APPENDICES

How Demand Shocks "Jumpstart" Technological Ecosystems and Commercialization: Evidence from the Global Electric Vehicle Industry

Appendix A: Comparison of alternative vehicle technologies by technical features

(i) Power source and key components by vehicle type

Electric vehicles depart from conventional gasoline vehicles in terms of the power source. Whereas gasoline vehicles are powered by internal combustion engines (ICE), electric vehicles (EVs) can be powered by an ICE and/or batteries. Key differences exist across the types of electric vehicles.
The U.S. Department of Energy explains these differences as follows[1]:

- HEVs are powered by an internal combustion engine and one or more electric motors that uses energy stored in a battery. The vehicle is fueled with gasoline to operate the internal combustion engine, and the battery is charged through regenerative braking, not by plugging in.
- PHEVs are powered by an internal combustion engine and an electric motor that uses energy stored in a battery. PHEVs can operate in all-electric (or charge-depleting) mode. To enable operation in all-electric mode, PHEVs require a larger battery, which can be plugged in to an electric power source to charge. To support a driver's typical daily travel needs, most PHEVs can travel between 20 and 40 miles on electricity alone, and then will operate solely on gasoline, similar to a conventional hybrid.
- BEVs or all-electric vehicles, have a battery that is charged by plugging the vehicle in to charging equipment. These vehicles always operate in all-electric mode and have typical driving ranges from 150 to 400 miles.

Apart from the differences in the power source, gasoline and electric powered vehicles also differ in terms of their key components and architecture (or the way the components are interconnected).
As illustrated in the Table A1, both gasoline and electric vehicles have some common components: auxiliary battery (in all types of EVs and gasoline vehicles), and ICE, exhaust system, fuel filler, fuel injection system, fuel line, fuel pump, fuel tank, and transmission system (in gasoline vehicles, HEVs and PHEVs). Hence, PHEVs and HEVs are more similar to gasoline vehicles in terms of the power source and components than BEVs. The stark difference in the power source also makes BEVs the more radical version of EV technologies.

There are however, important differences in the key components between gasoline vehicles and EVs: all EVs have a traction battery, electric traction motor, electric generator, DC-to-DC converter, and power electronics controller that are absent in gasoline vehicles.

Within EVs there are some differences in the key components: Only PHEVs and BEVs have a charge port that converts the AC power to DC, and on-board charger that communicates with the battery. Hence, PHEVs and BEVs are more similar in terms of their power source and components than HEVs.

[1] https://afdc.energy.gov/vehicles/electric.html

Table A1

	Gasoline	Hybrid	Plug-in Hybrid	Electric
Battery (auxiliary)	The battery provides electricity to start the engine and power vehicle electronics/accessories.	In an electric drive vehicle, the low-voltage auxiliary battery provides electricity to start the car before the traction battery is engaged; it also powers vehicle accessories.	In an electric drive vehicle, the low-voltage auxiliary battery provides electricity to start the car before the traction battery is engaged; it also powers vehicle accessories.	In an electric drive vehicle, the auxiliary battery provides electricity to power vehicle accessories.
Charge port			The charge port allows the vehicle to connect to an external power supply in order to charge the traction battery pack.	The charge port allows the vehicle to connect to an external power supply in order to charge the traction battery pack.
DC/DC Converter		This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.	This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.	This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.
Electrical generator		Generates electricity from the rotating wheels while braking, transferring that energy back to the traction battery pack. Some vehicles use motor generators that perform both the drive and regeneration functions.	Generates electricity from the rotating wheels while braking, transferring that energy back to the traction battery pack. Some vehicles use motor generators that perform both the drive and regeneration functions.	Generates electricity from the rotating wheels while braking, transferring that energy back to the traction battery pack. Some vehicles use motor generators that perform both the drive and regeneration functions.
Electric traction motor		Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.	Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.	Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.
Electronic control module	The ECM controls the fuel mixture, ignition timing, and emissions system; monitors the operation of the vehicle; safeguards the engine from abuse; and detects and troubleshoots problems.			
Exhaust system	The exhaust system channels the exhaust gases from the engine out through the tailpipe. A three-way catalyst is designed to reduce engine-out emissions within the exhaust system.	The exhaust system channels the exhaust gases from the engine out through the tailpipe. A three-way catalyst is designed to reduce engine-out emissions within the exhaust system.	The exhaust system channels the exhaust gases from the engine out through the tailpipe. A three-way catalyst is designed to reduce engine-out emissions within the exhaust system.	
Fuel Filler	A nozzle from a fuel dispenser attaches to the receptacle on the vehicle to fill the tank.	A nozzle from a fuel dispenser attaches to the receptacle on the vehicle to fill the tank.	A nozzle from a fuel dispenser attaches to the receptacle on the vehicle to fill the tank.	
Fuel injection system	This system introduces fuel into the engine's combustion chambers for ignition.	This system introduces fuel into the engine's combustion chambers for ignition.	This system introduces fuel into the engine's combustion chambers for ignition.	

Fuel line	A metal tube or flexible hose (or a combination of these) transfers fuel from the tank to the engine's fuel injection system	A metal tube or flexible hose (or a combination of these) transfers fuel from the tank to the engine's fuel injection system	A metal tube or flexible hose (or a combination of these) transfers fuel from the tank to the engine's fuel injection system	
Fuel pump	A pump that transfers fuel from the tank to the engine's fuel injection system via the fuel line.	A pump that transfers fuel from the tank to the engine's fuel injection system via the fuel line.	A pump that transfers fuel from the tank to the engine's fuel injection system via the fuel line.	
Fuel tank	This tank stores gasoline on board the vehicle until it's needed by the engine.	This tank stores gasoline on board the vehicle until it's needed by the engine.	This tank stores gasoline on board the vehicle until it's needed by the engine.	
Internal combustion engine (spark ignited)	In this configuration, fuel is injected into either the intake manifold or the combustion chamber, where it is combined with air, and the air/fuel mixture is ignited by the spark from a spark plug.	In this configuration, fuel is injected into either the intake manifold or the combustion chamber, where it is combined with air, and the air/fuel mixture is ignited by the spark from a spark plug.	In this configuration, fuel is injected into either the intake manifold or the combustion chamber, where it is combined with air, and the air/fuel mixture is ignited by the spark from a spark plug.	
On-board charger			Takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery. It also communicates with the charging equipment and monitors battery characteristics such as voltage, current, temperature, and state of charge while charging the pack.	Takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery. It also communicates with the charging equipment and monitors battery characteristics such as voltage, current, temperature, and state of charge while charging the pack.
Power electronics controller		This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.	This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces	This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.
Thermal system (cooling)		This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.	This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.	This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.
Traction battery pack		Stores electricity for use by the electric traction motor.	Stores electricity for use by the electric traction motor.	Stores electricity for use by the electric traction motor.
Transmission	The transmission transfers mechanical power from the engine and/or electric traction motor to drive the wheels.	The transmission transfers mechanical power from the engine and/or electric traction motor to drive the wheels.	The transmission transfers mechanical power from the engine and/or electric traction motor to drive the wheels.	The transmission transfers mechanical power from the electric traction motor to drive the wheels.

Source: https://afdc.energy.gov/vehicles/how-do-all-electric-cars-work; We have retained the original definitions and descriptions for accuracy**.**

(ii) Battery characteristics

As shown in Table A2, EVs differ in terms of their battery characteristics. While most HEVs used NiMH batteries, PHEV and BEVs used Li-ion batteries. Thus, the battery technologies differ based on price, useful life, safety and raw materials/minerals used in the batteries. Moreover, due to the differences in how the electric powertrain is used in each type of EV, the battery characteristics differ in term of energy capacity, power to energy ratio, weight, and charge cycles. These differences in the types of batteries and the battery characteristics across HEVs, PHEVs and BEVs hold implications for their commercialization. This data are compiled from multiple sources including the U.S. Department of Energy's website, industry

Table A2

	Hybrid	**Plug-in Hybrid**	**All Electric**
Battery technology[2]	Most HEVs employ nickel metal hydride (NiMH) batteries.	Rechargeable high-energy lithium-ion (Li-ion) batteries.	Rechargeable high-energy lithium-ion (Li-ion) batteries.
Battery charging[3]	Regenerative braking	Regenerative braking Level 1 charger:2-5 miles/hour Level 2 charger: 10-30 miles/hour DCFC: 100-200+ miles in 30 minutes	Regenerative braking Level 1 charger:2-5 miles/hour Level 2 charger: 10-30 miles/hour DCFC: 100-200+ miles in 30 minutes
Battery maintenance	Because PHEVs and HEVs have internal combustion engines, maintenance requirements are similar to those of conventional vehicles. The electrical system (battery, motor, and associated electronics) typically requires minimal scheduled maintenance, and brake systems generally last longer than those on conventional vehicles because of regenerative braking.	Because PHEVs and HEVs have internal combustion engines, maintenance requirements are similar to those of conventional vehicles. The electrical system (battery, motor, and associated electronics) typically requires minimal scheduled maintenance, and brake systems generally last longer than those on conventional vehicles because of regenerative braking.	All-electric vehicles typically require less maintenance than conventional vehicles because: -The battery, motor, and associated electronics require little to no regular maintenance -There are fewer fluids, such as engine oil, that require regular maintenance -Brake wear is significantly reduced due to regenerative braking -There are far fewer moving parts relative to a conventional fuel engine.
Total energy capacity[4] (Usable energy capacity)	1.5 kWh (0.8kWh)	14.4 kWh (11.4kWh)	99.0 kWh (88.0 kWh)
Energy density	1.9 kWh/100 lbs	4.0 kWh/100 lbs	7.5kWk/100lbs
Power to energy ratio	23.3 W/Wh	5.6 W/Wh	2.8 W/Wh
Weight	77 lbs	364 lbs	1323 lbs
Charge cycles[5]	100,000	4000-8000	1000-4500

[2] https://www.caranddriver.com/research/a32768969/hybrid-battery/ Accessed Jan 15, 2024

[3] https://afdc.energy.gov/vehicles/electric_consumers.html Accessed Jan 15 2024.

[4] https://www.caranddriver.com/news/a15345397/battery-taxonomy-the-differences-between-hybrid-and-ev-batteries/ Data for battery energy capacity, power/energy ratio, weight, charge cycles based on Ford models. Accessed Jan 15, 2024

[5] https://www.pnas.org/doi/epdf/10.1073/pnas.1807115115 Estimates for charge cycles can vary based on factors such as battery technology and temperature.

