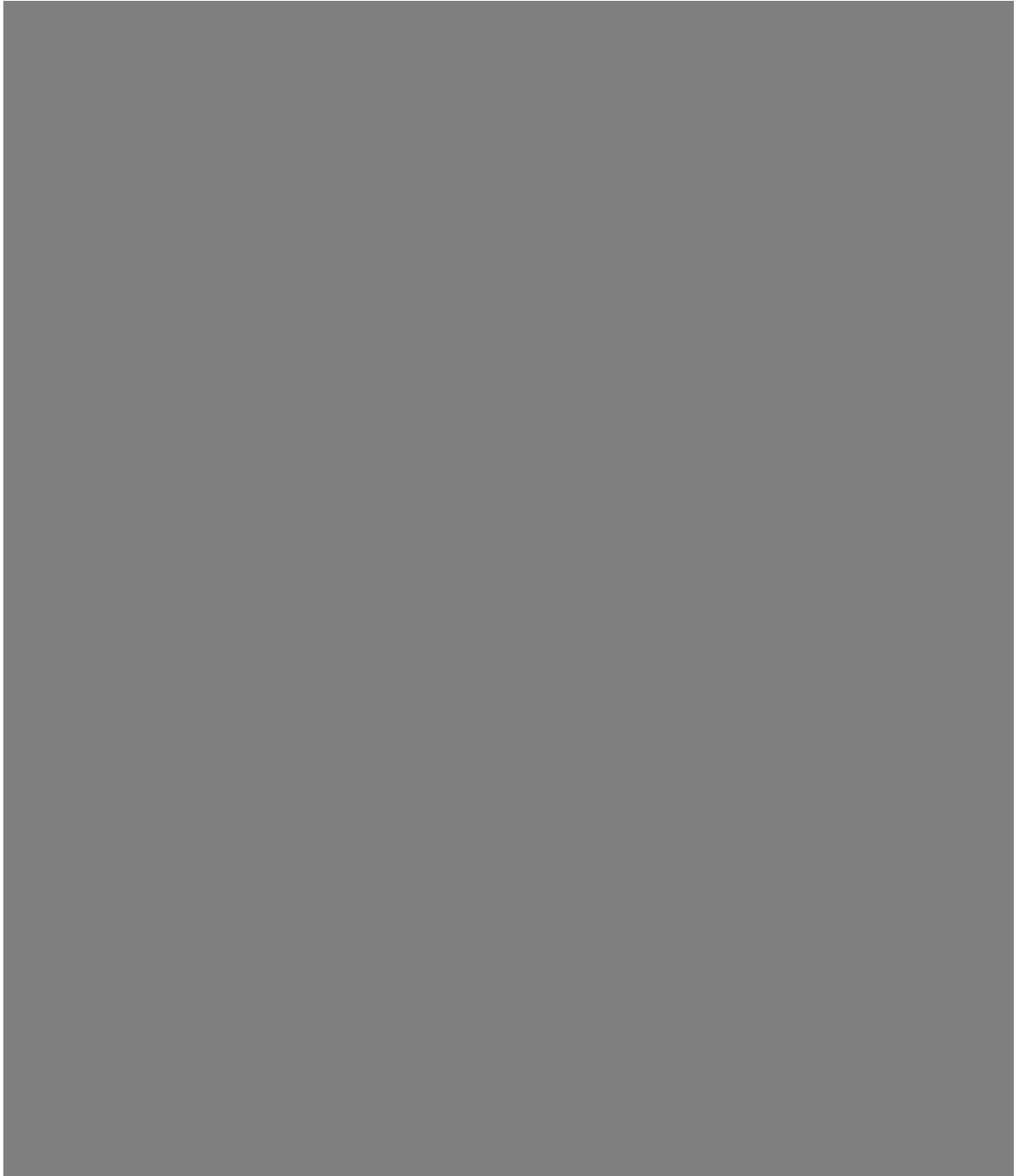
Tue 16 Aug 2022

Out[]:=

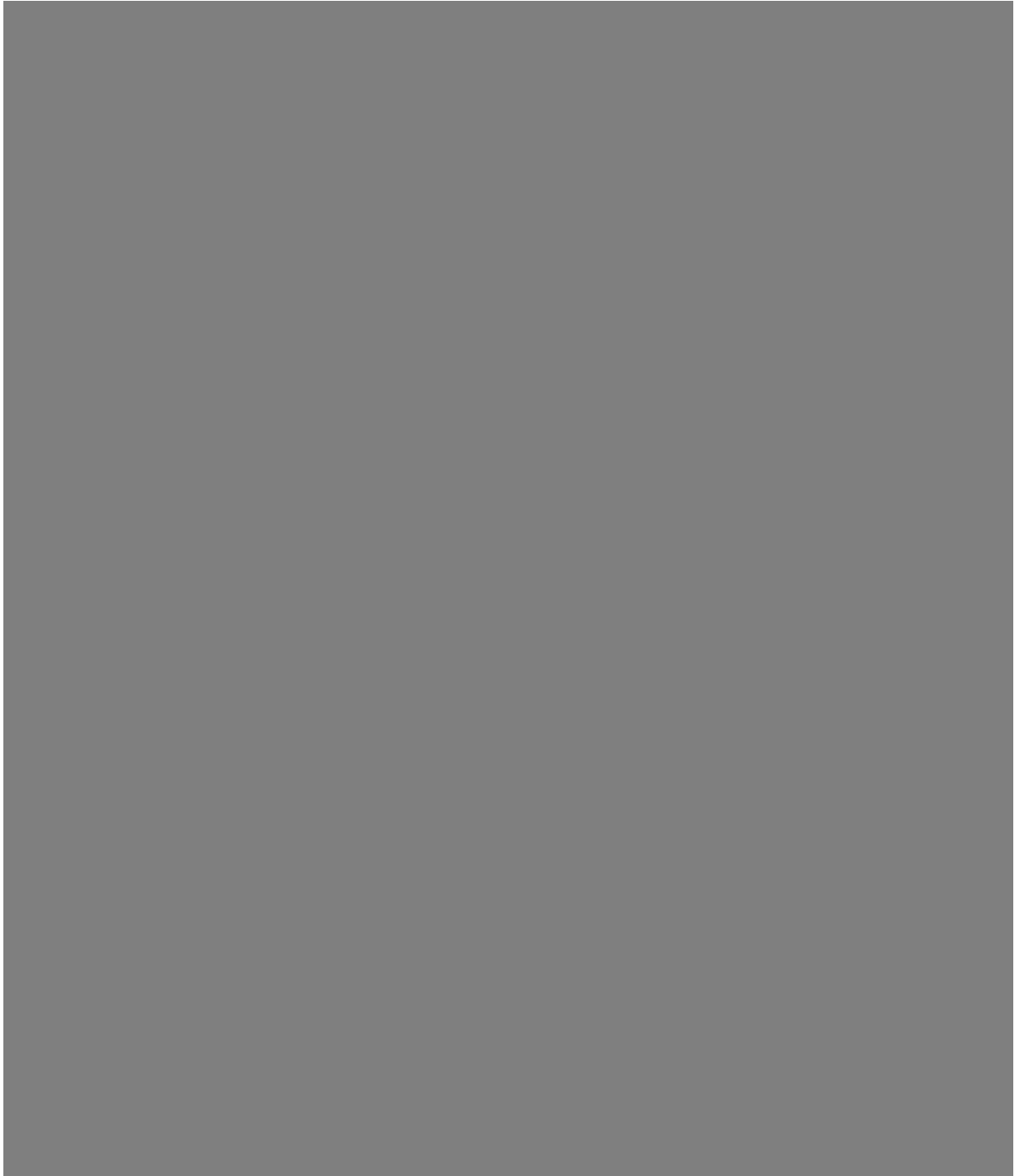
{ {Pre-IRA, Tesla Motors, }



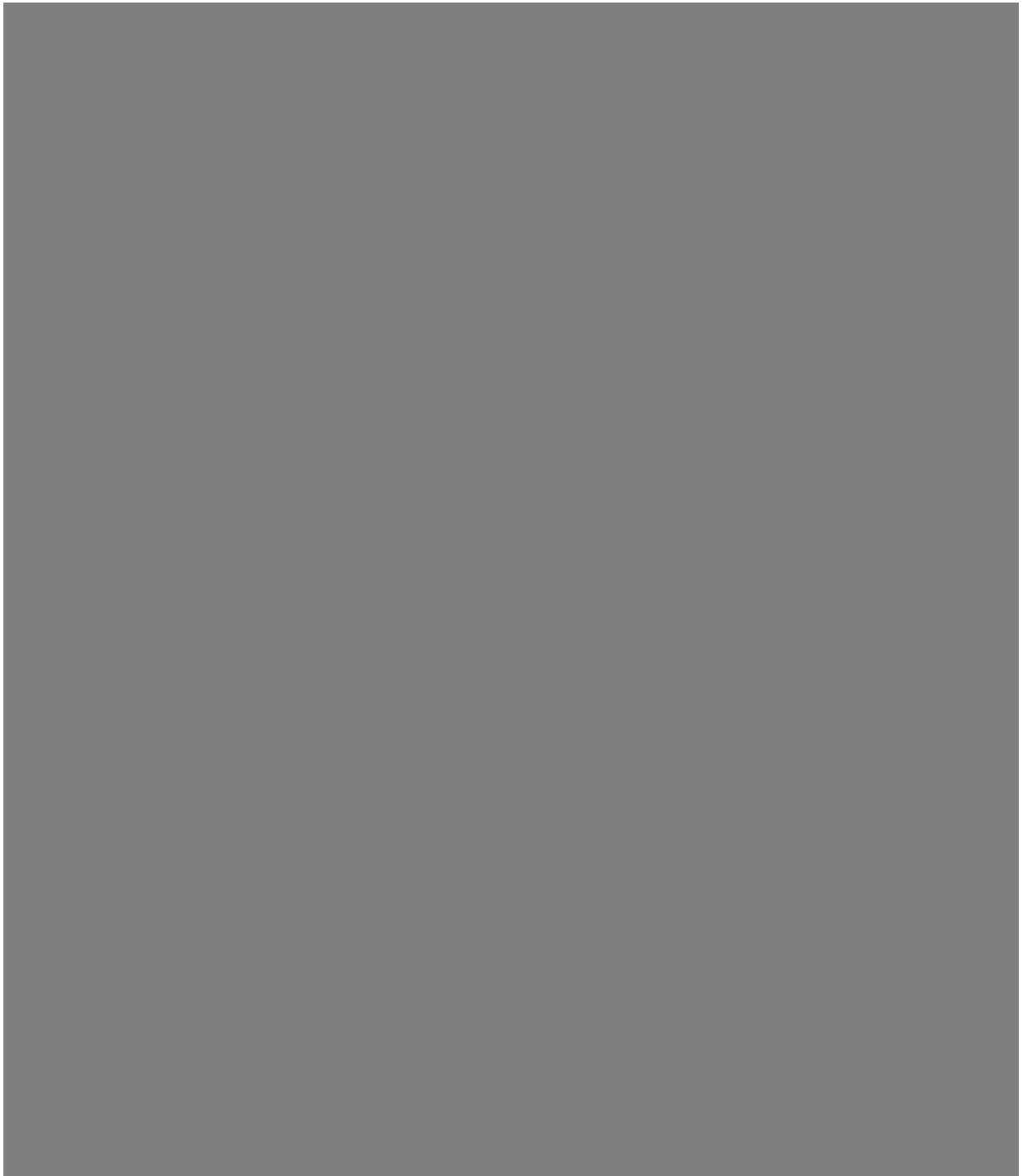
