

# Chapter 7

## A Comparison of Policy Measures Promoting Electric Vehicles in 20 Countries



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**Abstract** This chapter compares and analyzes policy measures that governments have implemented in 20 countries, on five continents, to promote consumer adoption of electric vehicles (EVs). These include subsidies for EV purchases, tax benefits, incentives for developing charging infrastructures, and traffic regulations such as free parking or the use of bus lanes. To assess the effectiveness of these measures, this study examines their influence on the market share of EVs in each country. Results indicate that the higher the level and amount of political incentives in a country, the higher the country's proportion of EVs. This is analyzed further in case studies of the Netherlands and Brazil by evaluating the countries' governance systems. While the Netherlands has benefited from a collaborative effort of public and private actors promoting EVs, Brazil still faces many challenges. Altogether, findings show that policy measures have a significant impact on EV adoption around the world and that stakeholders from different sectors must work together to maximize the effectiveness of these policies. Therefore, countries wishing to raise EV penetration should do so through a range of governmental incentives and a collaborative governance system.

**Keywords** Electric vehicles · Policy measures · International comparison Governance systems

### 7.1 Introduction

Governmental support for electric vehicles (EVs) has been on the rise in many countries over the past several years. Yet, apart from a few exceptions, such as Norway and the Netherlands, consumer sales of EVs are still rather low in most countries

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around the world. The majority of market shares still lie significantly below 2% (OECD/IEA 2016). Differences exist in the forms and levels of national governments' consumer incentives and market shares of EVs (EAFO 2017a; EV-Volumes 2017; IEA IA-HEV 2016; OICA 2017a). Using a cross-national perspective to compare these diverse policy measures is valuable to analyze their effectiveness. It is also important to note that there are different levels at which EV penetration is promoted. For example, there are international agreements, such as initiatives by the International Energy Agency (IEA) or emission standards set by the European Union (EU). National measures include financial subsidies, tax incentives, or legislation regarding EVs. Furthermore, there are measures at regional and local levels, such as the largest Dutch cities offering monetary incentives on top of the national ones (van der Steen et al. 2015). Nonetheless, the focus in this analysis is at the country level, since most policies are set by national governments and this perspective allows for comparing policy strategies in different countries. Therefore, it is possible to draw generalizable conclusions regarding effective policy measures supporting EV penetration than would be possible with a focus on more global or local cases.

Previous research has predominantly focused on policy measures in cities, a single country, or a comparison between two countries (e.g., Zhang et al. 2011; Bakker and Trip 2013; Holtsmark and Skonhøft 2014; Figenbaum et al. 2015; Li 2016). For example, Bakker and Trip (2013) investigate how cities can effectively promote EVs with policy measures. They find that municipal governments can support the adoption process of EVs through policies such as investments in charging infrastructure. However, their findings also show that most lobbying in this regard occurs at the regional and national levels, which further highlights the importance of focusing on a country level. Moreover, Figenbaum et al. (2015) take a closer look at the successful adoption of EVs in Norway and investigate how policy measures contribute to this. Results demonstrate that various different factors influenced the successful diffusion of EVs—most importantly the large incentives offered by the Norwegian government. Li (2016) also highlights the importance of governmental policies supporting EVs, particularly regarding infrastructure developments, in a comparative study examining China and Brazil. The author points out that China is far ahead of Brazil in terms of consumer adoption of EVs, due to stronger policies and infrastructure investments.

In addition to this, some studies have also taken international perspectives to investigate policy measures promoting EV penetration (e.g., Sierzchula et al. 2014; Haddadian et al. 2015; Lieven 2015). Sierzchula et al. (2014) were among the first to examine the influence of policy measures on EV adoption across a range of countries. Using data from 2012, the authors analyzed the impact of financial incentives on the market share of EVs in 30 countries. While their findings revealed a positive correlation of monetary incentives and charging infrastructure with EV market shares, they found no support for a causal effect. One of the main reasons for this is certainly that market shares were still very low in 2012, with EVs accounting for only approximately 0.35% in all 30 countries that were included in this analysis. This has changed significantly over the past few years. Norway, which had an EV market share of approximately 3.1% in 2012, reached a market share of nearly 30%

in 2016 (EV-Volumes 2017; OICA 2017a; Sierzchula et al. 2014). It is important to investigate how policies have recently influenced this sales growth. Another global study (Lieven 2015) examined the effects of policy measures promoting EVs by looking at consumer preferences in 20 countries on five continents. Results indicate that consumers appreciate financial incentives but consider a sufficient charging network on freeways to be an absolute must-have. Other policy measures, such as free access to fast lanes or bus lanes, received less positive responses from consumers. Overall, findings suggest that policies supporting the development of a charging infrastructure as well as monetary incentives should be the most effective incentives to promote EV adoption.