(iii) Energy efficiency and environmental emissions

EVs also differ in terms of their energy efficiency and environmental emissions. Although all-electric BEVs are more expensive, their annual operating costs are the lowest. BEVs also perform better than PHEVs and HEVs in terms of fuel economy, and CO2 emissions making BEVs the most energy efficient and environmentally-friendly EV option. It is worth noting that PHEV/BEV total emissions (tailpipe + upstream) can vary by state/location based on the energy sources used for power generation.

Table A3

	Gasoline	**Hybrid**	**Plug-in Hybrid**	**All Electric**
Fuel Economy[6]	28 mpg	50 mpg	47/108 mpge	118 mpge
All Electric Range		N/A	27 miles	239 miles
MSRP	$22800	$24690	$29590	$39990
Annual Operating Cost		$2972	$2858	$2556
Annual Emissions (tailpipe + upstream) (National Averages based on U.S. data)[7]	7360 pounds of CO2 equivalent from gasoline	6898 pounds of CO2 equivalent from gasoline.	1885 pounds of CO2 equivalent from electric; 2939 pounds of CO2 equivalent from gasoline	2817 pounds of CO2 equivalent

[6] Fuel economy, all electric range, MSRP and annual operating cost: For comparison purposes only. The 2022 Kia Niro is used based on its availability in hybrid, PHEV, and all-electric configurations to provide the most equal comparison. https://afdc.energy.gov/vehicles/electric_consumers.html Accessed Jan 15, 2024

[7] https://afdc.energy.gov/vehicles/electric_emissions.html. Based on assumptions with 2021 data from EIA. Estimated for Kia Soul based on data from https://www.fueleconomy.gov/feg/Find.do?action=sbsSelect&id=46918&id=47447&id=46975&id=46962&tabIndex=3# Accessed Jan 15, 2024.

Kia gasoline and EV comparisons[8]

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	2017 Kia Soul	2017 Kia Optima Hybrid	2017 Kia Optima Plug-in Hybrid	2017 Kia Soul Electric
Personalize Edit Vehicles	Gasoline Vehicle 1.6 L, 4 cyl, Automatic (AM7), Turbo MSRP: $16,100 - $22,800	Hybrid Vehicle Gasoline 2.0 L, 4 cyl, Automatic (AM6) MSRP: $25,995 - $30,990	Plug-in Hybrid Vehicle Gasoline-Electricity 2.0 L, 4 cyl, Automatic (AM6) MSRP: $35,210 Plug-in Hybrid Calculator Possible Tax Break	Electric Vehicle Automatic (A1) MSRP: $32,250 - $35,950 Possible Tax Break
EPA Fuel Economy 1 gallon of gasoline=33.7 kWh Show electric charging stations near me	Regular Gasoline 28 MPG combined city/highway; 26 city, 31 highway 3.6 gal/100mi Gasoline: 398 miles Total Range	Regular Gasoline 42 MPG combined city/highway; 39 city, 46 highway 2.4 gal/100mi Gasoline: 668 miles Total Range	Elec + Gas: 103 MPGe combined city/highway; .0 gal/100mi of gas + 33 kWh/100mi Reg. Gas: 40 MPG combined city/highway; 2.5 gal/100mi Gasoline Only 29 miles Elec + Gas; All Elec: 0-29 mi 610 miles Total Range	Electricity 105 MPGe combined city/highway; 120 city, 92 highway 32 kWh/100 mi Electricity: 93 miles Total Range
			About Plug-in Hybrid Cars	About All-Electric Cars
Unofficial MPG Estimates from Vehicle Owners Learn more about "My MPG" Disclaimer	User MPG estimates are not yet available for this vehicle	Average based on 1 vehicle 41.8 MPG View Individual Estimates	Average based on 2 vehicles 54.3 MPG 45 Lo → 69 Hi Not comparable to EPA fuel economy because these estimates do not include electricity use.	User MPG estimates are not yet available for this vehicle
You save or spend* Note: The average 2024 vehicle gets 28 MPG	You SAVE **$0** in fuel costs over 5 years compared to the average new vehicle	You SAVE **$3,000** in fuel costs over 5 years compared to the average new vehicle	You SAVE **$4,500** in fuel costs over 5 years compared to the average new vehicle	You SAVE **$5,750** in fuel costs over 5 years compared to the average new vehicle
Annual Fuel Cost*	$1,850	$1,250	Electricity + Gasoline: $950	$700
Cost to Drive 25 Miles	$3.10	$2.07	$1.24 (on a single charge) $2.17 (driving on gas only)	$1.20
Cost to Fill the Tank	$49	$55	$50 (gas only)	
Tank Size	14.2 gallons	15.9 gallons	14.5 gallons	

*Based on 45% highway, 55% city driving, 15,000 annual miles and current fuel prices. Personalize.
MSRP and tank size data provided by Edmunds.com, Inc.
Range on a tank and refueling costs assume 100% of fuel in tank will be used before refueling.

[8] https://www.fueleconomy.gov/feg/Find.do?action=sbsSelect&id=46918&id=47447&id=46975&id=46962&tabIndex=3#

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	2017 Kia Soul	2017 Kia Optima Hybrid	2017 Kia Optima Plug-in Hybrid	2017 Kia Soul Electric
Personalize Edit Vehicles	Gasoline Vehicle 1.6 L, 4 cyl, Automatic (AM7), Turbo MSRP: $16,100 - $22,800	Hybrid Vehicle Gasoline 2.0 L, 4 cyl, Automatic (AM6) MSRP: $25,995 - $30,990	Plug-in Hybrid Vehicle Gasoline-Electricity 2.0 L, 4 cyl, Automatic (AM6) MSRP: $35,210 Plug-in Hybrid Calculator Possible Tax Break	Electric Vehicle Automatic (A1) MSRP: $32,250 - $35,950 Possible Tax Break
Energy Impact Score				
Annual Petroleum Consumption 1 barrel = 42 gallons	Regular Gasoline 10.6 barrels	Regular Gasoline 7.1 barrels	Electricity + Gasoline 3.2 barrels	Electricity 0.1 barrels
Greenhouse Gas Emissions				
Units: Grams per mile Show: Tailpipe CO2	Regular Gasoline 320 grams per mile 6 (1–10 Best)	Regular Gasoline 212 grams per mile 9 (1–10 Best)	Electricity + Gasoline 97 grams per mile 10 (1–10 Best)	Electricity 0 grams per mile 10 (1–10 Best)
EPA Smog Rating				
State of purchase: Select State				

*Based on 45% highway, 55% city driving, 15,000 annual miles and current fuel prices. Personalize.

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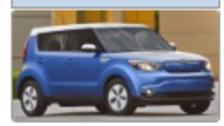
Personalize / Edit Vehicles	2017 Kia Soul	2017 Kia Optima Hybrid	2017 Kia Optima Plug-in Hybrid	2017 Kia Soul Electric
	Gasoline Vehicle	Hybrid Vehicle Gasoline	Plug-in Hybrid Vehicle Gasoline-Electricity	Electric Vehicle
				
	1.6 L, 4 cyl, Automatic (AM7), Turbo	2.0 L, 4 cyl, Automatic (AM6)	2.0 L, 4 cyl, Automatic (AM6)	Automatic (A1)
	MSRP: $16,100 - $22,800	MSRP: $25,995 - $30,990	MSRP: $35,210 Plug-in Hybrid Calculator Possible Tax Break	MSRP: $32,250 - $35,950 Possible Tax Break
Vehicle Specification Data				
EPA Size Class	Small Station Wagons	Midsize Cars	Midsize Cars	Small Station Wagons
Drive	Front-Wheel Drive	Front-Wheel Drive	Front-Wheel Drive	Front-Wheel Drive
Stop-Start Technology	No	Yes	Yes	No
Cylinder Deactivation				
Gas Guzzler	No	No	No	No
Turbocharger	Yes	No	No	No
Supercharger	No	No	No	No
Passenger Volume	101 ft^3 (4 door)	105 ft^3 (4 door)	105 ft^3 (4 door)	97 ft^3 (4 door)
Luggage Volume	24 ft^3 (4 door)	13 ft^3 (4 door)	10 ft^3 (4 door)	19 ft^3 (4 door)
Fuel Type	Regular Gasoline	Regular Gasoline	Regular Gas and Electricity	Electricity
Engine Descriptor	SIDI	SIDI	SIDI; PHEV	
Transmission Descriptor				
Electric Motor/Battery			50kW IPMSM	81 kW AC PMSM
Time to Charge Battery			2.7 hrs at 240V	4 hrs at 240V

APPENDIX B

HEV demand, and comparisons with plugins (BEVs and PHEVs)

By 2008 (when the Tesla Roadster was launched) non-plugin hybrids (such as the Toyota Prius introduced in 1997) were by far the most widely commercially available electric vehicles. Figure B1 below describes the percentage of different technologies among electric vehicle sales by country (lowess smoothed over all countries in the sample)

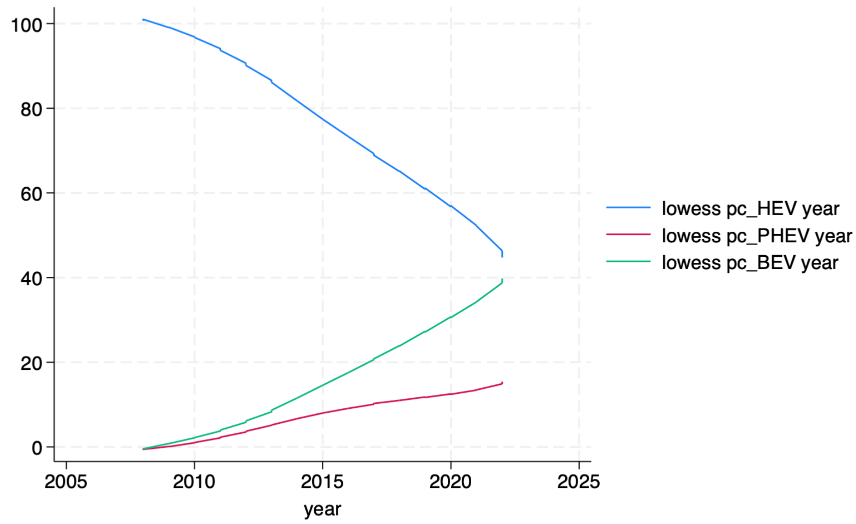


Figure B1

Yet there are divergent paths in different country environments. For example, the US market (and the Canadian market) was highly dominated by HEVs in 2008 and continues to be in later years. Figure B2 below shows the percentage sales of different technologies among electric vehicles in the US over time.