}, {Pre-IRA, Rivian Automotive},



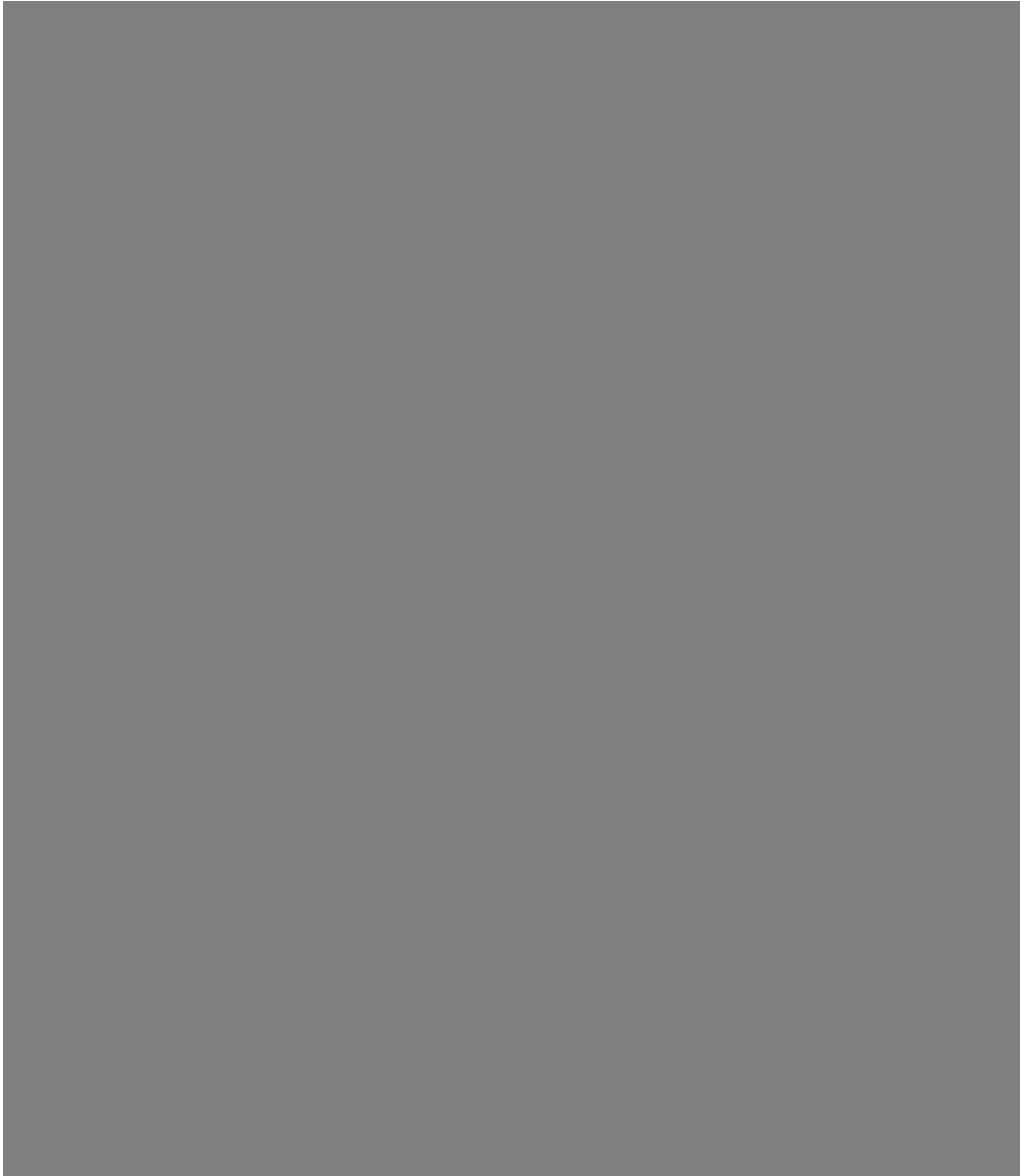
$\}, \{ \text{Pre-IRA}, \text{Ford},$



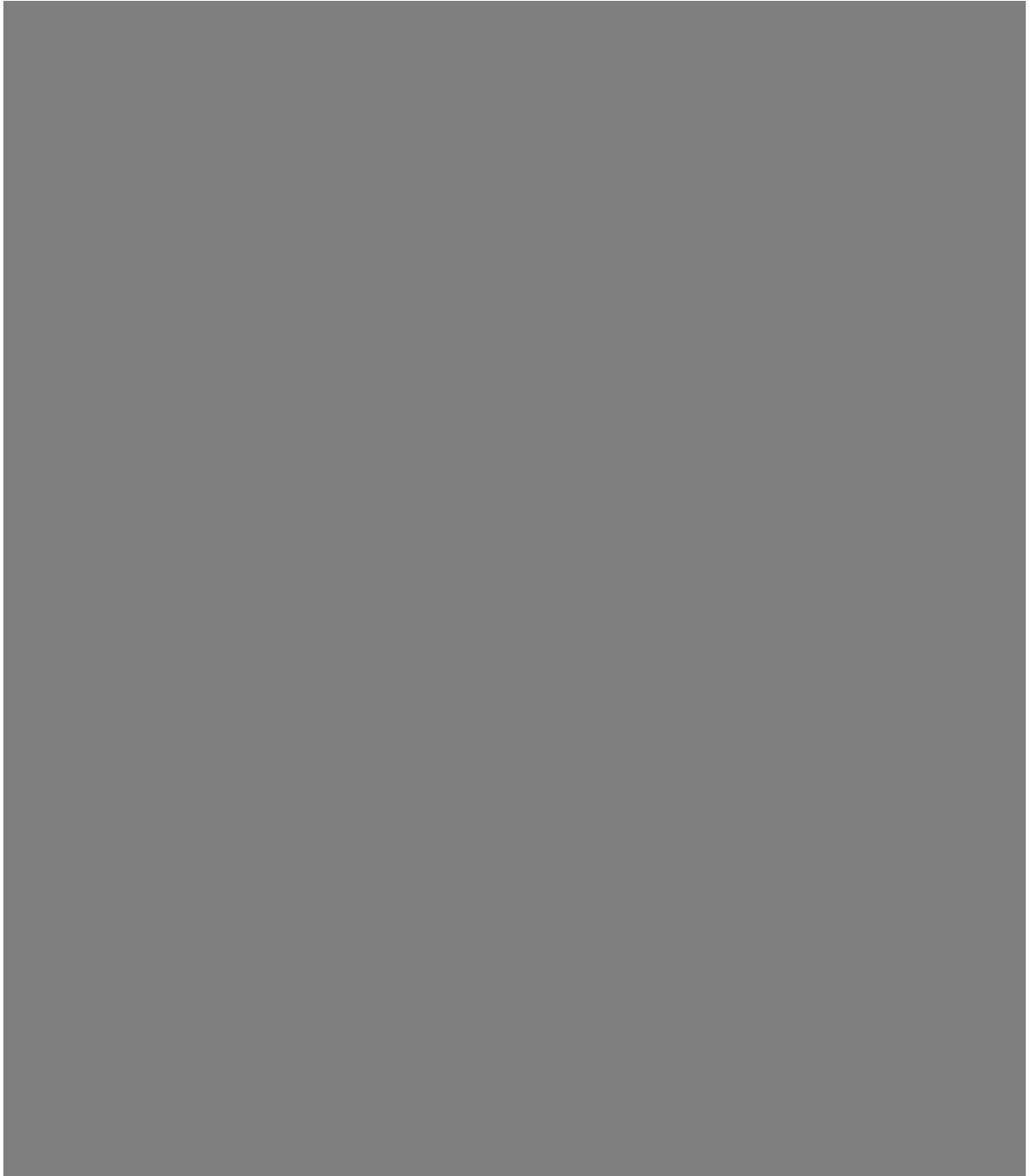
$\}, \{ \text{Pre-IRA}, \text{Ferrari},$