Building on Lieven's (2015) findings, this chapter will take a closer look at policy measures promoting EV penetration in the same 20 countries considered in the previous research. It will do so by first comparing the different incentives that governments implemented in these countries and then investigating their influence on EV market shares. Based on this analysis, two cases will be explored more closely—the Netherlands and Brazil—to determine in more detail how national governance systems have supported or inhibited EV penetration in these countries. This chapter aims to provide an international overview of the different types and levels of incentives that governments offer to promote EV penetration in 20 countries. It also discusses how to assess the successfulness of these measures. In order to do so, the following hypotheses, formulated on the basis of prior research findings, will be tested:

H1: Monetary measures, traffic regulations, and infrastructure measures to promote EVs have a positive impact on the market share of EVs.

H2: The interaction of monetary measures and a country's charging infrastructure has the strongest positive influence on the market share of EVs.

## **7.2 Policy Measures Promoting EVs in 20 Countries**

These hypotheses will be tested in the following sections to determine the impact of various policy measures on EV penetration in 20 countries. First, it will be outlined how data was collected and how certain figures were determined for this analysis. An overview of the different types of policy measures that have been implemented in the 20 countries will then be presented. Finally, a structural equation model will allow for testing the previously formulated hypotheses.

### ***7.2.1 Data Collection***

In order to compare policy measures across nations and construct a structural equation model assessing their influence on EV market shares, data was gathered

from a range of secondary sources for 20 countries (Australia, Belgium, Brazil, Canada, China, France, Germany, Hong Kong, India, Italy, Japan, Korea, the Netherlands, Norway, Russia, South Africa, Switzerland, Taiwan, the UK, and the USA). Data was collected for both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), as this dataset was assumed to represent all consumers interested in cars with electric propulsion. In this chapter, EVs refer to both BEVs and PHEVs.

With regard to policy measures, all forms of incentives that directly affected consumers purchasing EVs were considered. This included financial measures, such as purchase subsidies, tax benefits, and other financial benefits (such as import-duty exemptions), infrastructure incentives (such as tax deductions for installing charging stations), and traffic regulations (such as the free use of fast or bus lanes or free parking). By focusing on consumer incentives, as opposed to incentives for companies to adopt EVs, it is possible to evaluate the impact of these measures on EV market shares from a consumer perspective.

The figures for EV market shares were calculated from the total number of EVs sold in each of the 20 countries in 2016. This data was provided by a Swedish consulting firm (EV-Volumes 2017) as a percentage of the total amount of vehicles sold during this period, according to the Organisation Internationale des Constructeurs d'Automobiles (OICA 2017a). The OICA differentiates between commercial vehicles and passenger cars in its data. Since this study focuses on incentives aimed at consumers and their adoption of EVs, only the number of passenger cars was included in the market share calculations.

The subsequent analysis of the fiscal measures was complex, since there are significant differences between countries and regional divergences within nations. Some countries offer a onetime tax benefit for EV purchasers, while others provide annual tax benefits for EV owners. For example, the Norwegian government allows a onetime exemption from the purchase tax for BEVs and a reduction for PHEVs (EAFO 2017a). In Switzerland, there are lowered, annual road taxes for electric cars (Bundesamt für Energie 2017). To compare countries with such different policy measures, the figures indicate the sum of all fiscal measures in a given country for a number of years. This assumes ownership for approximately 10 years and that currencies, such as the Euro or the American dollar, remain approximately equal during the time period. The figures in this analysis should primarily be interpreted as indicators for a country's incentive level.

In addition, non-monetary policies, specifically traffic regulations such as free access to fast or bus lanes, and infrastructure investments, were expressed in terms of dummy variables in the structural equation model analyzing the influence of policy measures on EV market shares. The respective variables show the existence, or nonexistence, of non-monetary measures and the relative extent to which they are present in a particular country.