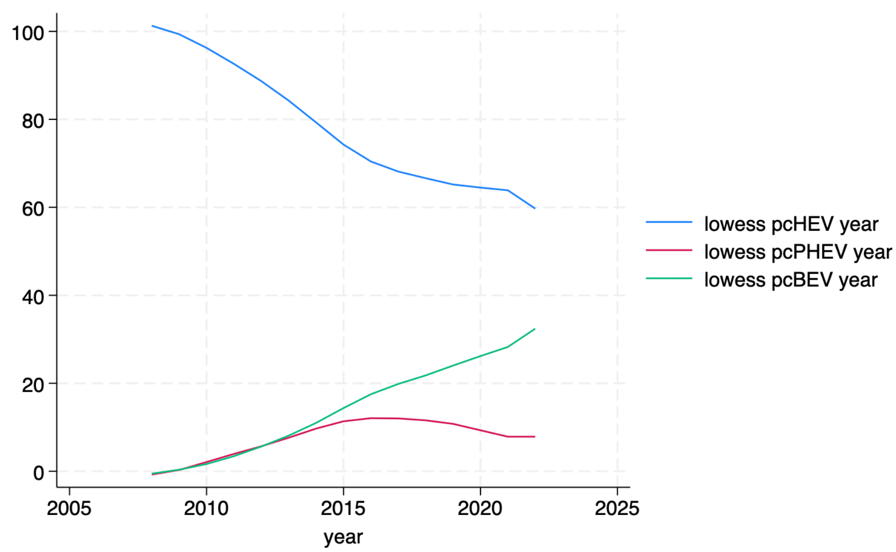


Figure B2

Other countries such as Germany (Figure B3) have seen a more accelerated trend of a dominance of hybrids being replaced with BEVs over time.

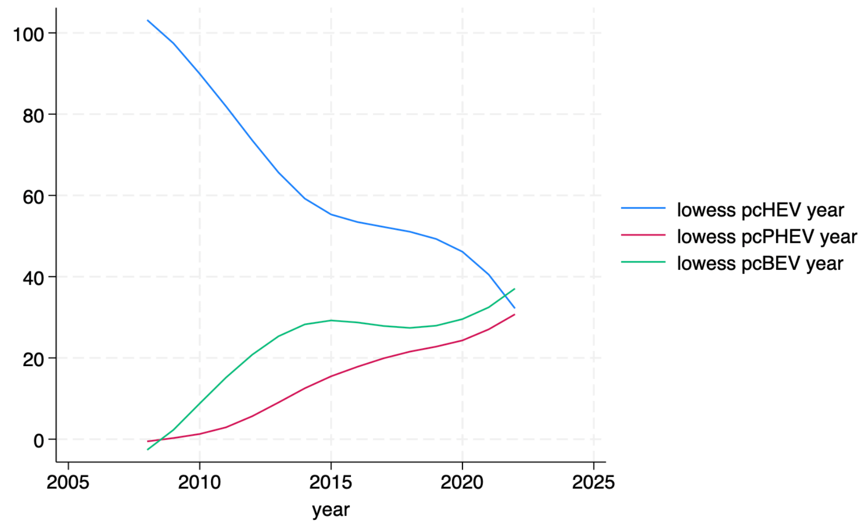


Figure B3

Still other markets such as China (Figure B4) have seen drastic shifts way from hybrids to BEVs, coinciding with a mix of mandates, incentives and vehicle taxes to reach environmental goals in the 5-year plans.

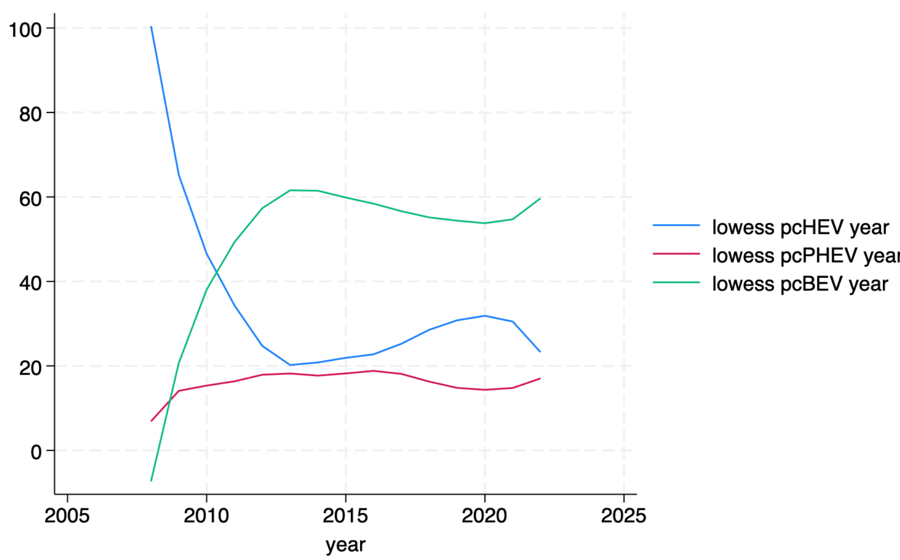


Figure B4

APPENDIX C

Market concentration
Much of the market for non-plugin hybrids (HEV) was dominated by Toyota, although new entrants emerged in later years with hybrids of their own. Figure C1 below describes the percentage of market share in HEVs held by Toyota during 2008-2022. The Y axis is the percentage of global sales (# units) of HEVs that were of Toyota models.

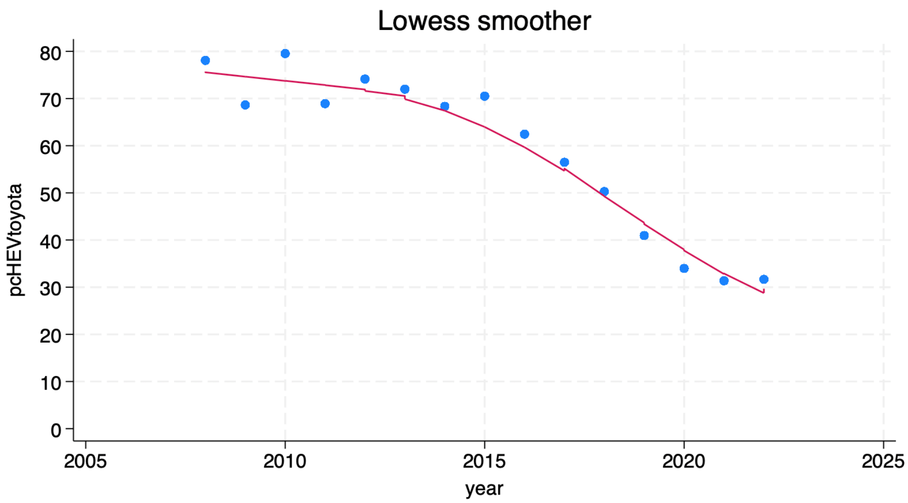


Figure C1

In comparison, the fledgling BEV market was much less concentrated. As an illustration (Figure C2) the market share (in terms of #units sold) of the most prominent BEV maker Tesla rose but still remained below 25% (and currently surpassed by BYD in BEV sales).

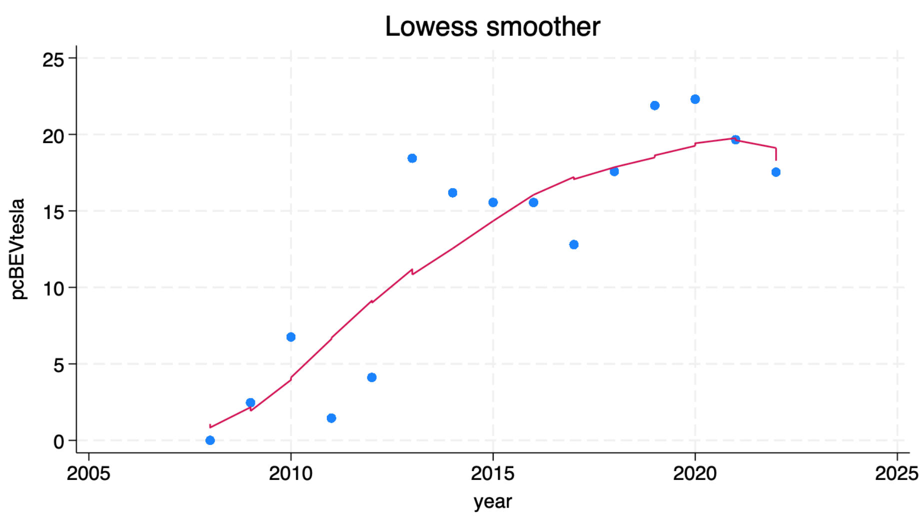


Figure C2

APPENDIX D

Extreme weather events and comparative impact on alternative electric vehicle technologies
While we conducted our main analyses using regressions, below we also considered simple graphical bivariate analysis of the impact of extreme weather events on demand for alternative electric vehicle technologies. Since we lack the use of controls for these bivariate comparisons, we standardized the variables on the Y and X axes to within-country deviations from the mean divided by the within country standard deviation. The lag structure in these graphical illustrations is the same as used in the main models, and these graphical effects should be interpreted as illustrative and correlational. The Y axis is the demand for different technologies (BEV, PHEV, HEV), and the X axis is extreme hot weather events.

Figure D1 below shows the comparisons for the 2008-2017 period leading up to the Paris Agreement. Since each EV technology demand measure is standardized within country as noted above, the key point of comparison is slopes between the different lines and not the intercepts. In Panel A (top left) all three lines are shown. In the 2008-2017 slice, all three technologies have a positive association with demand shocks in these pairwise fits, with HEV demand (green line) having a lower slope compared to BEV (blue line) and PHEV demand (red line). Panels B, C, and D show these lines separately with shaded 95% confidence intervals.