}, {Pre-IRA, Toyota, }



}, {Pre-IRA, Honda, }



}}

Out[]=

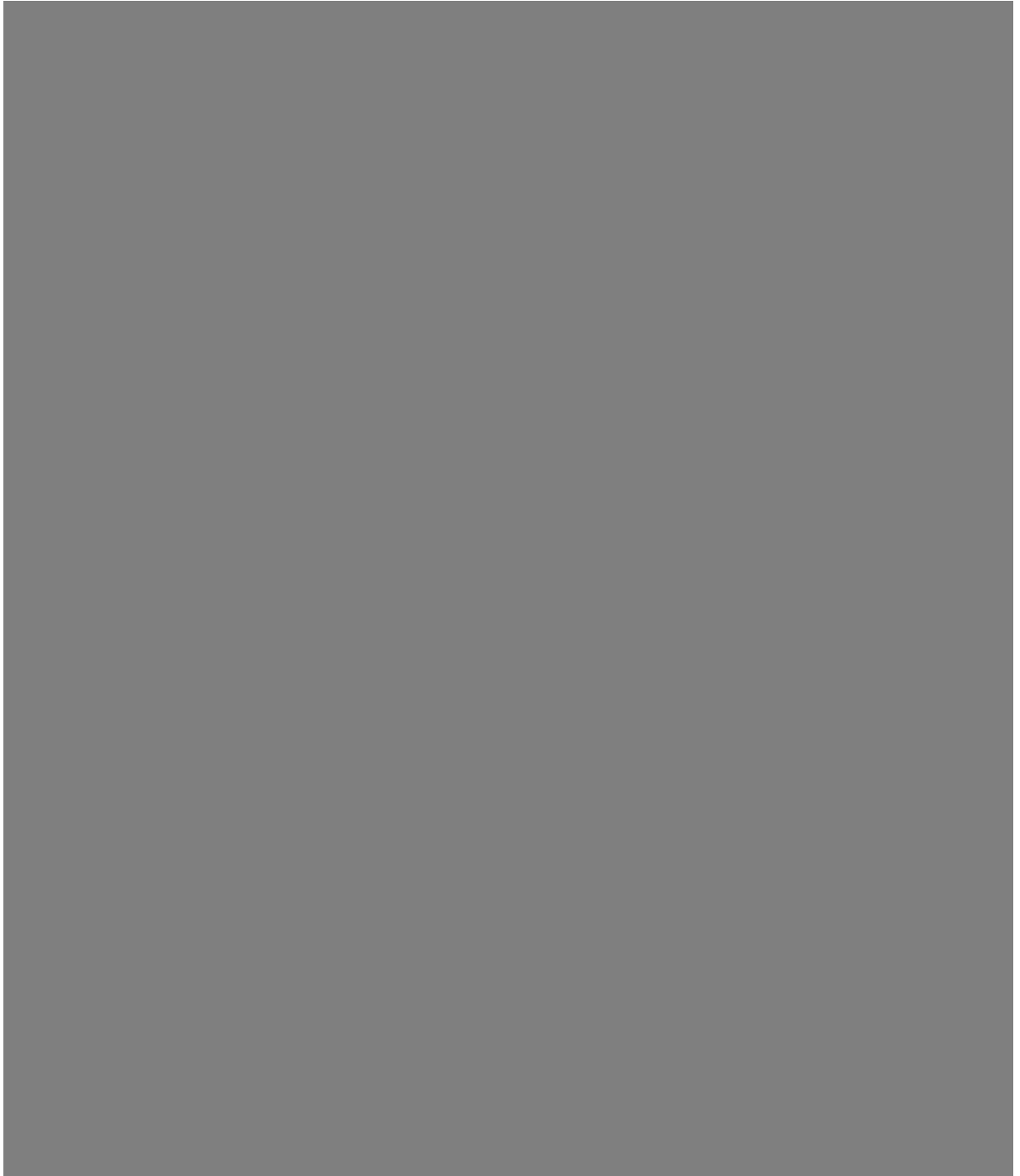
{ {Post-IRA, Tesla Motors ,



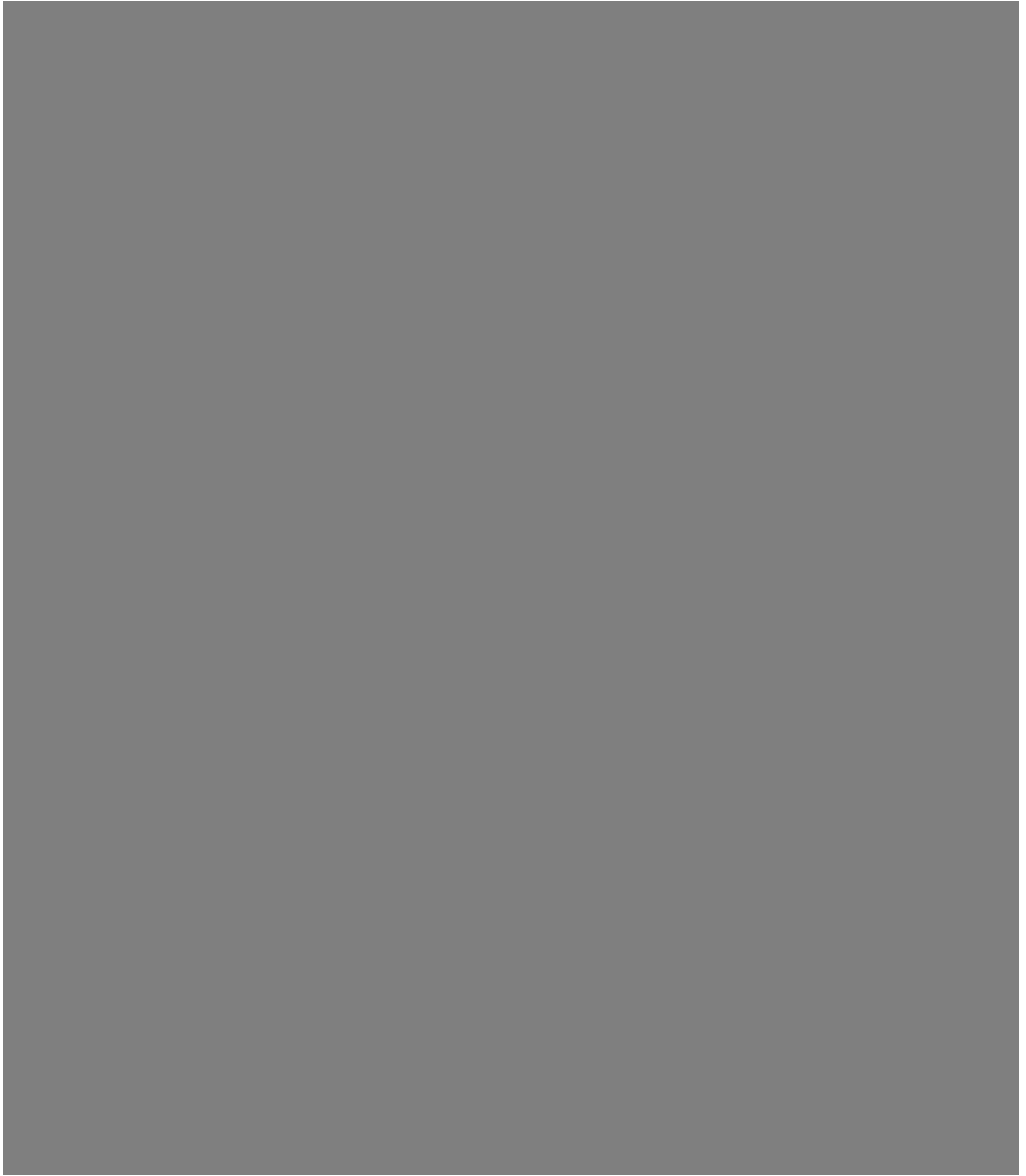
}, {Post-IRA, Rivian Automotive},



$\}, \{ \text{Post-IRA}, \text{Ford},$



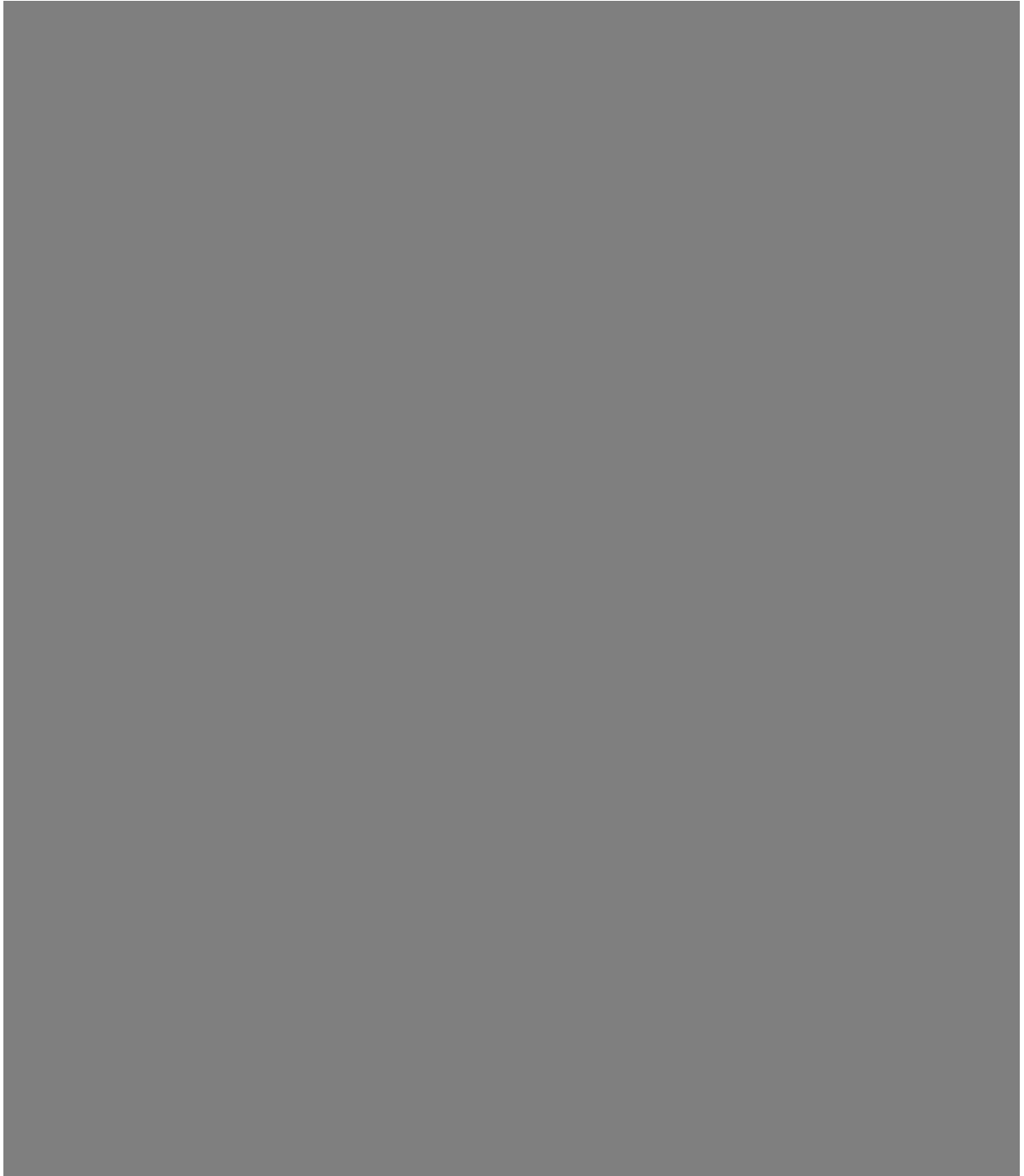
$\}, \{ \text{Post-IRA}, \text{Ferrari},$



}, {Post-IRA, Toyota},



}, {Post-IRA, Honda ,



}}

California's EV Mandate

On August 25, 2022, California announced a ban on the sale of new gasoline-powered vehicles by 2035.