The number of charging stations was collected for each country, in order to analyze the extent to which such incentives promoted the development of national charging networks. Various sources were compared for this (ChargeHub 2017; EAFO 2017a, b; Environmental Protection Department 2017; OECD/IEA 2016;

PlugShare 2017), since it was not always possible to determine from just one source if figures indicated single charger or station with one or more charging spots. This comparison indicates the pervasiveness of charging networks in the 20 countries. Furthermore, the number of charging stations was expressed in relative terms to compare the different nations. Specifically, a country's total number of charging stations was divided by its population (Worldometers 2017) and by its length of highway kilometers (NationMaster 2017). These two figures were both taken into account in the structural equation model for the variable indicating the number of charging stations.

## 7.2.2 Findings

Based on the data gathered on existing policy measures promoting EV penetration in the 20 countries, an overview was constructed to show the types of incentives that exist in each country, as Table 7.1 shows. All countries, except Australia and

**Table 7.1** Overview of national policy measures promoting EV penetration in 20 countries in 2016

	Purchase subsidies	Tax benefits	Other financial benefits	Infrastructure measures	Traffic regulations
Australia					
Belgium	x	x		x	
Brazil		x	x		
Canada	x			x	x
China	x	x			x
France	x	x		x	
Germany	x	x			x
Hong Kong		x			
India	x	x	x		
Italy	x	x		x	x
Japan	x				
Korea	x	x			x
Netherlands		x		x	
Norway		x		x	x
Russia			x		
South Africa					
Switzerland		x			
Taiwan		x			
UK	x	x		x	x
USA	x	x		x	x

South Africa, offered some form of incentive for consumers to purchase EVs in 2016. These two exceptions were taken into account for the subsequent analysis investigating the influence of policy measures on market shares. By including countries that do not offer incentives, the data can show a more complete picture. The different types of political incentives, specifically monetary measures, infrastructure measures, and traffic regulations, will first be outlined in more detail in a cross-country comparison.

### 7.2.2.1 Monetary Measures

Monetary measures include incentives such as purchase subsidies and tax benefits for EV buyers. As can be seen from Table 7.1, these are the most common measures taken by governments in the 20 countries considered in this analysis. In fact, all of the countries, except Australia and South Africa, offer some form of fiscal incentive for EV buyers. Nonetheless, there are significant cross-country differences between these fiscal measures. For example, Belgium and Canada both offer financial incentives but primarily on a regional basis. In the USA, there are also differences between states. In addition to the national tax incentive of US\$2500 to US\$7500 (Office of Energy Efficiency & Renewable Energy 2018), a number of states have also implemented statewide subsidies. For example, California offers additional rebates of up to US \$2500 (van der Steen et al. 2015). However, most other countries predominantly offer incentives at only a national level. For example, Germany, China, France, India, Italy, Korea, and the UK have implemented a combination of both purchase subsidies and tax benefits. The values and extents of these benefits differ significantly (Beltramello 2012; EAFO 2017a; Government of NCT of Delhi 2016; IEA IA-HEV 2014, 2016; Kim and Yang 2016; OECD/IEA 2016; Rokadiya and Bandivadekar 2016; van der Steen et al. 2015). In addition, various changes have already occurred in terms of the types and levels of incentives offered over time. For example, while Japan used to have a combined policy of subsidies and tax benefits in the form of acquisition and tonnage tax exemptions between 2009 and 2012 (JAMA 2010a), it now only offers purchase subsidies under the Green Vehicle Purchasing Promotion and the Clean Energy Subsidy program (Hao et al. 2014; JAMA 2010b). Therefore, policy strategies should not be considered fixed, since governments adapt them over time.

Moreover, countries such as Brazil, Hong Kong, the Netherlands, Norway, Switzerland, and Taiwan do not offer any national subsidies but different forms of tax benefits. For example, EV owners in Brazil have benefited from a reduction in the Motor Vehicle Property Tax (MVPT) since 2014, the level of which differs between regions within the country (such as a 50% reduction in São Paulo) (Benvenuti et al. 2016; Prefeitura de São Paulo 2015). In the Netherlands, EV owners are exempt from registration and road taxes (50% reduction for PHEVs), although a slow phaseout of fiscal incentives for PHEVs has been announced for the period between 2017 and 2020 (EAFO 2017a; IEA IA-HEV 2013). Other countries offer purchase, registration, and/or annual road-tax exemptions or reductions. In Norway, this greatly affects the price of EVs, since the purchase tax, which is the

same as the country's import tax, equals 25% (EAFO 2017a). Combined with an annual road tax that is reduced to 455 kroner (approximately US\$55) from 2820 or 3290 kroner (approximately US\$344 or US\$400) for conventional vehicles (The Norwegian Tax Administration 2017). This can add up to a total fiscal incentive of approximately US\$25,000 over 10 years.