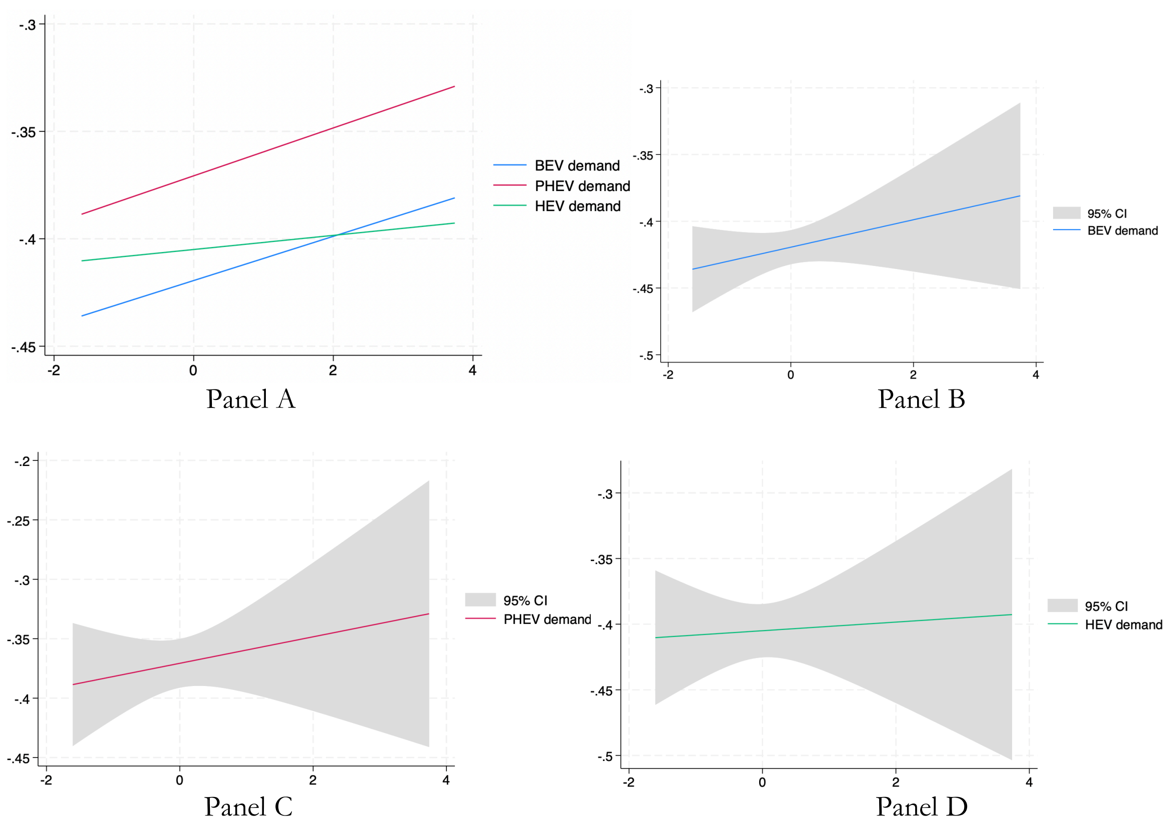


Figure D1
(Y Axis: Within country standardized demand, X axis: Within country standardized extreme hot weather events)

Next, we compare these relationships for the 2017-2022 period. Figure D2 below shows technology demand by electric vehicle technology vs. extreme hot weather events. Both demand and the weather shock measures are standardized within country as in the previous figure. In Panel A the effect of extreme weather events on all three relationships are shown.

The effect of extreme weather events on BEV demand continue to have a positive association, and stronger than the association for PHEV demand. Conversely in this period, the association between HEV demand and extreme hot weather events declines. Note that these do not reflect demand in and of itself but its relationship with extreme hot weather events in the 2017-2022 period. Panels B, C, and D show the same lines with 95% confidence intervals. Note that adding confidence intervals changes the scale of the graphs so the slopes look slightly different compared to Panel A.

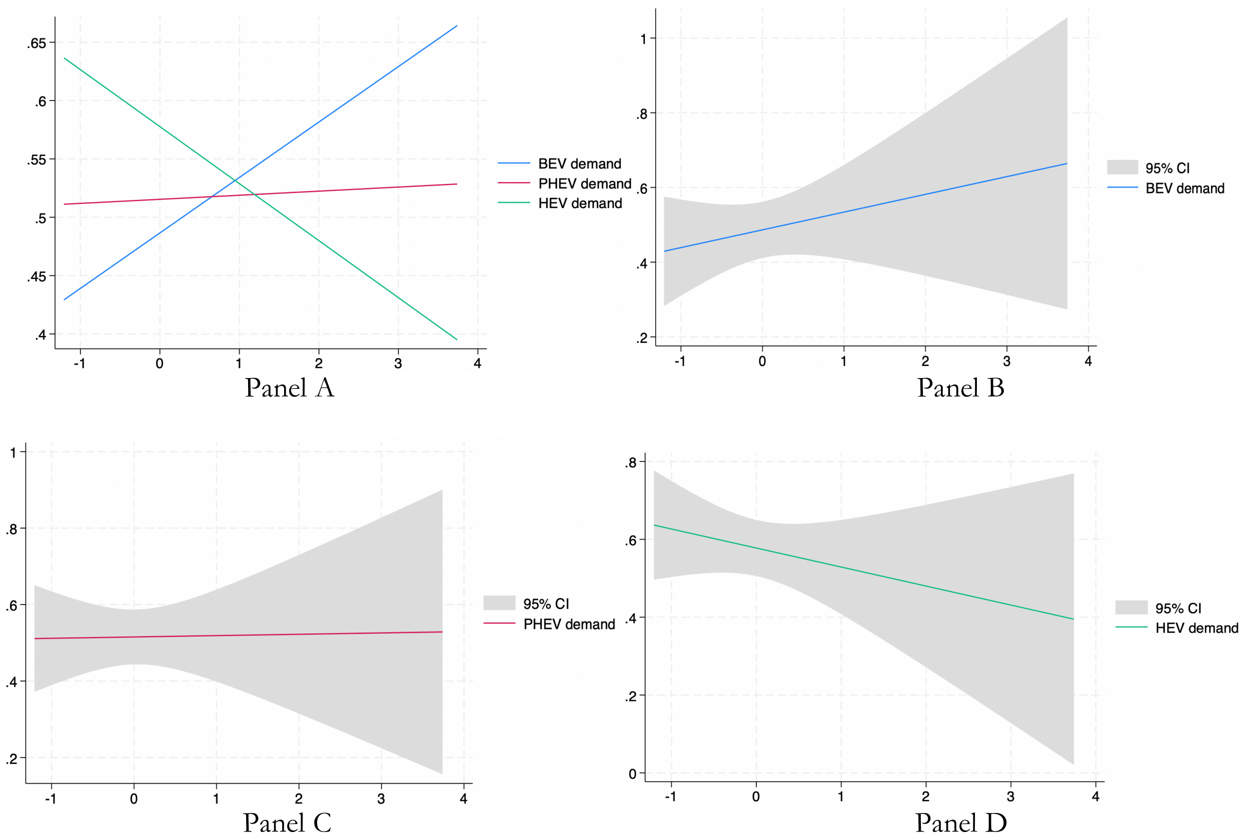


Figure D2
(Y Axis: Within country standardized demand, X axis: Within country standardized extreme hot weather events)

In this period, the Paris Agreement of 2017 pushed countries into establishing emissions targets, and multiple regulatory changes were being made globally to aid a switch to cleaner electric vehicles (International Energy Agency, 2023[9]). Further since HEVs were already a widely established technology among electric vehicles in our study period, the leap to HEVs for consumers is a much shorter one, and potentially less affected by temporal shocks such as weather. Additionally, many of the subsidies (but not all) even in major markets shifted to focusing on zero emission vehicles such as BEV (ACEA, 2021[10]). While relative environmental taxes on fossil fuel vehicles are agnostic to which alternative technology consumers potentially switch to, subsidies on alternative fuel vehicles have largely moved to being available for zero emissions vehicles in most countries (ACEA, 2021).

[9] https://www.iea.org/data-and-statistics/data-tools/global-ev-policy-explorer Accessed Jan 15 2024.
[10] https://www.acea.auto/files/Electric_vehicles-Tax_benefits_purchase_incentives_European_Union_2021.pdf Accessed Jan 15, 2024.

APPENDIX E

Pre-2008 conditions

Our main analyses begin 2008 onwards when BEVs were still fledgling but starting to gain traction, such as with the commercial launch of the Tesla Roadster in 2008 (Forbes, 2022) two years after its announcement by Tesla in 2006. The start period of 2008 also was two years before the launch of the first commercially available PHEV, the Chevy Volt in 2010 (Department of Energy, 2024).

Prior to that, the commercially available electric vehicle market was almost entirely dominated by HEVs (Figure B1, Appendix B). Among HEVs, Toyota held a dominant position prior to 2008 (e.g. Figure C1, Appendix C). Among Toyota hybrids pre-2008, the Prius family, launched in 1997 in Japan and introduced globally in 2000, was pretty much the dominant marque. While in the years since 2000, Toyota had launched hybrid versions of other models, the Prius family was the dominant model, especially in global sales. For example, in the US (Alternative Fuels Data Center 2017) after the launch of the Prius in 2000, Toyota also released other hybrids such as the Lexus RX400h (2005), Highlander (2005), Camry (2006), Lexus GS 450h (2006), and Lexus LS600hL (2007) hybrids, neither of which displaced Prius from being the dominant marque in the HEV space. Thus, an analysis of Toyota Prius offers a good proxy for HEV demand in the 1997-2008 period.