(*Generate two interactive trading charts (pre- and post-event)
for each company around the date of California's ban*)

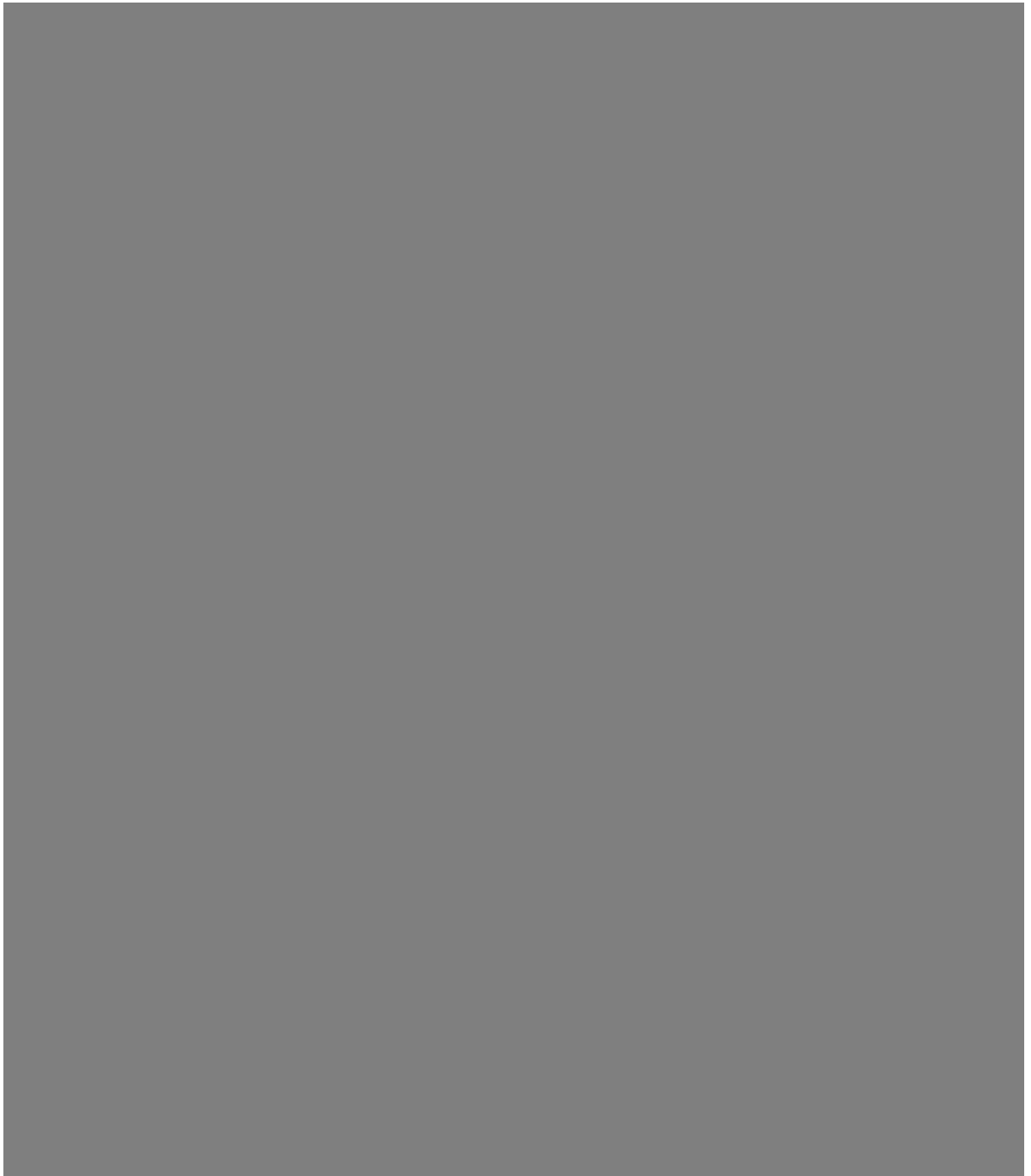
```
In[ ]:= date = DateObject["08/25/2022", "Day"]
helperYesterday[x_] := PreviousDate[x, "Day"]
helperTomorrow[x_] := NextDate[x, "Day"]
Table[{"Pre Event", Interpreter["Financial"][i], InteractiveTradingChart[
  FinancialData[i, "OHLCV", {Nest[helperYesterday, date, 7], date}],
  Appearance → "Line", PlotTheme → "Business"]}, {i, symbol}]
Table[{"Post Event", Interpreter["Financial"][i], InteractiveTradingChart[
  FinancialData[i, "OHLCV", {date, Nest[helperTomorrow, date, 7]}],
  Appearance → "Line", PlotTheme → "Business"]}, {i, symbol}]
```