In addition, some countries have implemented a number of other financial incentives. For example, Brazilian EV purchasers have been exempt from the import duty since 2015 (Benvenuti et al. 2016), and the Russian government has allowed zero tariff on imported EVs since 2014 (Gazeta 2016).

Overall, there are significant differences in the types and levels of monetary measures that governments implemented to promote EV penetration in the 20 studied countries. Table 7.2 shows a more detailed overview of the total values of fiscal incentives.

### 7.2.2.2 Infrastructure Measures

In addition to these financial measures, various governments also provide incentives for developing a charging infrastructure. These incentives come in very different forms and, similar to the monetary measures, may also vary between regions in the same country. For example, Canadian EV owners in British Columbia may receive a reduction of up to CAN\$500 for a residential electric charging station (IEA IA-HEV 2012). In Ontario, there is a 50% purchase and installation incentive of up to CAN\$1000 (IEA IA-HEV 2013). In Québec, individuals may receive up to CAN\$270 for the equipment for charging stations and CAN\$195 for installation (IEA IA-HEV 2016). In the Netherlands, there are also some regional differences between Friesland, which offers a €500 discount on private charging points, and partial subsidies for charging spots in Rotterdam (van der Steen et al. 2015). Similarly, local governments and states in the USA (such as California) provide rebates and tax credits for charging stations (Berman 2017; van der Steen et al. 2015). Other countries, including Belgium, France, Italy, Norway, and the UK, offer nationwide incentives such as tax deductions or subsidies for private charging point installations, public funding, or the free use of charging infrastructure (EAFO 2017a; van der Steen et al. 2015). The relative extent to which countries offer such infrastructure measures is summarized in Table 7.2.

### 7.2.2.3 Traffic Regulations

Traffic regulations are often altered in favor of EV drivers to support the widespread sales of EVs. These regulations include access to high-occupancy-vehicle (HOV) lanes, highways, toll roads, bridges, and ferries in places such as Canada, the USA, and Norway (EAFO 2017a; IEA IA-HEV 2008, 2016). Moreover, EVs are offered free, or reduced-fee, parking in urban areas in Germany, Italy, Korea, Norway, some local areas in the UK, and in certain states in the USA (Berman 2017; EAFO 2017a; IEA IA-HEV 2011, 2016; Kim and Yang 2016). Other

Table 7.2 Data for 20 countries

Country	EVs sold in 2016	Total sales 2016	EV market share 2016 (%)	Monetary measures	Infrastructure measures	Traffic regulation	Charging stations total	Pop. in millions	Chargers per 1 mio. population	Highway km	Chargers per highway km
Australia	1433	927,274	0.15	0	0	0	60	24,642	2.43	1700	0.04
Belgium	9598	539,519	1.78	6500	1	0	1715	11,444	149.86	1763	0.97
Brazil	48	1,676,722	0.00	500	0	0	60	211,243	0.28	11,000	0.01
Canada	10,842	661,088	1.64	6000	1	1	4465	36,626	121.91	16,900	0.26
China	350,578	24,376,902	1.44	6000	0	2	81,000	1,388,233	58.35	97,355	0.83
France	34,205	2,015,177	1.70	7000	1	0	16,000	64,939	246.39	11,392	1.40
Germany	28,079	3,351,607	0.84	4000	0	0.2	24,667	80,636	305.91	12,845	1.92
Hong Kong	1367	41,600	3.29	8000	0	0	1500	7402	202.65	100	15.00
India	1023	2,966,637	0.03	3000	0	0	328	1,342,513	0.24	1208	0.27
Italy	3463	1,824,968	0.19	5000	1	0.5	2205	59,798	36.87	6661	0.33
Japan	23,438	4,146,459	0.57	5000	0	0	40,000	126,045	317.35	7383	5.42
Korea	6108	1,533,813	0.40	5000	0	0.5	1270	50,705	25.05	4044	0.31
Netherlands	23,129	382,825	6.04	20,000	1	0	28,246	17,033	1658.31	2808	10.06
Norway	45,685	154,603	29.55	25,000	2	3	8734	5331	1638.40	664	13.15
Russia	416	1,239,680	0.03	2000	0	0	200	143,375	1.39	1400	0.14
S. Africa	159	361,289	0.04	0	0	0	40	55,436	0.72	1927	0.02
Switzerland	5654	317,318	1.78	5000	0	0	3828	8454	452.80	1361	2.81