Below we describe the pre-2008 progression (1997-2007) of the Prius and its relation to extreme weather events in 5 prominent markets: Japan, USA, Netherlands, UK, and Canada. Table E1 below lists the sales of the Prius family in these markets (in thousands) by year for the pre-2008 period. These 5 countries together accounted for 253 out of 281 thousand (~ 90%) of Priuses sold in 2007 (Toyota, 2008)

Table E1: Sales of Prius pre-2008 in select markets (in thousands)

Year	Japan	Netherlands	UK	USA	Canada
1997	0.3				
1998	17.7				
1999	15.2				
2000	12.5	0.02	0.2	5.6	0.2
2001	11.0	0.4	0.6	15.6	0.4
2002	6.7	0.1	0.3	20.1	0.2
2003	17.0	0.0	0.4	24.6	0.3
2004	59.8	1.1	1.6	54.0	1.9
2005	43.7	2.7	3.8	107.9	2.0
2006	48.6	2.4	5.0	107.0	2.0
2007	58.3	2.2	8.8	181.2	2.6

Sources in the footnote[11]

[11] Netherlands: https://www-statista-com.ezp2.lib.umn.edu/statistics/1063538/total-sales-of-toyota-prius-cars-in-the-netherlands/ All footnoted links last accessed Jan 15, 2024.
UK: https://www-statista-com.ezp2.lib.umn.edu/statistics/310740/toyota-prius-sales-in-the-united-kingdom/
Japan: https://global.toyota/en/detail/300059
US: https://web.archive.org/web/20220517013453/https://carsalesbase.com/us-toyota-prius/
Canada: Subtracting US sales numbers (https://web.archive.org/web/20220517013453/https://carsalesbase.com/us-toyota-prius/) from the North America sales numbers at https://global.toyota/en/detail/300059

Next, although we have a limited sample, we conducted a set of simple regressions of number of Prius Sales by country-year on number of extreme hot weather events (with a similar year lag as the main models, but with a very sparse specification). Table E2 below shows these models. The sample is restricted to post-availability, so the zeroes for US, UK, NL, and Canada 1997-1999 are not used in the estimation sample. Models (i) and (ii) report robust standard errors clustering on country and Model (iii) and (iv) report the same for year. Models (i) and (iii) are OLS specifications and Models (ii) and (iv) are Poisson specifications that can natively model the skewed distribution of sales in the 5 countries. The coefficient on extreme hot weather events is largely positive across models suggesting that, as the earliest commercially available electric vehicles, Prius demand in the pre-2008 period was also associated with extreme weather events.

Table E2: OLS and Poisson models predicting Prius Sales in thousands by country-year.

	(i)	(ii)	(iii)	(iv)
Model	OLS	Poisson	OLS	Poisson
Clustering level	Country	Country	Year	Year
Extreme hot weather events	11.051	0.320	11.051	0.320
	[0.002]	[0.004]	[0.187]	[0.011]
	(1.444)	(0.112)	(7.797)	(0.126)
Constant	10.163	2.545	10.163	2.545
	[0.245]	[0.000]	[0.026]	[0.000]
	(7.467)	(0.580)	(3.878)	(0.242)
N	43	43	43	43
AIC	425	1614	425	1614
R-squared	0.199		0.199	
Wald χ^2		8.173		6.422
F statistic	58.597		2.009	
Model test p-value	0.002	0.004	0.187	0.011

Note: Cluster-robust standard errors in parentheses, and p-values in square brackets. Two Tailed Tests.

References to Appendix E (All links last accessed Jan 15, 2024)

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APPENDIX F: Details on Control Variables

We included several control variables which account for confounding firm characteristics, country characteristics, and firm-country characteristics (i.e. country market positions of firms). We included indicator variables for calendar year to account for industry wide global shifts in demand and the regulatory environment. We also included indicators for market region which are often used as decision making geographic divisions in auto firms, and account for the economic, environmental and institutional factors that could possibly drive responsiveness to extreme weather events in increasing demand, or drive rates of entry and scaling.

We discuss summary statistics and pairwise correlations in Table 1 of the paper. Note that the control variables (apart from the dummy variables) are used in their z-score standardized for comparability of coefficients. Note also that when running the main models we report models both without control variables and with control variables.

Country-level control variables

We controlled for the following time-varying country-level variables to account for market attractiveness from socio-economic and environmental standpoints. Below we describe the controls and also explain how they might possibly confound the relationship between the dependent and independent variables.

Country GDP growth rate (YoY) as a control for economic growth which influences the degree of environmental degradation, and impetus for shifts to cleaner technologies (Grossman and Krueger, 1995; Kahn and Zheng, 2016).

Percentage of country market that is urban accounts for markets that tend to have additional policy impetus for electric vehicle adoption (Bakker and Trip, 2013) but urban areas are also often vanguards in the adaptation to new innovations (Lin, 2011).

Vehicle environmental taxes as % GDP drives adoption of alternatives to fossil fuel vehicles (e.g. Shao, Yang, and Zhang, 2019). The variation in fuel-specific taxes in general has been hailed as the 'single most powerful climate policy instrument implemented to date' (e.g. Sterner, 2007).

Percent population with access to clean fuel technologies of any kind, is a proxy for broader regulatory attention to such environmental technologies. This also affects the extent to which users see clean technology as an overarching civic goal rather than a unique feature of certain new technologies.

CO2 emissions (kg per unit GDP) which in combination with economic growth has been found to be a driver for alternative technology adoption (Tucker, 1995), and in general is a focal point of discussion around electric vehicles as a source of mitigating such emissions.

Pollution exposure as a % of population accounts for the manner in which pollution is distributed across space affects the extent to which it becomes a salient concern for consumers. For example, countries with polluting industrial regions that are far away from where the majority of people live (e.g. Frank and Kavage, 2008), might have a weaker impetus for mitigating technologies, compared to when the population is exposed to more pollution. Accordingly, the cognitive and material impact of heat waves tends to be amplified when exposure to pollution is higher (Analitis et al, 2014).

Natural resource rents as a % of GDP as a measure of the country's (and consumers') reliance on natural resources as a source of GDP (and livelihoods); Mercure et al (2018) for example suggested that countries that are heavily reliant on fossil fuel production and exports are likely to take major hits to GDP from 'stranded' legacy fuel assets even as technology trajectories shift away from it. One would expect economic and political actors in such markets to have greater incentives and corporate lobbying to impede electric vehicle scaling among both consumers and automakers (e.g. Paine et al, 2006).

% Electricity generated by fossil fuels in country since how power is generated (e.g. coal vs natural gas vs hydro/wind) is a key input into both policy conditions and users' perceptions of electric vehicles as 'clean' (Ajanovic and Haas, 2016), since the extent to which electric vehicles reduce net emissions are influenced by the extent to which electricity used to power such vehicles itself is clean.

Firm level control variables

Firm-level[12] control variables comprise financial and technological features of firms, at the global and national levels. As noted before firms were identified based on the aggregate of brands in their umbrella, and that resulted in several global subsidiaries being aggregated into firms. For example, Audi is Volkswagen's higher end brand and they would be classified under the Volkswagen umbrella instead of being treated as a separate firm.

Global total sales of EVs & hybrids of the firm, and its G*lobal operating revenue* (including legacy technology vehicles), measure firm size in the electric vehicles space and the automotive industry in general, since firm size is a widely appreciated factor in innovation and new market entry (e.g. Chandy and Tellis, 2000).

Proportion hybrids in firm's global electric vehicles portfolio accounts for a firm's pre-existing product portfolio in EVs.

Electric autos only is a dummy to control for the potential double edged sword of specialization (Jain and Mitchell, 2022), and to 'mark' unique firms such as Tesla and Fisker that operate only in the electric vehicles space.

Global R&D expenses of the firm accounts for a firm's strategic focus on innovation, which is quite germane for a new technology.

EV-related patents' forward citations accounts for the value of the firm's base of related technological knowledge (e.g. Jaffe and Trajtenberg, 2002); we use its log (ln) in the last 5-yr window.

Global export revenues and *Number of global subsidiaries* control for the extent to which the firm is global, in two ways—the firm's export activity and global experience can reduce liability of foreignness in new markets where a firm proposes to enter and scale (Zhao and Guillen, 2015).

Number of local competitors and its squared term account for a focal firm's competitors that have already entered the electric auto market in the country (PHEV and BEV), thereby accounting for competitive dynamics, and also ecological forces influencing entry (Lomi & Larsen, 1996).

Firms' local operating revenue and Number of employees control for firms' local commitments in legacy technologies in fossil fuel auto operations (as discussed in the main manuscript as an interacting variable).

Changes in firms' local market share in fossil fuel autos accounts for the influence of local performance in the legacy technology as an endogenous driver of entry and portfolio change (e.g. Martin and Mitchell, 1998).

Home market for the firm is a dummy variable which accounts for whether the target market is a firm's home country (dummy set to 1), or a foreign market (0) which can influence a firm's entry and scaling decisions due to institutional costs (Zaheer, 2002).

[12] As noted before firms were identified based on the aggregate of brands in their umbrella, and that resulted in several global subsidiaries being aggregated into firms. For example, Audi is Volkswagen's higher end brand and they would be classified under the Volkswagen umbrella instead of being treated as a separate firm.

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APPENDIX G: Robustness Checks: GSEM models and Latent Variable approaches

Our hypotheses propose how demand shocks driven by extreme weather events drive firm entry and subsequent escalation of commitments to EVs in country markets. The empirical strategy therefore, closely follows the hypothesized multi-stage processes. Thus, when estimating firm entry driven by demand shocks, we condition on the demand surge driven by extreme weather events. Further, when estimating post entry evolution of firm portfolios and complementor acquisitions, we condition on having entered in the first place. Our models therefore do not estimate the hypothesized outcomes independently, but instead condition on the steps involved in the hypothesized processes. Nonetheless, we ran robustness checks using an alternative modeling framework of path modeling via GSEM, or Generalized Structural Equation Models (Preacher et al 2007, Skrondal & Rabe-Hesketh 2004), to rule out alternative paths to the proposed hypotheses.

<Insert Table G1 here>

In Table G1 we present results from the GSEM models. In Model 36 we estimate the impact of extreme weather events on charging stations and BEV demand, while allowing for recursive paths between the latter. Model 36(a) shows results similar to the ones reported earlier that extreme weather events positively influence BEV demand. Additionally the number of charging stations also are positively associated with BEV demand as expected, independent of the effects of the extreme weather events. The second part of the GSEM Model 36(b) shows that extreme weather events by themselves do not have positive significant impacts on charging stations except through its impact on influencing BEV demand (which is positive and significant). The establishment of public fast-charging stations is often a longer process driven by evangelizing through private and public politics, and enthusiast activity (Kirsch, 2000; Dutta et al., 2018) and being such a long drawn out process, it is unlikely to see immediate responses to shocks such as extreme weather events.