Out[]:=

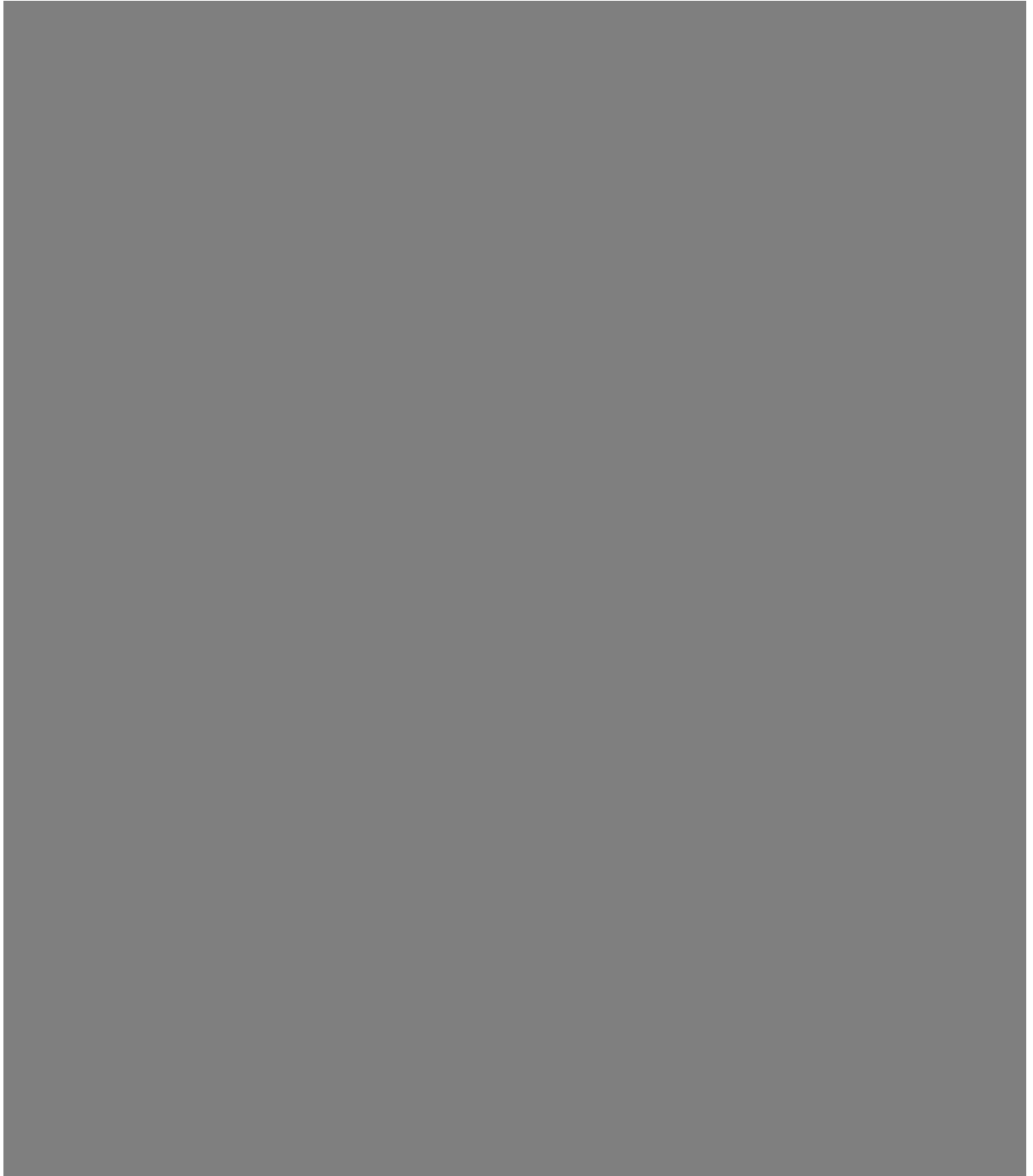
Thu 25 Aug 2022

Out[]:=

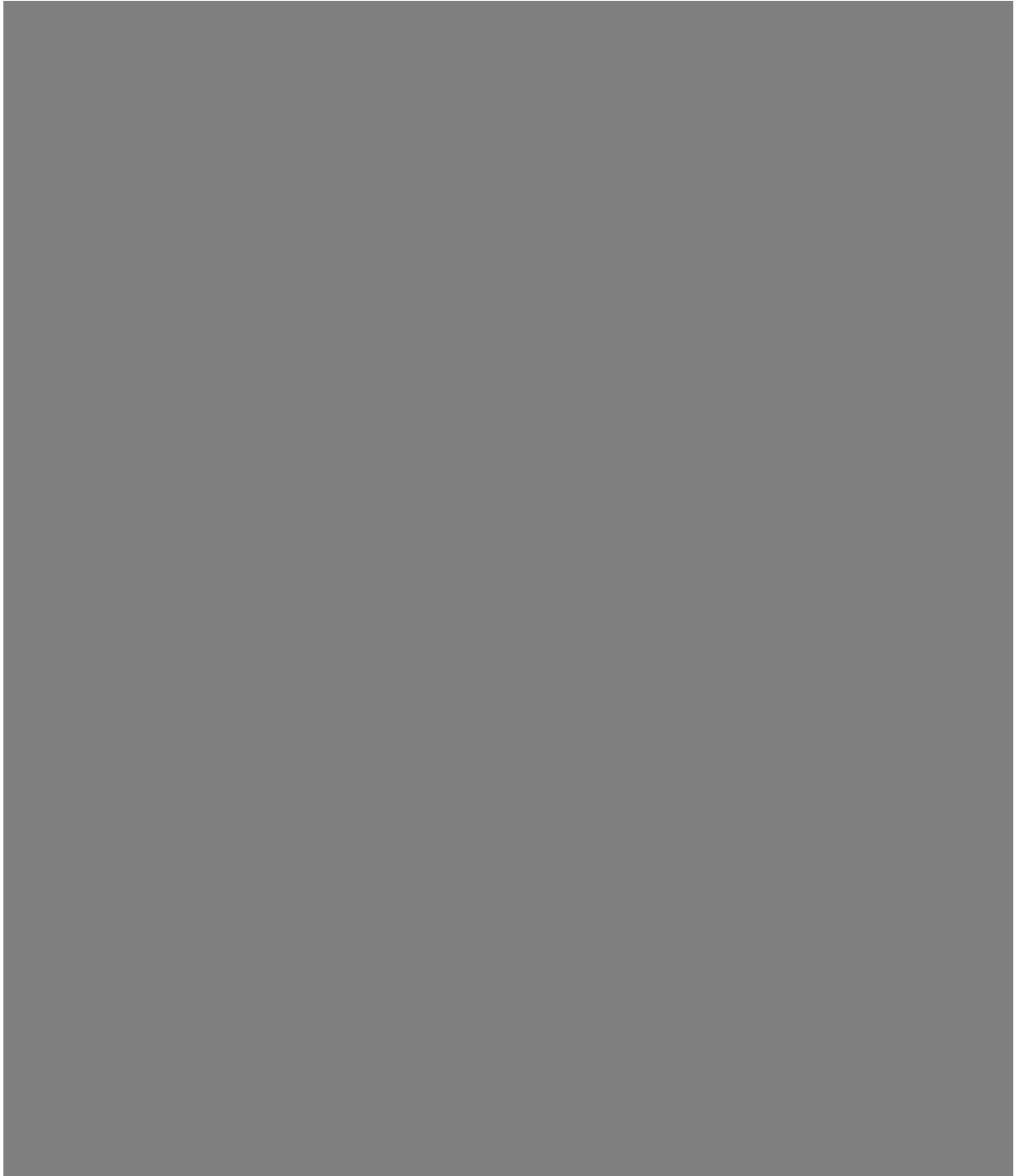
{ {Pre Event, Tesla Motors, }



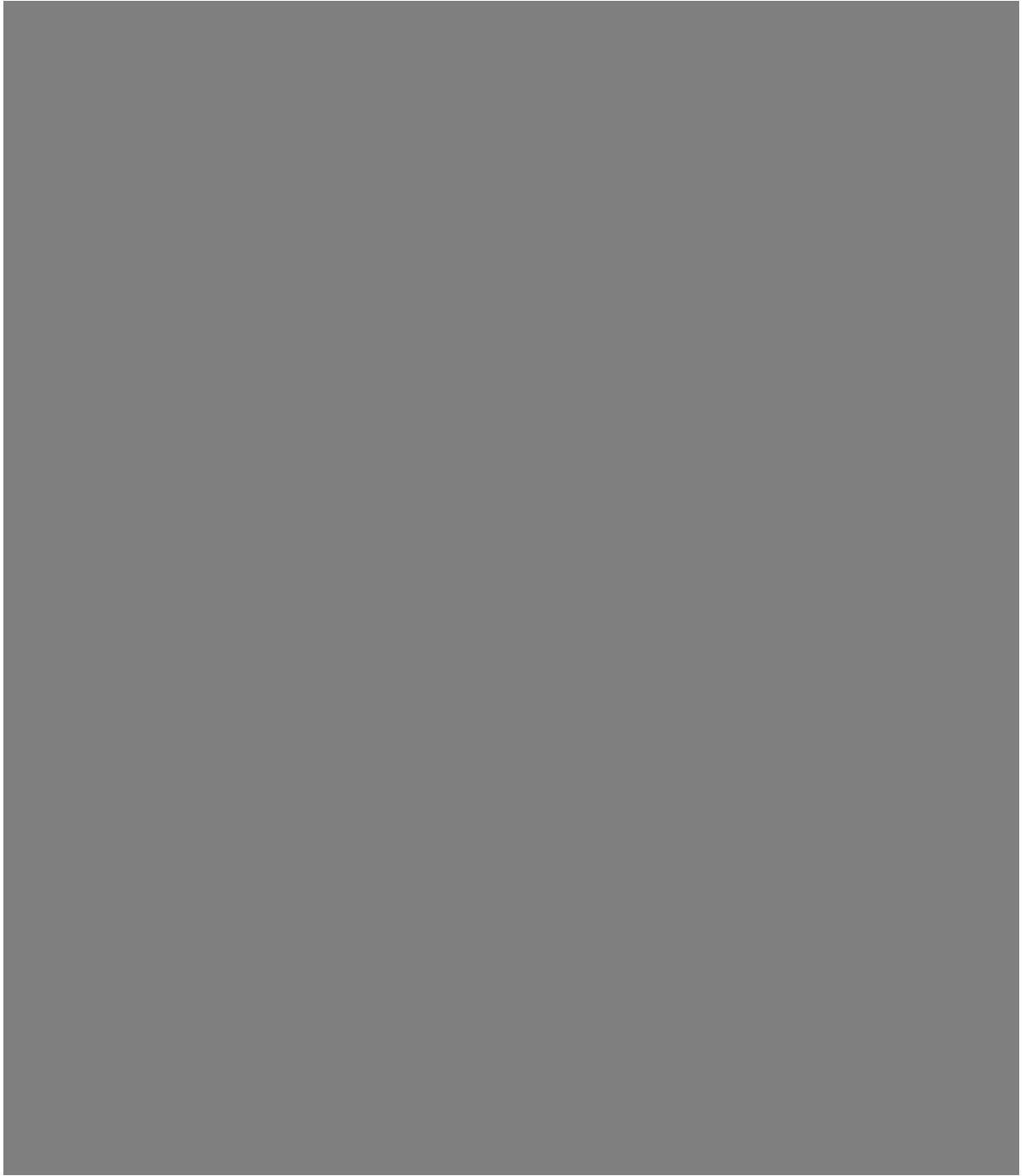
}, {Pre Event, Rivian Automotive ,



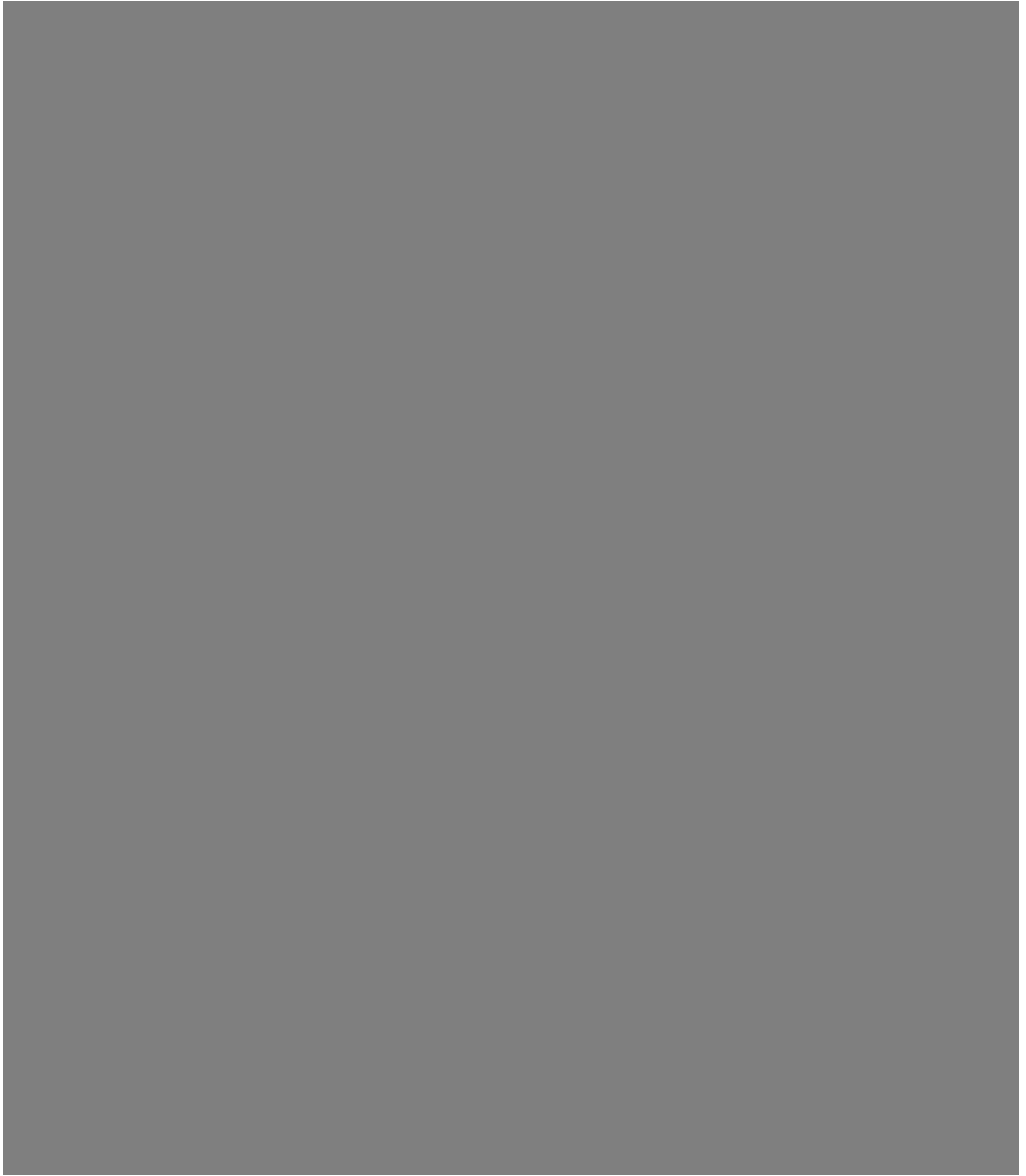
}, {Pre Event, Ford, }



}, {Pre Event, Ferrari, }



}, {Pre Event, Toyota ,



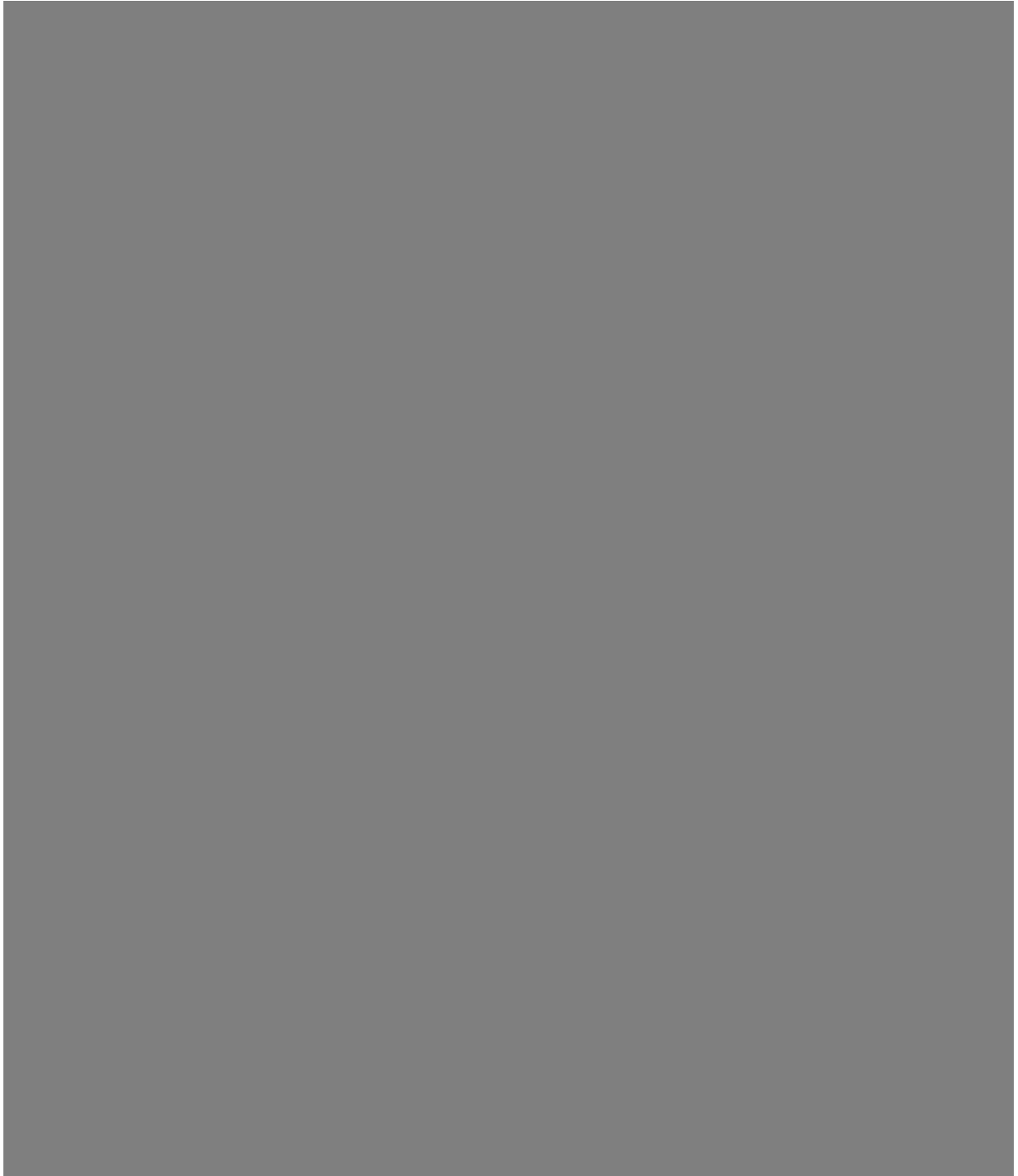
}, {Pre Event, Honda, }



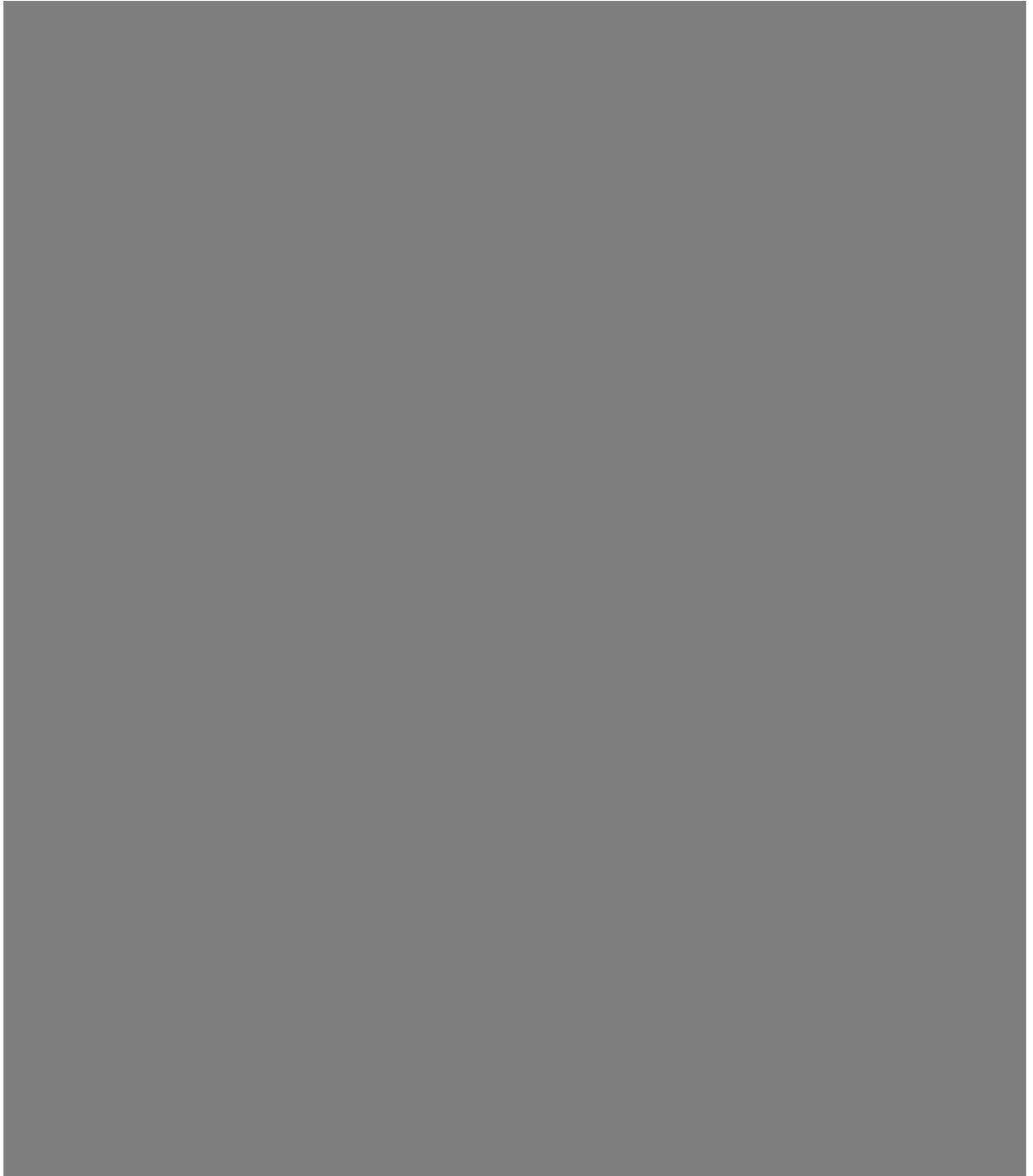
}}

Out[⌘]=

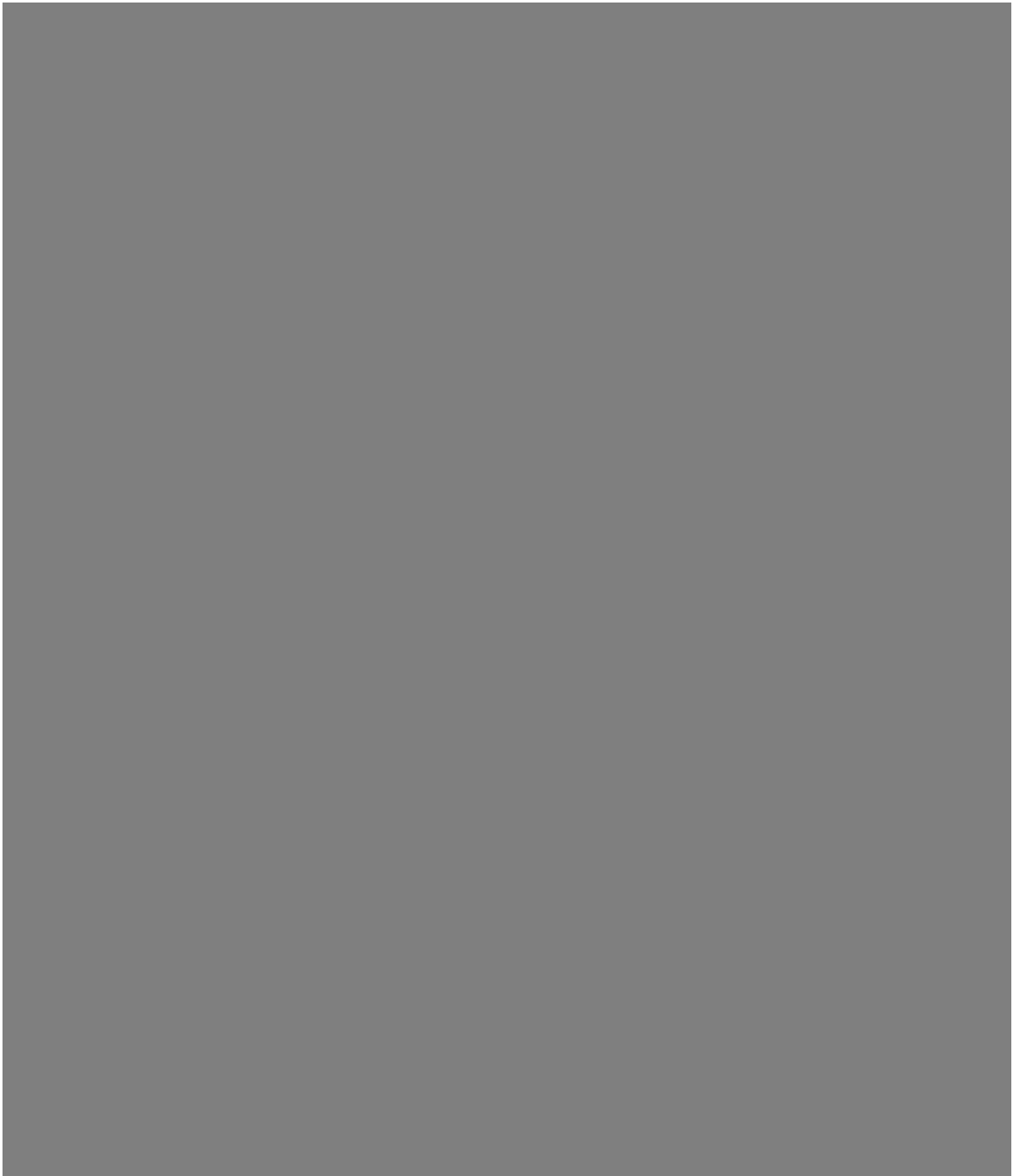
{ {Post Event, Tesla Motors ,



}, {Post Event, Rivian Automotive, }



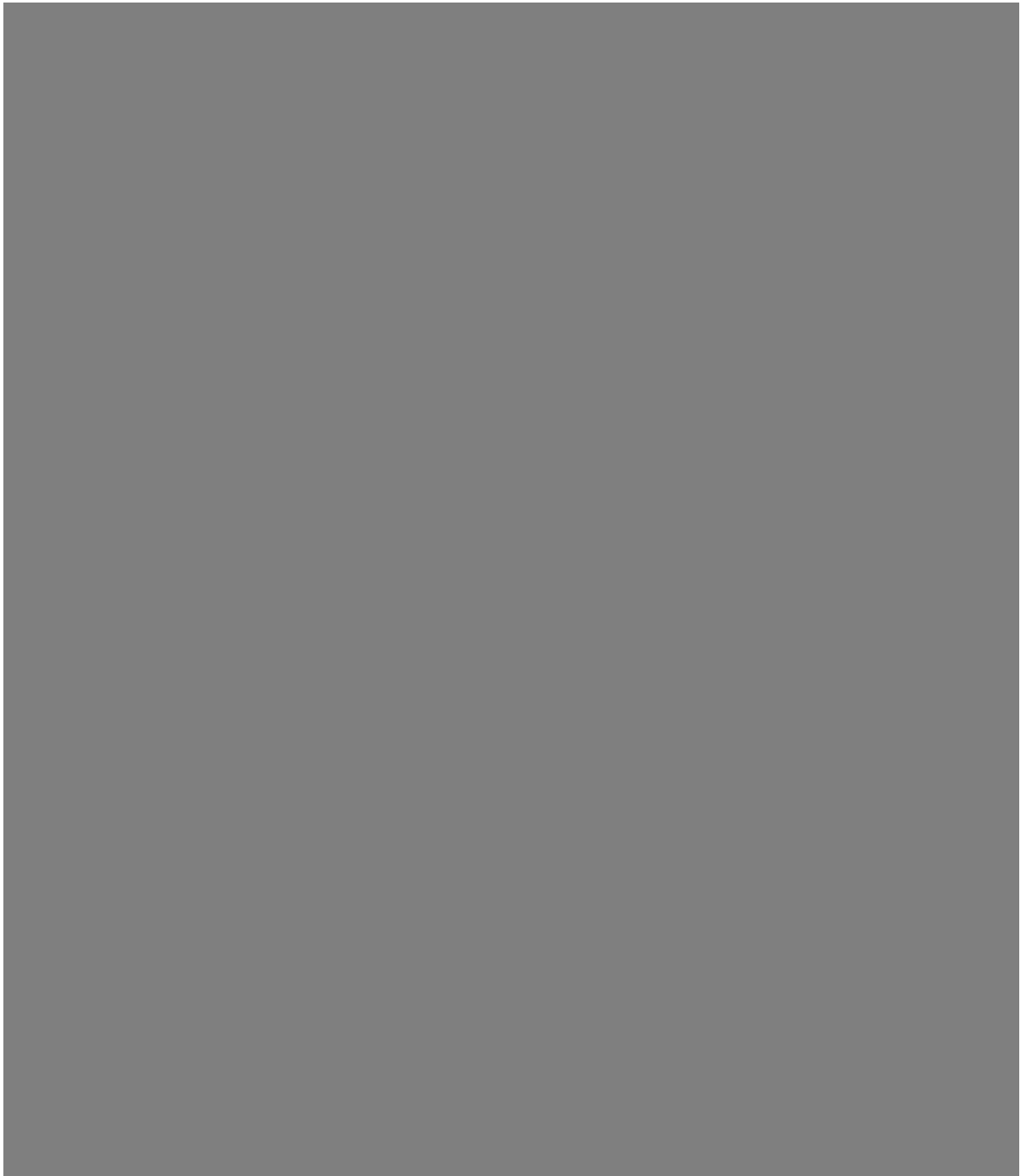
}, {Post Event, Ford ,