(continued)



Table 7.2 (continued)

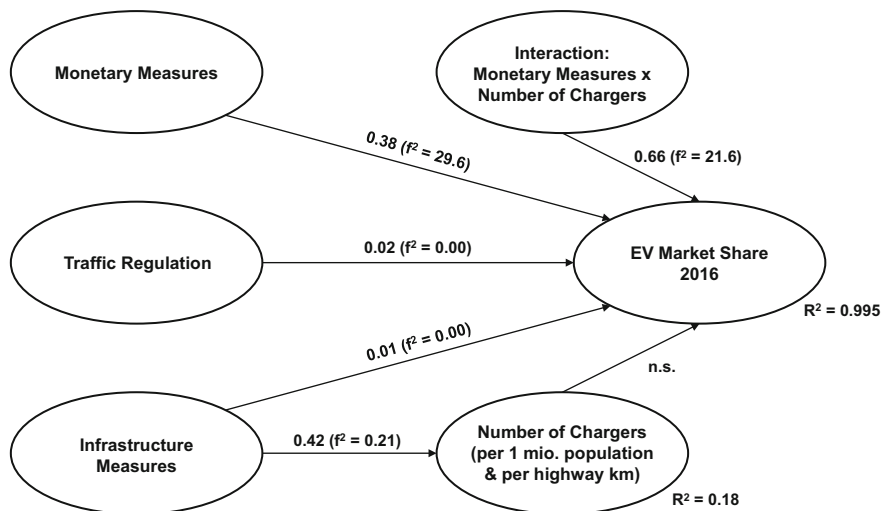
Country	EVs sold in 2016	Total sales 2016	EV market share 2016 (%)	Monetary measures	Infrastructure measures	Traffic regulation	Charging stations total	Pop. in millions	Chargers per 1 mio. population	Highway km	Chargers per highway km
Taiwan	2	206,092	0.00	2000	0	0	360	23,405	15.38	1335	0.27
UK	39,351	2,692,786	1.46	6000	1	1	12,320	65,511	188.06	6016	2.05
USA	158,212	6,872,729	2.30	7500	2	1	42,918	326,474	131.46	75,008	0.57

Sources EV sales (EV-Volumes 2017); total sales (OICA 2017a); monetary measures (Beltramello 2012; Benvenuti et al. 2016; Bundesamt für Energie 2017; EAFO 2017a; Environmental Protection Department 2017; Gazeta 2016; Government of NCT of Delhi 2016; Hao et al. 2014; IEA IA-HEV 2008, 2012, 2013, 2014, 2016; JAMA 2010b; Kim and Yang 2016; Maurer 2014; Mock and Yang 2014; OECD/IEA 2016; Prefeitura de São Paulo 2015; PwC 2016; Rokadiya and Bandivadekar 2016; van der Steen et al. 2015); infrastructure measures (Berman 2017; EAFO 2017a; IEA IA-HEV 2012, 2013, 2016; van der Steen et al. 2015); traffic regulations (Berman 2017; EAFO 2017a; IEA IA-HEV 2008, 2011, 2016; Kim and Yang 2016; OECD/IEA 2016); charging stations (ChargeHub 2017; EAFO 2017a, b; Environmental Protection Department 2017; OECD/IEA 2016; PlugShare 2017); population (Worldometers 2017); highway km (NationMaster 2017)

incentives include free use of bus lanes, such as in Germany and Norway (EAFO 2017a). China has implemented a policy of free, unrestricted number plates for EVs in cities such as Beijing or Shanghai, where it is otherwise very difficult to receive a number plate with a conventional vehicle (OECD/IEA 2016; Zhu et al. 2017). The UK introduced another urban policy in 2013, in which EVs are exempt from the congestion charge in London, which can otherwise cost up to an annual £2000 (EAFO 2017a). Further incentives are also offered at local levels, such as in Korea, the UK, and the USA (Berman 2017; EAFO 2017a; Kim and Yang 2016). Table 7.2 shows the relative levels at which such policies have been implemented in the 20 countries.