Another possible source of confounding, especially in the overall path between extreme weather events, demand, and entry, might come from an unobserved latent variable. For example, there might be unobserved forces that drive more demand as well as complements and entry by hub firms. In parallel, an alternative pathway could be that extreme weather events drive investment in complements and that is what is associated with a demand surge and subsequent entry by firms, rather than the other way round. To account for both these forces, we ran a 3-equation model with latent variables in a GSEM framework. This is reported as Model 37 (a), (b), and (c) in Table 9. These models were estimated with a sparse specification since the full set of controls leads to non-convergence, especially when estimating a latent variable. We added an unobserved latent variable in these models, which is constrained to 1 in the entry equation (so it unequivocally drives firm entry) while being estimated in the other two equations (BEV demand and complementor acquisitions).[13]

Model 37(a) estimates the effect of extreme extreme weather events on BEV demand. The number of extreme hot weather events has a positive and significant impact on demand for BEVs in the country market as before, but complementor acquisitions do not have a significant effect on demand (at least in the short run). Model 37(b) simultaneously estimates the number of complementor acquisitions by a firm in the country pre-entry. We find that extreme weather events do not directly influence complementor acquisitions, nor is there a significant effect of BEV demand on complementor acquisitions in this model. These findings lend support to our contention that weather driven demand shocks are potentially alternative paths to entry that tide over complementor bottlenecks, rather than driving the latter initially. Model 37(c) simultaneously estimates firm entry into the electric vehicle country market. Both past complementor acquisitions and the EV demand shock are positive significant predictors of entry. Since the variables are z-scored in the model, we find that the demand shock has a larger magnitude of impact on entry, even when considering the alternative path of entry owing to investments in complements. Together the GSEMs support our proposed mechanism that demand shocks driven by extreme weather events drive entry, rather than the alternative path of extreme weather events

[13] We use standard errors clustering on firm*country in these models instead of bootstrap SE since we have a binary outcome (entry) which obviates the ability to correctly estimate bootstrap SEs in GSEMs.

driving investments in complements in mediating entry.[14] This is robust to the inclusion of an unobserved latent variable constrained to drive entry, but with a path coefficient estimated for EV demand (Model 37(a)) and complementor acquisitions (Model 37(b)).

Table G1: Supplementary Analyses. Model 36(a,b) is a Generalized Structural Equation model over a limited sample (limited by charging stations data) at the country-year level. Model 37(a, b, c) is a GSEM over the full sample of firm*country*year (up until the firm enters a country year or is censored without entry at the end of the window).

	Model 36(a)	Model 36(b)	Model 37(a)	Model 37(b)	Model 37(c)
Equation family/link	Gaussian	Gaussian	Gaussian	Gaussian	Bernoulli/Logit
Dependent variable:	BEV demand	Charging Stations	BEV demand	Complementor Acquisitions	Entry by firm in a country next year
Extreme weather events					
Extreme hot weather events	0.779[0.001] (0.236)	-0.035[0.933] (0.419)	0.286[0.000] (0.021)	-0.014[0.700] (0.037)	
Extreme cold weather events	1.746[0.243] (1.494)	0.594[0.673] (1.405)	0.021[0.060] (0.011)	0.004[0.598] (0.007)	
Other Path Variables					
Number of charging stations in country market	0.114[0.000] (0.022)				
BEV demand		3.287[0.000] (0.148)		0.091[0.453] (0.121)	1.016[0.000] (0.175)
Latent (Unobserved) variable			-0.183[0.001] (0.054)	0.032[0.222] (0.026)	Constrained to 1
Number of complementor (EV-related) acquisitions by the firm in country market			-0.096[0.534] (0.155)		0.066[0.024] (0.030)
Cumulative no. of past complementor firm acquisitions by firm in country since 2000				0.061[0.222] (0.050)	
Year indicators			Yes	Yes	Yes
Market region indicators			Yes	Yes	Yes
Constant			0.022[0.297] (0.021)	-0.034[0.000] (0.006)	-26.183[0.000] (1.576)
Num Observations	92			28334	
Log Psuedolikelihood	-392.31			-55975.2	
Akaike Inf. Criterion	804.62			111996.4	

Robust standard errors in parentheses, clustered on country (Model 36 a, b) and on firm*country (Model 37 a, b, c). *p* values in square brackets, two tailed tests.

[14] Note that change in local portfolios (away from PHEVs and towards EVs) post entry, are events happening in a subsequent sample, so they need to be estimated through selection models rather than being estimable within the same sample as entry. As Table 4 previously showed firms accelerate their local complementor investments further as they gain experience in the country market.

APPENDIX H: Long form Tables

Table 2(L). (Long form version of Table 2 in manuscript) Tests of main hypotheses H1 and H2

	Model 1	Model 2a	Model 2b	Model 2c	Model 3a	Model 3b	Model 4	Model 5	Model 6
DV:	BEV demand	BEV demand	BEV demand	BEV demand	PHEV demand	HEV demand	Firm entry	Firm entry	Firm entry
Model:	OLS	OLS	OLS	OLS	OLS	OLS	IV Probit	IV Probit	IV Probit
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Market region dummies	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Extreme weather events:									
Extreme hot weather events	0.383[0.001] (0.112)	0.376[0.000] (0.091)	0.639[0.000] (0.093)	0.342[0.002] (0.102)	0.641[0.002] (0.191)	0.034[0.409] (0.041)			
Extreme cold weather events	0.034[0.463] (0.046)	0.028[0.649] (0.062)	0.018[0.769] (0.061)	0.003[0.972] (0.072)	0.071[0.451] (0.094)	0.007[0.779] (0.023)			
Extreme hot weather events X Vehicle env. taxes (%GDP)			-.760[0.003] (0.243)						
Extreme hot weather events X Dummy for Chinese market				-.394[0.001] (0.113)					
Dummy for Chinese market				2.282[0.000] (0.248)					
Demand Shocks:									
BEV demand predicted on extreme weather events							0.249[0.001] (0.073)	3.084[0.003] (1.051)	3.151[0.001] (0.989)
PHEV demand predicted on extreme weather events								-1.200[0.034] (0.567)	-1.247[0.018] (0.528)
HEV demand (non-instrumented variable)									-0.019[0.502] (0.028)
Country market level controls									
Country GDP growth rate (YoY)		-0.068[0.314] (0.067)	-0.065[0.346] (0.069)	-0.082[0.273] (0.074)	-0.068[0.350] (0.073)	-0.041[0.113] (0.025)		0.030[0.249] (0.026)	0.032[0.200] (0.025)
Percentage of country market that is urban		-0.012[0.722] (0.034)	-0.024[0.423] (0.030)	-0.003[0.922] (0.027)	0.034[0.484] (0.049)	-0.038[0.379] (0.043)		0.009[0.704] (0.025)	0.010[0.667] (0.024)
Vehicle environmental taxes as % GDP of country		0.085[0.526] (0.133)	0.139[0.276] (0.126)	-0.058[0.351] (0.062)	0.070[0.635] (0.146)	0.015[0.764] (0.050)		0.047[0.366] (0.052)	0.046[0.368] (0.051)
Percent population with access to clean fuel technologies of any kind		-0.005[0.934] (0.063)	0.011[0.874] (0.072)	0.001[0.987] (0.047)	-0.041[0.570] (0.071)	0.118[0.266] (0.105)		-0.019[0.556] (0.032)	-0.024[0.453] (0.032)
Country CO2 emissions (kg per unit GDP)		0.165[0.268] (0.147)	0.152[0.319] (0.151)	-0.072[0.177] (0.053)	0.084[0.523] (0.130)	-0.016[0.793] (0.058)		-0.026[0.366] (0.029)	-0.025[0.369] (0.028)
Natural resource rents as a % of GDP		-0.252[0.210] (0.198)	-0.212[0.249] (0.181)	-0.144[0.313] (0.141)	-0.382[0.087] (0.219)	-0.113[0.279] (0.103)		-0.036[0.395] (0.043)	-0.033[0.423] (0.042)
% Electricity generated by fossil fuels in country		-0.065[0.305] (0.063)	-0.066[0.274] (0.060)	-0.004[0.925] (0.044)	0.059[0.494] (0.085)	0.004[0.905] (0.029)		-0.021[0.639] (0.044)	-0.018[0.676] (0.043)
Pollution exposure as a % of population		0.005[0.933] (0.060)	0.010[0.852] (0.056)	-0.015[0.770] (0.050)	-0.067[0.403] (0.079)	0.073[0.210] (0.057)		-0.040[0.050] (0.020)	-0.041[0.045] (0.021)
Firm global controls:									
Global total sales of EVs & hybrids of the firm								0.272[0.000] (0.058)	0.269[0.000] (0.057)
Proportion hybrids in firm's global electric vehicles portfolio								0.092[0.003] (0.031)	0.091[0.003] (0.030)
Global operating revenue of firm								0.198[0.000] (0.051)	0.196[0.000] (0.050)
Log EV-related patent citations in the last 5 yrs								0.282[0.000] (0.054)	0.278[0.000] (0.052)
Global R&D expenses of firm								-0.011[0.737] (0.032)	-0.010[0.752] (0.032)

Global export revenue of firm								0.069[0.000]	0.068[0.000]
								(0.019)	(0.018)
Total number of global subsidiaries of firm								-0.128[0.000]	-0.127[0.000]
								(0.029)	(0.028)
Dummy: Firm makes electric autos only								0.199[0.002]	0.198[0.002]
								(0.065)	(0.064)
Firm local controls:									
Number of local competitors already offering electric autos								1.220[0.000]	1.224[0.000]
								(0.184)	(0.177)
Square of # local competitors offering electric autos								-0.020[0.000]	-0.020[0.000]
								(0.004)	(0.004)
Local operating revenue of firm in fossil fuel autos								-0.012[0.814]	-0.011[0.821]
								(0.050)	(0.051)
Local number of employees in fossil fuel auto operations								0.014[0.783]	0.015[0.768]
								(0.050)	(0.051)
Change in firms' local market share in fossil fuel autos								-0.972[0.125]	-0.958[0.127]
								(0.633)	(0.628)
Dummy: Local market is home market for firm								1.085[0.023]	1.057[0.020]
								(0.476)	(0.455)
Constant	-0.287[0.000]	-0.564[0.052]	-0.030[0.890]	-0.216[0.057]	-0.709[0.019]	-0.18[0.172]	-2.110[0.000]	-1.708[0.010]	-1.671[0.009]
	(0.063)	(0.284)	(0.217)	(0.111)	(0.292)	(0.13)	(0.024)	(0.663)	(0.644)
1st Stage: *Instruments:*							Yes	Yes	Yes
All controls in 1st stages							Yes	Yes	Yes
Extreme weather events predicting BEV demand:									
Extreme hot weather events							0.285[0.000]	0.125[0.000]	0.123[0.000]
							(0.021)	(0.009)	(0.009)
Extreme cold weather events							-0.007[0.357]	0.034[0.000]	0.034[0.000]
							(0.008)	(0.004)	(0.004)
Extreme weather events predicting PHEV demand:									
Extreme hot weather events								0.266[0.000]	0.263[0.000]
								(0.022)	(0.022)
Extreme cold weather events								0.027[0.000]	0.027[0.000]
								(0.006)	(0.006)
Number of observations	443	443	443	443	443	443	31531	28334	28334
Log psuedolikelihood	-417.9	-410.9	-402.5	-390.1	-551.5	-631.5	-33981.9	-16478.2	-16405.9
Akaike Information Criterion	863.8	865.7	851.0	824.2	1146.9	1307.0	67977.9	33176.4	33037.7
Model R-squared	0.234[.000]	0.257[.000]	0.285[.000]	0.324[0.000]	0.323[.000]	0.045[0.328]			
Wald Chi2 statistic							11.4[.001]	1614.3[.000]	1633.4[.000]

Clustered robust standard errors in parentheses, with clustering on country (Models 1-3) and firm-country (Models 4, 5, 6). Two tailed tests, p-values in square brackets. For these and other tables demand DVs are standardized (Models 1-3) to enable comparability between alternate EV technologies as noted in the Data section. Control variables (except indicators and time) are standardized to enable comparability across coefficients on variables with differing underlying scales.