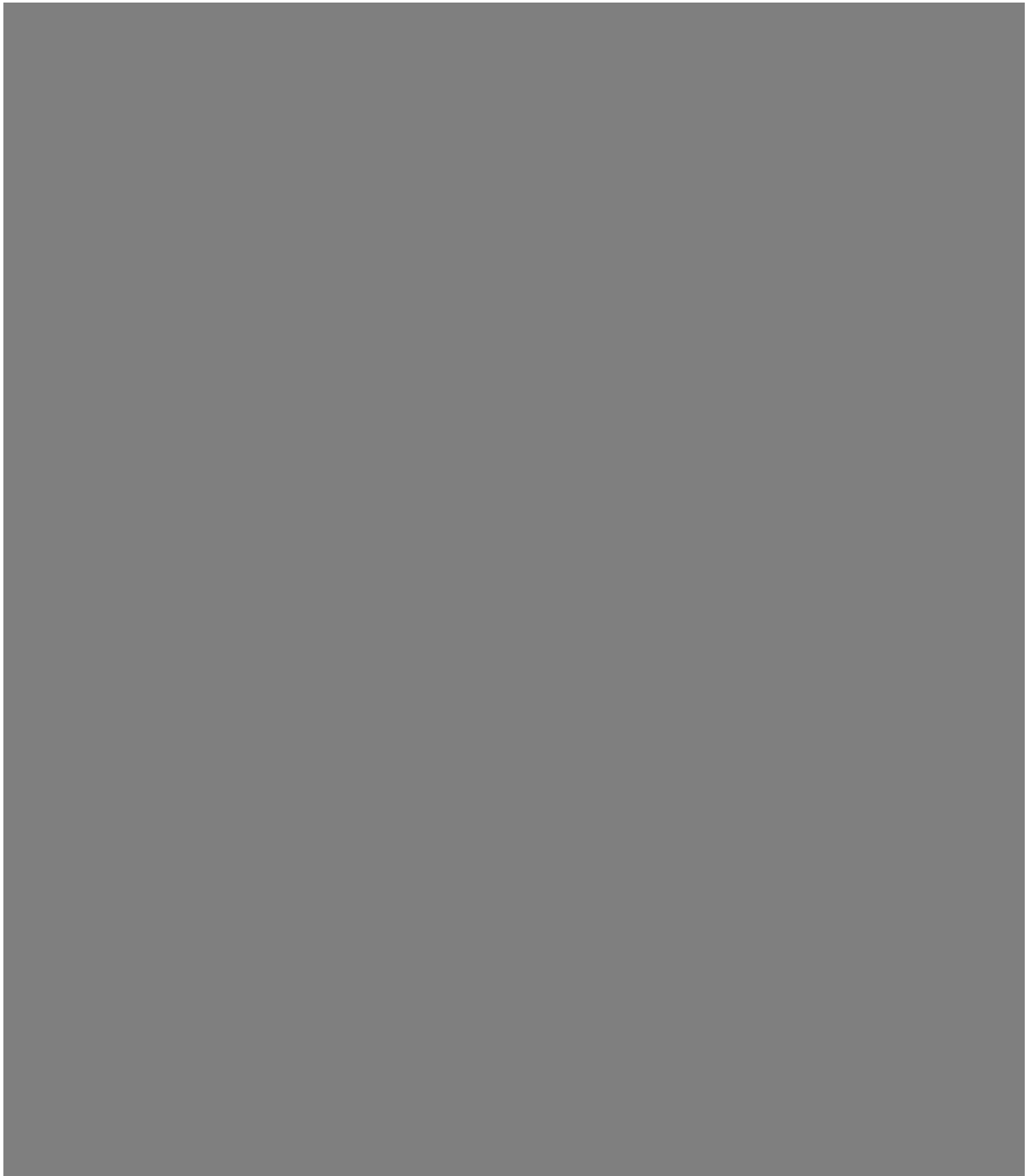
}, {Post Event, Ferrari ,



}, {Post Event, Toyota, }



}, {Post Event, Honda,



}}

Exploratory Analysis

Regression Analysis

(*Regress each company's annual return on Nasdaq composite index market return to determine alpha and beta
 Alpha → denotes how much the stock is overperforming or underperforming the market
 Beta → denotes the volatility of the stock
 *)

```
In[*]:= Table[
  nasYrRet = FinancialData["^COMP", "FractionalChange", {{2022}, {2024}}, "Month"];
  stockYrRet = FinancialData[i, "FractionalChange", {{2022}, {2024}}, "Month"];
  corYrData = Transpose[{nasYrRet["Values"], stockYrRet["Values"]}];
  Correlation[corYrData];
  TableForm[{Interpreter["Financial"][i]["Company"],
    lm = LinearModelFit[QuantityMagnitude@corYrData, x, x],
    lm["RSquared"],
    lm["ParameterTable"],
    Show[ListPlot[Thread[Tooltip[QuantityMagnitude@corYrData,
      Table[DateString[i, {"MonthName", " ", "Year"}], {i, nasYrRet["Dates"]}]]],
      FrameLabel → {"NASDAQ\nAnnual Return (%)", "Selected Stock \nAnnual Return (%)"},
      Frame → True, ImageSize → 400, PlotTheme → "Scientific",
      GridLines → Automatic, PlotStyle → Darker@Red],
      Plot[lm[x], {x, -50, 50}]]],
    {i, {"TSLA", "RIVN", "F", "RACE", "TM", "HMC"}}]
```