#### 7.2.2.4 Influence of Policy Measures on EV Market Shares

In order to determine the effectiveness of policy measures, their influence on EV market shares was calculated. This was done by first adding together all monetary measures for each country, and expressing infrastructure measures and traffic regulations in terms of dummy variables, indicating the existence and relative strength of these measures in a given country. Moreover, the number of chargers, as an indicator for the prevalence of a charging infrastructure, was included in the analysis. Table 7.2 summarizes all of the data. The variables in bold were used for further analysis. Specifically, a structural equation model with partial least squares regression (PLS) was constructed (Fig. 7.1). Due to the relatively small sample size



**Fig. 7.1** Partial least squares (PLS) model. Note  $f^2$ , the Cohen's effect size, indicates the strength of the regression coefficients (0.02 denotes a small effect, 0.15 a midsize effect, and 0.35 a strong effect).  $R^2$ , the coefficient of determination, indicates how much of the variance can be explained in the model

of 20 countries, this analysis reports Cohen's effect size  $f^2$  (Cohen 1988). This measure is independent of sample size (Selya et al. 2012) and represents the change in  $R^2$ , the coefficient of determination, when a given effect is included in the model.

In the base model with monetary measures, traffic regulations, infrastructure measures, and existing charging stations, both monetary incentives and regulation measures have a positive effect on EV market share ( $\beta_{\text{Monetary Measures}} = 0.60$ ;  $f^2 = 0.34$ ;  $\beta_{\text{Traffic Regulation}} = 0.21$ ;  $f^2 = 0.11$ ). Therefore, the higher the incentives that the governments provide, the higher the market share of EVs in the respective countries. Moreover, the effect of infrastructure measures on the EV market share appears to be mediated by the number of charging stations ( $\beta_{\text{Chargers}} = 0.42$ ;  $f^2 = 0.21$ ), which have a positive effect on EV market share ( $\beta_{\text{Infrastructure-Chargers}} = 0.22$ ;  $f^2 = 0.09$ ). Therefore, the higher the incentives for charging infrastructure are, the higher the number of chargers. Altogether, this results in a higher EV market share. Since all three measures show a positive impact on the percentage of EV registrations in 2016, H1 is supported.

Taking monetary measures, traffic regulations, and infrastructure measures with the number of chargers, approximately 89% of the variance in the market share of EVs can be explained by the model ( $R^2 = 0.887$ ). Figure 7.1 depicts a further analysis, which includes an interaction term of the monetary measures and the number of chargers. This interaction effect has a positive influence on the market share of EVs ( $\beta_{\text{Interaction}} = 0.66$ ;  $f^2 = 21.6$ ). The effect is very strong, even to the extent that it suppresses the impacts of traffic regulations, infrastructure, and the direct effect of the number of charging stations. Overall, the effect raises the explained variance in the market share of EVs to almost 100% ( $R^2 = 0.995$ ).

Therefore, the analysis with PLS shows that all policy measures, particularly monetary incentives, have a positive effect on EV market shares. Moreover, monetary measures, in combination with a sufficient charging infrastructure, have an even stronger overall impact on the percentage of EVs in a country. Therefore, H2 is also supported.

As the comparison and analysis of policy measures promoting EV penetration in 20 countries have shown, significant differences exist between countries in terms of the types and levels of available incentives and consumer sales of EVs. Based on this analysis, it is recommended that governments which want to support a more widespread adoption of EVs should do so through a strategy of combined policy measures. In particular, monetary incentives in the form of subsidies or tax benefits may provide an initial stimulus for consumers to consider purchasing an EV rather than a conventional vehicle. However, as Lieven's (2015) consumer study showed, a sufficient charging infrastructure is also a key. Governments should not only focus on short-term incentives but also take a more long-term perspective and provide investments for necessary EV charging networks.

### 7.3 More Successful and Less Successful Governance Systems for EVs

As the previous analysis shows, policy measures have a significant influence on EV market shares. The data in Table 7.2 also highlights the strong differences between countries, in terms of EV incentives and market shares. In particular, the Netherlands (with the second-highest EV market share) and Brazil (with the second-lowest EV market share) showed some considerable differences in the types and levels of incentives that the respective governments implemented. In fact, the Dutch government provides approximately 40 times higher a monetary incentive than does Brazil. In addition, the Netherlands also implemented a number of infrastructure measures, which was not the case in Brazil.

Apart from the policy measures discussed above, there are certainly other factors that influenced the stronger penetration of EVs in the Netherlands and the lower market shares in Brazil. The following case studies will discuss how the governance systems in these two countries supported or hindered a strong EV penetration. In particular, this chapter will consider which actors were involved in this process, and which actions might have contributed to the relative successfulness or unsuccessfulness of EV sales among consumers in the Netherlands and Brazil. The following case studies will show that the two countries offer a valuable comparison, as the Netherlands has taken a variety of proactive measures at the national and local levels to support EV penetration. These have been supported by various stakeholders, which strengthened their effectiveness. Brazil, on the other hand, lacks the necessary support at the country and supranational levels to effectively promote EVs among consumers.