Table 3(L). (Long form version of Table 3) Interaction models for tests of H3(a) (Models 7, 8, 9) and H3(b) (Model 10)

DV (from 2nd stage of IV probit)	(7) Firm entry	(8) Firm entry	(9) Firm entry	(10) Firm entry	(11) Firm entry (Full Model)
BEV demand predicted on extreme weather events	11.435[0.000] (2.030)	2.495[0.000] (0.480)	5.138[0.000] (0.704)	3.272[0.001] (0.975)	5.217[0.000] (0.673)
Predicted BEV demand X Log number of charging stations in country pre-entry	-1.102[0.000] (0.225)				
Predicted BEV demand X Number of potential complementor firms in country pre-entry		-0.340[0.021] (0.148)			
Predicted BEV demand X Number of complementary (EV related) startups in country pre-entry			-0.008[0.000] (0.002)		-0.008[0.000] (0.002)
Predicted BEV demand X Overlap between firm's global portfolio and country product market characteristics				-0.311[0.019] (0.133)	-0.268[0.012] (0.106)
Country level controls:					
PHEV demand predicted on extreme weather events	-0.941[0.001] (0.289)	1.134[0.037] (0.543)	-0.453[0.254] (0.397)	-1.257[0.016] (0.522)	-0.511[0.202] (0.400)
Country GDP growth rate (YoY)	0.000[0.000] (0.000)	0.051[0.025] (0.023)	0.064[0.006] (0.023)	0.036[0.144] (0.024)	0.068[0.002] (0.022)
Percentage of country market that is urban	-0.159[0.004] (0.055)	0.014[0.524] (0.022)	0.015[0.368] (0.017)	-0.004[0.870] (0.027)	0.006[0.728] (0.019)
Environmental taxes on fossil fuel autos as % GDP of country	0.091[0.687] (0.227)	-0.045[0.434] (0.058)	-0.025[0.536] (0.041)	0.041[0.425] (0.051)	-0.028[0.484] (0.040)
Percent population with access to clean fuel tech	0.718[0.057] (0.377)	-0.041[0.186] (0.031)	-0.058[0.025] (0.026)	-0.029[0.370] (0.032)	-0.063[0.012] (0.025)
Country CO2 emissions (kg per unit GDP)	0.469[0.000] (0.079)	0.018[0.553] (0.030)	0.022[0.424] (0.027)	-0.039[0.185] (0.030)	0.014[0.637] (0.029)
Natural resource rents as a % of GDP	-1.410[0.000] (0.266)	-0.052[0.168] (0.038)	-0.047[0.106] (0.029)	-0.037[0.371] (0.041)	-0.048[0.087] (0.028)
% Electricity generated by fossil fuels in country	0.326[0.002] (0.105)	-0.098[0.000] (0.025)	-0.002[0.966] (0.038)	-0.015[0.717] (0.043)	0.003[0.946] (0.037)
Pollution exposure as a % of population	-0.005[0.959] (0.094)	-0.046[0.016] (0.019)	-0.049[0.032] (0.023)	-0.038[0.054] (0.020)	-0.047[0.028] (0.021)
Firm level global controls:					
Global total sales of electric vehicles of the firm	0.125[0.044] (0.062)	0.262[0.000] (0.049)	0.197[0.007] (0.074)	0.262[0.000] (0.049)	0.195[0.002] (0.064)
Proportion PHEV in firm's global electric vehicles portfolio	-0.112[0.085] (0.065)	0.084[0.002] (0.027)	0.058[0.104] (0.036)	0.091[0.001] (0.028)	0.059[0.064] (0.032)
Global operating revenue of firm	0.045[0.489] (0.065)	0.185[0.000] (0.049)	0.141[0.016] (0.059)	0.196[0.000] (0.050)	0.140[0.015] (0.058)
Log EV-related patent citations in the last 5 yrs	0.262[0.015] (0.107)	0.251[0.000] (0.052)	0.198[0.009] (0.076)	0.277[0.000] (0.053)	0.195[0.008] (0.074)
Global R&D expenses of firm	0.106[0.150] (0.074)	-0.020[0.502] (0.030)	-0.016[0.583] (0.028)	-0.016[0.619] (0.032)	-0.018[0.515] (0.028)
Global export revenue of firm	0.267[0.016] (0.111)	0.059[0.001] (0.017)	0.042[0.076] (0.024)	0.068[0.000] (0.017)	0.042[0.053] (0.022)
Total number of global subsidiaries of firm	-0.111[0.201] (0.087)	-0.114[0.000] (0.028)	-0.091[0.015] (0.037)	-0.125[0.000] (0.028)	-0.090[0.012] (0.036)
Dummy: Firm makes electric autos only	0.008[0.926] (0.084)	0.172[0.005] (0.061)	0.129[0.065] (0.070)	0.206[0.002] (0.066)	0.133[0.066] (0.072)

Firm local controls:					
Local number of competitors already offering electric autos	-1.941[0.000]	1.730[0.000]	1.659[0.000]	1.199[0.000]	1.637[0.000]
	(0.372)	(0.209)	(0.216)	(0.165)	(0.195)
Square of the above variable	0.022[0.000]	-0.031[0.000]	-0.031[0.000]	-0.020[0.000]	-0.031[0.000]
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)
Local operating revenue of firm in fossil fuel autos	0.234[0.065]	-0.029[0.657]	-0.034[0.600]	-0.015[0.802]	-0.036[0.614]
	(0.127)	(0.065)	(0.065)	(0.058)	(0.072)
Local number of employees in fossil fuel auto operations	0.017[0.829]	-0.001[0.980]	0.022[0.730]	0.016[0.781]	0.023[0.737]
	(0.076)	(0.059)	(0.063)	(0.058)	(0.069)
Change in firms' local market share in fossil fuel autos	-1.247[0.065]	-0.808[0.163]	-0.624[0.223]	-0.976[0.117]	-0.634[0.206]
	(0.677)	(0.579)	(0.513)	(0.623)	(0.501)
Dummy: Local market is home market for firm	2.342[0.024]	1.188[0.002]	1.010[0.012]	1.002[0.034]	0.948[0.024]
	(1.039)	(0.383)	(0.404)	(0.473)	(0.421)
Log number of charging stations in country pre-entry	-0.240[0.048]				
	(0.121)				
Number of potential complementor firms in country pre-entry		-0.309[0.039]			
		(0.149)			
Number of complementary (EV-related) startups in the country pre-entry			-0.014[0.003]		-0.014[0.001]
			(0.005)		(0.004)
Overlap between firm's global electric vehicles portfolio and country product market characteristics				0.139[0.167]	0.058[0.537]
				(0.101)	(0.094)
Constant	-2.750[0.045]	-0.863[0.200]	-0.180[0.836]	-1.684[0.009]	-0.180[0.830]
	(1.371)	(0.674)	(0.867)	(0.646)	(0.842)
Num. Observations	2075	28334	28334	28334	28334
Log psuedolikelihood	-4927.952	-55812.795	-149127.88	-19539.831	-19539.831
Akaike Information Criterion	10101.903	111939.591	298569.76	39393.661	39393.661
Wald Chi2	597.8[0.000]	1938.5[0.000]	2611.2[0.000]	1694.7[0.000]	1694.7[0.000]
Endogenous Variables	*BEV demand, PHEV demand, BEV dem X Log number of charging stations*	*BEV demand, PHEV demand, BEV dem X No. of potential complementors*	*BEV demand, PHEV demand, BEV dem X Number of EV-related startups*	*BEV demand, PHEV demand, BEV dem X Portfolio overlap bw firm and ctry*	*BEV demand, PHEV demand, BEV dem X EV startups, BEV dem X overlap*
First stage instruments: *(1st stage model not shown, has a similar specification as the main 2-step models for entry except for additional instruments)*	*# extreme hot weather events, # extreme cold weather events, # extreme hot weather events X Log number of charging stations in country pre-entry*	*# extreme hot weather events, # extreme cold weather events, # extreme hot weather events X Number of potential complementor firms in country pre-entry*	*# extreme hot weather events, # extreme cold weather events, # extreme hot weather events X Number of complementary (EV-related) startups in the country pre-entry*	*# extreme hot weather events, # extreme cold weather events, # extreme hot weather events X Overlap between firm's portfolio and country product market characteristics*	*# extreme hot weather events, # extreme cold weather events, # extreme hot weather events X Num complementary startups, #extreme hot weather events X Overlap*

Notes: Models 7-9 are tests of Hypothesis H3(a) with three different ways of measuring complementors. Model 10 is a test of Hypothesis H3(a-b). Robust Standard errors clustering on firm-country in parentheses, and p-values in square brackets. Two-tailed tests.

Table 4(L). (Long form version of Table 4 in manuscript) Heckman Selection Models predicting proportion PHEVs in firm's local electric vehicles portfolio after entering the country electric vehicles market (Models 12, 14) and Number of EV-related complementor acquisitions by firm in country (Models 13, 15).