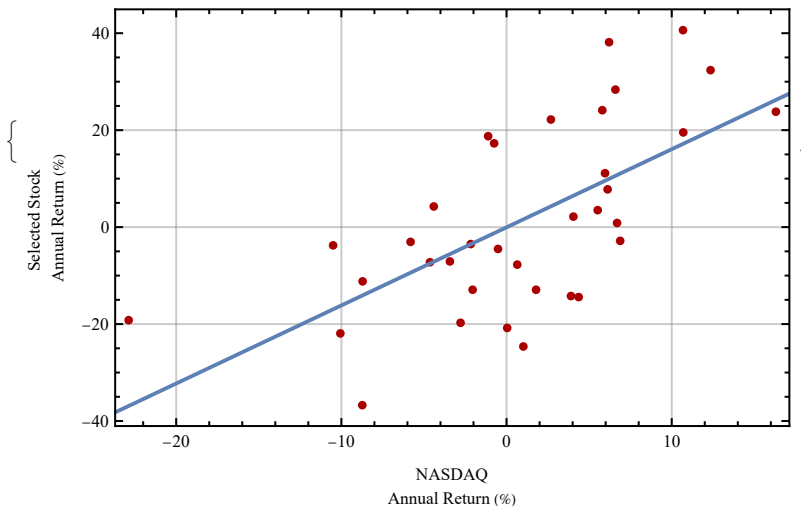
Out[*]=

Tesla

FittedModel[$-0.0409 + 1.61 x$]

0.412277

	Estimate	Standard Error	t-Statistic	P-Value
1	-0.0409117	2.53924	-0.0161118	0.987242
x	1.61101	0.334836	4.81133	0.0000321292

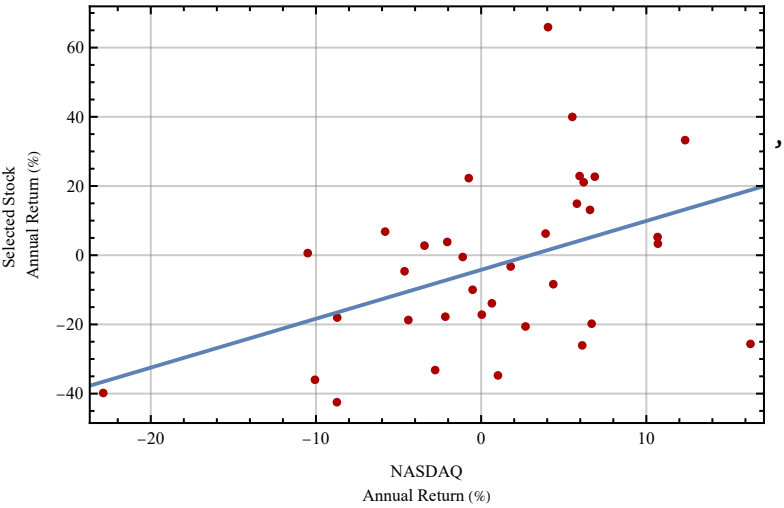


Rivian Automotive

FittedModel [-4.22 + 1.41 x]

0.197752

	Estimate	Standard Error	t-Statistic	P-Value
1	-4.22054	3.75805	-1.12306	0.269515
x	1.41337	0.495555	2.85209	0.00743874

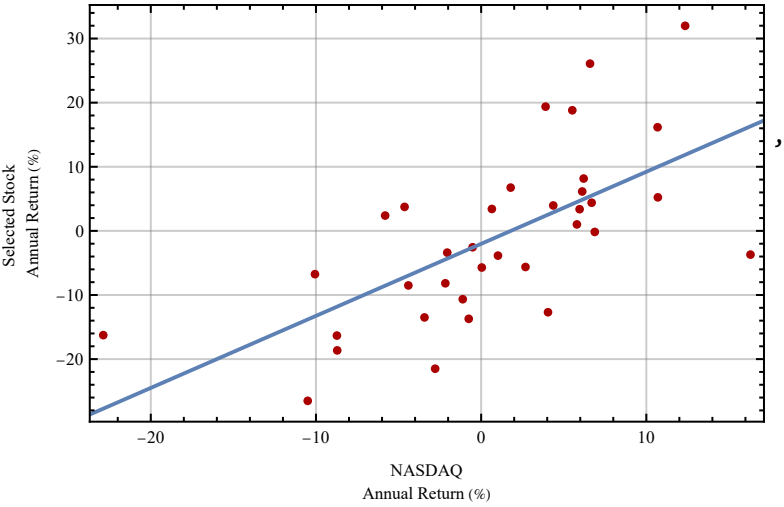


Ford Motor

FittedModel [-2.02 + 1.12 x]

0.425833

	Estimate	Standard Error	t-Statistic	P-Value
1	-2.01886	1.72269	-1.17193	0.249618
x	1.12381	0.227162	4.94718	0.0000215513

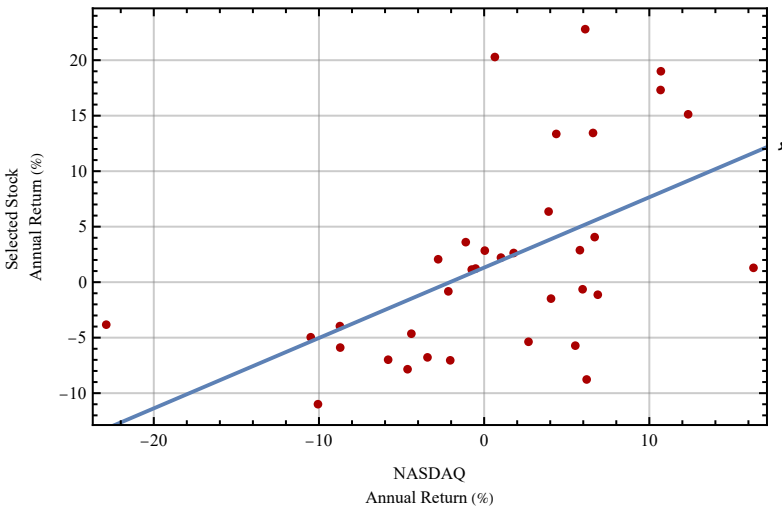


Ferrari

FittedModel [1.31 + 0.634 x]

0.290838

	Estimate	Standard Error	t-Statistic	P-Value
1	1.31174	1.30712	1.00353	0.322906
x	0.634097	0.172364	3.67883	0.000828826

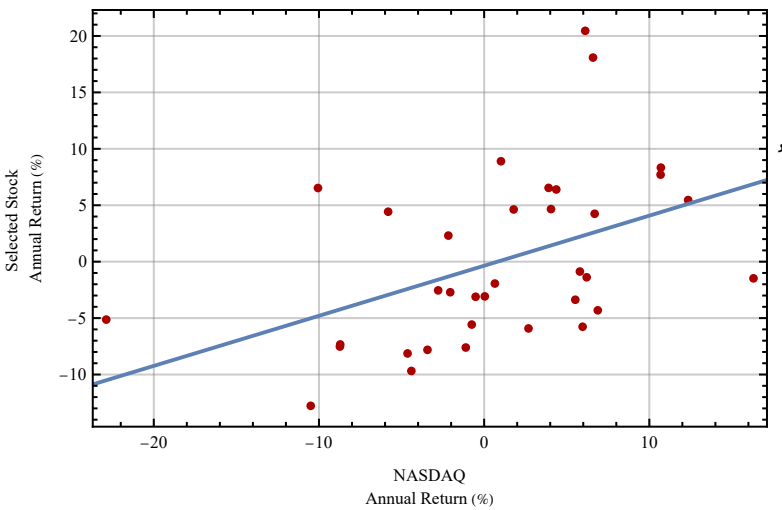


Toyota Motor

FittedModel [-0.358 + 0.444 x]

0.201201

	Estimate	Standard Error	t-Statistic	P-Value
1	-0.358475	1.16722	-0.307119	0.760682
x	0.443745	0.153915	2.88306	0.00688033

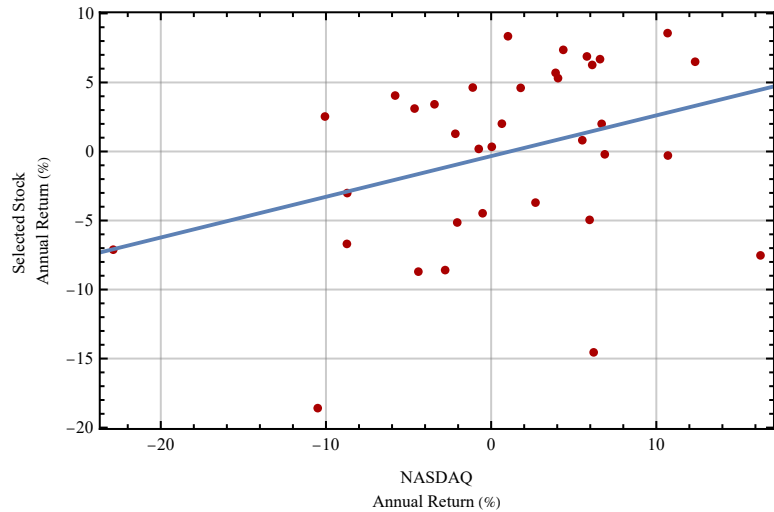


Honda Motor Co

FittedModel [$-0.334 + 0.295x$]

0.116589

	Estimate	Standard Error	t-Statistic	P-Value
1	-0.333865	1.07131	-0.311643	0.757273
x	0.294813	0.141268	2.08691	0.0446987



Correlation Matrix

```

In[ ]:= (*How the stock prices of these companies have moved together since 2022*)
stockData = Table[QuantityMagnitude[
  Normal[FinancialData[i, "FractionalChange", {{2022}, {2024}, "Month"}]] [[All, 2]], {i,
  stocks}];
stockCM = Correlation[Transpose[stockData]];
TableForm[ccm, TableHeadings -> {stocks, stocks}]

```

Out[]//TableForm=

	Tesla Motors	Rivian Automotive	Ford	Ferrari	Toyota
Tesla Motors	1.	0.500061	0.473467	0.316886	0.186937
Rivian Automotive	0.500061	1.	0.402843	0.0326089	0.0414513
Ford	0.473467	0.402843	1.	0.497348	0.596749
Ferrari	0.316886	0.0326089	0.497348	1.	0.631732
Toyota	0.186937	0.0414513	0.596749	0.631732	1.
Honda	0.0288353	0.0471415	0.329758	0.27549	0.450962