#### 7.3.1 Case Study: The Netherlands

The Netherlands has seen significant growth in its number of EVs over the past several years and become a global leader in EV sales (IEA IA-HEV 2016). In fact, it has the second-highest EV market share worldwide, after Norway (Mock and Yang 2014). Having set a target for 2015 of 15,000 to 20,000 EVs on Dutch roads, this was largely exceeded, with a total of 90,000 EVs by the end of 2015 (IEA IA-HEV 2016). A key reason for this is the high monetary incentive that the government has implemented, as van't Hull and Linnenkamp (2015) highlighted. Results from the previous analysis further support this. According to van't Hull and Linnenkamp (2015), various projects have also been implemented by different cities and regions in the Netherlands, such as offering additional subsidies to meet European air quality targets for 2015. More recently, the 2016–2020 Electric Transport Green Deal was signed by 18 parties, including the central Dutch government, the Formula E Team, and a variety of other market players (Netherlands Enterprise Agency 2017). A central aim of the Green Deal is that 10% of new

passenger cars must have electric power. In addition to various policies and initiatives promoting EVs in the Netherlands, another important driver has been collaboration between various actors, including national, regional, and local governments, and different companies, organizations, and other stakeholders. This will be highlighted further in this case study by first analyzing additional initiatives on top of national policies, and the development of the charging infrastructure in the Netherlands. This case study will then provide an overview of the actors involved in promoting EVs to consumers.

First, it is important to note that there are other policy measures and initiatives in the Netherlands in addition to the national ones. For example, Amsterdam and Utrecht provide fiscal incentives on top of the ones offered by the central government (van der Steen et al. 2015). While this was taken into account to some extent in the previous analysis, local measures provide additional awareness of EV incentives and, most likely, greater willingness for potential buyers to purchase an EV. Further initiatives have started at the local level, such as the MRA-Electric (Amsterdam Metropolitan Area Electric, MRA-E), initiated by local Amsterdam authorities to support the widespread rollout of electro-mobility in the Amsterdam metropolitan area (MRA) (van't Hull and Linnenkamp 2015). In collaboration with the government and the market, this project contributed to developing a charging infrastructure in the area. Moreover, carsharing systems with EVs have significantly expanded over the past several years (IEA IA-HEV 2016). For example, Daimler has set up its car2go system in Amsterdam, with 300 electric Smart Fortwo cars (van't Hull and Linnenkamp 2015). While this does not directly contribute to passenger car sales, it does bring consumers in closer contact with EVs by providing opportunities for firsthand experiences with such vehicles. Initiatives such as this may also indirectly contribute to greater EV purchase. Similarly, introducing large numbers of EVs in airport taxi fleets at Schiphol (van't Hull and Linnenkamp 2015) may have further contributed to growing EV acceptance in the Netherlands. Finally, the Vereniging Elektrische Rijders (VER) initiative is an association for EV drivers, which acts as an information and linking platform for continuous support of electric cars (IEA IA-HEV 2016). Therefore, EV owners also receive non-governmental support and necessary information to ease the adoption process.

In addition, there have been significant improvements in developing charging infrastructure in the Netherlands, which has certainly also contributed to growing EV market shares. For example, the Green Deal, which was signed in 2015, provides governmental support of €5.7 million for developing a national charging infrastructure (IEA IA-HEV 2016). However, approximately 80% of the charging stations were installed beforehand by the E-Laad Foundation, a partnership among Dutch grid operators that provided municipalities with free chargers (Bakker and Trip 2015). All other chargers were primarily installed by larger cities such as Amsterdam, Rotterdam, Utrecht, and The Hague (Bakker and Trip 2015; van't Hull and Linnenkamp 2015). There are also further initiatives by the private sector to support a national charging network. For example, the German retailer Lidl set up fast-charging stations for EVs at a number of its stores, in collaboration with ABB (Netherlands Enterprise Agency 2017). The charging infrastructure in the

Netherlands has expanded over the past several years through initiatives and collaborations of various actors in the public and private sectors.