DV (Second Stage in Heckman models)	(12) Proportion of hybrids in firm's local electric vehicles portfolio	(13) Number of complementor acquisitions by firm in country	(14) Proportion of hybrids in firm's local electric vehicles portfolio	(15) Number of complementor acquisitions by firm in country
Key independent variables and interactions:				
Years since entering the local electric autos market	-0.027[0.000] (0.005)	0.004[0.032] (0.002)	-0.026[0.000] (0.005)	0.003[0.039] (0.002)
Years since entry X Local operating revenue of firm in fossil fuel autos			0.005[0.036] (0.002)	0.001[0.759] (0.002)
Years since entry X Local number of employees in fossil fuel auto operations			-0.005[0.058] (0.003)	0.000[0.919] (0.001)
Path dependence controls				
Proportion PHEV in firm's electric vehicles portfolio at the time of entry	0.737[0.000] (0.032)		0.787[0.000] (0.034)	
Cumulative number of EV-related acquisitions by the firm in the country since start of panel		0.010[0.451] (0.013)		0.009[0.528] (0.014)
Country controls				
Country GDP growth rate (YoY)	0.017[0.159] (0.012)	-0.003[0.258] (0.003)	0.022[0.037] (0.010)	-0.003[0.265] (0.003)
Percentage of country market that is urban	0.003[0.793] (0.010)	-0.002[0.404] (0.002)	0.005[0.672] (0.011)	-0.002[0.424] (0.002)
Environmental taxes on fossil fuel autos as % GDP of country	0.013[0.482] (0.019)	-0.013[0.121] (0.008)	0.008[0.724] (0.021)	-0.012[0.127] (0.008)
Percent population with access to clean fuel tech	0.013[0.149] (0.009)	0.004[0.144] (0.003)	0.004[0.702] (0.011)	0.004[0.148] (0.003)
Country CO2 emissions (kg per unit GDP)	-0.009[0.304] (0.009)	-0.003[0.164] (0.002)	-0.011[0.274] (0.010)	-0.003[0.165] (0.002)
Natural resource rents as a % of GDP	0.019[0.207] (0.015)	0.003[0.548] (0.004)	0.024[0.105] (0.015)	0.002[0.563] (0.004)
% Electricity generated by fossil fuels in country	-0.011[0.170] (0.008)	-0.002[0.660] (0.004)	-0.007[0.451] (0.009)	-0.002[0.675] (0.004)
Pollution exposure as a % of population	0.007[0.299] (0.007)	0.002[0.472] (0.003)	0.010[0.159] (0.007)	0.002[0.480] (0.003)
Firm level (global) controls:				
Global total sales of EVs & hybrids of the firm	-0.027[0.016] (0.011)	-0.005[0.044] (0.002)	-0.065[0.000] (0.010)	-0.005[0.046] (0.002)
Proportion hybrids in firm's global electric vehicles portfolio	-0.010[0.098] (0.006)	-0.001[0.615] (0.003)	-0.030[0.000] (0.007)	-0.001[0.609] (0.003)
Global operating revenue of firm	-0.012[0.416] (0.015)	-0.011[0.030] (0.005)	-0.048[0.004] (0.017)	-0.011[0.027] (0.005)
Log EV-related patent citations in the last 5 yrs	0.036[0.006] (0.013)	-0.001[0.559] (0.002)	-0.017[0.242] (0.015)	-0.001[0.492] (0.002)
Global R&D expenses of firm	0.011[0.240] (0.010)	0.007[0.049] (0.004)	0.020[0.101] (0.012)	0.007[0.046] (0.004)
Number of subsidiaries of the firm globally	0.002[0.820] (0.009)	-0.001[0.832] (0.003)	0.018[0.086] (0.010)	-0.001[0.868] (0.003)

Global export revenue of firm	-0.005[0.153] (0.004)	-0.000[0.872] (0.001)	-0.016[0.000] (0.004)	-0.000[0.765] (0.001)
Dummy: Firm makes electric autos only	-0.086[0.000] (0.021)	-0.016[0.068] (0.009)	-0.136[0.000] (0.023)	-0.016[0.067] (0.009)
Firm local controls:				
Local number of competitors already offering electric autos	-0.010[0.769] (0.035)	-0.034[0.036] (0.016)	-0.111[0.001] (0.032)	-0.034[0.036] (0.016)
Square of the above variable	0.000[0.939] (0.000)	0.000[0.047] (0.000)	0.000[0.008] (0.000)	0.000[0.048] (0.000)
Local operating revenue of firm in fossil fuel autos	0.013[0.010] (0.005)	0.003[0.547] (0.004)	0.002[0.775] (0.006)	0.001[0.829] (0.006)
Local number of employees in fossil fuel auto operations	-0.015[0.003] (0.005)	-0.002[0.727] (0.005)	-0.001[0.821] (0.006)	-0.003[0.616] (0.006)
Change in firms' local market share in fossil fuel autos	0.327[0.151] (0.228)	0.065[0.312] (0.064)	0.295[0.258] (0.261)	0.070[0.299] (0.067)
Dummy: Local market is home market for firm	-0.054[0.268] (0.049)	0.022[0.199] (0.017)	-0.241[0.000] (0.054)	0.021[0.210] (0.017)
Constant				
Num. Observations	29920	29920	29920	29920
Num. Selected Observations for 2nd stg (post entry panel)	2578	2578	2578	2578
Log Psuedolikelihood	-3195.354	-2147.015	-3528.026	-2145.822
Akaike Information Criteria	6532.709	4436.031	7200.053	4437.643
Wald chi2	5110.033	18.608	5518.297	22.137

Robust standard errors clustering on firm-country in parentheses, and p-values in square brackets. Two Tailed Tests. Also see notes to Table 4 in the main manuscript.

Table 5(L). (Longer form version of Table 5) Mediation of extreme weather events on EV demand by attention to climate change (16-19) effects on environmental policy (20,21), and effects of repeated shocks on EV demand (22).

DV:	(16) Log Google Trends score for climate change	(17) BEV demand	(18) PHEV demand	(19) HEV demand	(20) 1-yr Change in vehicle environment al taxes	(21) 3-yr change in vehicle environment al taxes	(22) BEV demand
Extreme hot weather events	0.033[0.006] (0.012)	0.347[0.003] (0.117)	0.507[0.000] (0.132)	0.038[0.490] (0.056)	0.003[0.396] (0.004)	0.007[0.484] (0.010)	0.515[0.000] (.084)
Extreme cold weather events	0.046[0.059] (0.024)	0.042[0.717] (0.116)	-0.021[0.816] (0.091)	-0.015[0.357] (0.016)	-0.003[0.712] (0.007)	-0.024[0.323] (0.024)	0.042[0.548] (0.070)
Log Google Trends score for climate change		0.206[0.028] (0.094)	0.185[0.011] (0.073)	-0.003[0.884] (0.023)			
Yrs since last extreme hot weather event							-0.015[0.199] (0.012)
Yrs since " * Extreme hot weather events (focal yr)							-0.048[0.000] (0.011)
Country GDP growth rate (YoY)	0.001[0.970] (0.036)	-0.087[0.213] (0.070)	-0.051[0.237] (0.043)	-0.072[0.203] (0.056)	0.015[0.009] (0.006)	0.028[0.026] (0.012)	-0.018[0.710] (0.047)
Percentage of country market that is urban	-0.008[0.738] (0.024)	0.048[0.232] (0.040)	0.042[0.101] (0.025)	-0.026[0.120] (0.016)	-0.003[0.379] (0.004)	-0.005[0.731] (0.013)	-0.011[0.694] (0.027)
World Bank (WDI) and OECD Environmental policy indicators:							
Existing relative environmental taxes on fossil fuel autos (as %GDP of country	0.053[0.146] (0.037)	0.199[0.283] (0.185)	0.106[0.291] (0.101)	0.035[0.521] (0.055)	-0.051[0.000] (0.014)	-0.179[0.000] (0.045)	0.062[0.570] (0.108)
Percent population with access to clean fuel tech	0.003[0.837] (0.015)	-0.060[0.395] (0.071)	-0.031[0.547] (0.052)	0.080[0.204] (0.063)	0.007[0.356] (0.007)	0.021[0.401] (0.025)	-0.014[0.777] (0.048)
Country CO2 emissions (kg per unit GDP)	-0.022[0.275] (0.020)	0.207[0.153] (0.145)	0.114[0.200] (0.089)	-0.034[0.380] (0.038)	0.000[0.956] (0.008)	0.006[0.859] (0.032)	0.126[0.307] (0.122)
Natural resource rents as a % of GDP	-0.009[0.525] (0.013)	-0.059[0.151] (0.041)	-0.045[0.083] (0.026)	-0.027[0.111] (0.017)	0.022[0.361] (0.024)	0.082[0.270] (0.073)	-0.185[0.238] (0.155)
% Electricity generated by fossil fuels in country	-0.031[0.055] (0.016)	-0.039[0.340] (0.041)	0.065[0.060] (0.035)	0.036[0.147] (0.025)	-0.005[0.281] (0.004)	-0.022[0.167] (0.016)	-0.069[0.185] (0.051)
Pollution exposure as a % of population	-0.005[0.839] (0.024)	-0.010[0.753] (0.032)	-0.056[0.055] (0.029)	0.034[0.515] (0.052)	0.007[0.154] (0.005)	0.022[0.198] (0.017)	0.009[0.855] (0.047)
Year indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mkt region indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.274[0.178] (0.203)	-0.890[0.021] (0.387)	-1.546[0.003] (0.527)	-0.187[0.151] (0.130)	0.001[0.970] (0.022)	0.059[0.473] (0.081)	-0.122[0.527] (0.192)
N	443	443	443	443	392	288	443
Wald Chi2	4911[0.000]	35.93[0.022]	90.18[0.000]	9.63[0.989]			
F Statistic					2.99[0.001]	2.81[0.002]	19.00[0.000]
AIC	208.059	1645.922	1579.832	1730.617	-817.253	-194.166	834.906

Note: Country*Year models with Bootstrap standard errors (16-19) and Robust standard errors clustering on country (20-22) in parentheses, and *p*-values in square brackets. Two-Tailed Tests. Demand DVs (BEV, PHEV, HEV) are standardized, as are control variables (except indicators and time) as noted previously.