Indeed, one key factor contributing to growing EV sales in the Netherlands has been the collaboration of many actors that have supported national EV penetration. For example, more than 40 parties signed the National Energy Agreement for Sustainable Growth, which aims to decrease CO<sub>2</sub> emissions in the mobility sector by 17% by 2030, and by 60% by 2050 (EAFO 2017a). Bakker et al. (2014) highlighted the importance of collaborations among various actors to achieve a more widespread adoption of EVs in their study on stakeholder interests, expectations, and strategies in the Netherlands to promote EV penetration. The authors conducted interviews with a variety of stakeholder representatives, including central and local governments, automotive manufacturers and importers, electricity producers, and various others. Findings showed that there is general support by these stakeholders to develop an EV system, even though their individual agendas differ. This is due to strong regulatory pressure on the automotive industry, pushing manufacturers to construct EVs. The various stakeholders took this as an opportunity to engage in EVs from early on and continuously learn from its impacts. Bakker et al. (2014) further note important factors that have contributed to the development of EVs, specifically in the Dutch context. A key reason why EVs have received support from various actors in the Netherlands is that the country does not have major car manufacturers, allowing the government to act more independently than is possible in other countries in which industrial interests are much more prevalent and inhibiting regarding consumer purchase of EVs. Overall, this case shows that the successful adoption of EVs in the Netherlands has been driven by political incentives, non-policy actions, and the country's wider governance system, in which public and private agents collaborate to seize opportunities for developing a national EV system.

### **7.3.2 Case Study: Brazil**

Compared to the Netherlands, the EV system in Brazil is much less developed. EVs make up an insignificant portion of the country's total car fleet to date (Benvenuti et al. 2016). Although there has been some growth over the past several years, Brazil still lags behind other countries, such as China and most developed countries in the world (Li 2016). Latin America generally faces a number of barriers regarding growth in EV penetration, given the lack of incentives, the high cost of EVs, insufficient charging infrastructure, and grid reliability issues (Marchán and Viscidi 2015; Teixeira et al. 2015). Nevertheless, Brazil is a particularly interesting case to investigate, since it offers various possibilities that could be beneficial for EVs. For example, more than 85% of Brazil's electricity is produced from renewable sources, and the country has further committed to reduce greenhouse gas (GHG) emissions in the future (Marchán and Viscidi 2015). Nonetheless, various

factors, particularly institutional barriers (Domingues and Pecorelli-Peres 2013), have inhibited EV sales in Brazil.

As the prior analysis shows, no direct subsidy is offered to Brazilian consumers for EVs (Benvenuti et al. 2016). Furthermore, current incentives are not sufficient for consumers to purchase an EV, due to the many perceived disadvantages of EVs (Marchán and Viscidi 2015). Although federal tax incentives may have slightly stimulated EV adoption, various obstacles still exist.

The high price of EVs in Brazil is one of these key issues inhibiting the more widespread adoption of EVs by consumers. Although tax reductions are in place, they still account for a significant proportion of the purchase price (Baran and Legey 2013; Marchán and Viscidi 2015). For example, a Renault Zoé costs approximately four times more than in France, since the Brazilian government offers no subsidy for EVs and taxes remain high, despite current incentives (Li 2016). Taking into consideration that Brazil's GDP per capita is less than a fourth of that in France (The World Bank 2017), the purchase price of EVs poses a significant, comparatively high barrier in Brazil.

Brazil's insufficient charging infrastructure is another major obstacle to diffusion of EVs. This is particularly an issue since Brazil is geographically large. Cars are often needed to go long distances, which necessitates a range that many EVs do not yet offer (Teixeira et al. 2015). While other countries, especially in Europe, have started to recognize the need to build a charging infrastructure as a means to raise EV penetration, the Brazilian government offers no support for developing such an infrastructure. As Li (2016) noted, this implies that investments in Brazil's charging network currently depend on the private sector. While companies such as CPFL Energia have started setting up charging points for EVs, particularly in the São Paulo area, much improvement is still required for consumers to be willing to pay the high EV purchase price (Li 2016). Greater collaboration is necessary between various actors, including energy companies, city planners, the government, and others, to develop a sufficient charging infrastructure in Brazil.

Moreover, various actors and economic factors still hinder growth of Brazilian EV penetration. In particular, there are strong lobbying groups with an interest in hampering the introduction of EVs in the country. Specifically, ethanol lobbying groups strongly oppose EVs due to concerns that it will lower ethanol consumption (Baran and Legey 2013; Marchán and Viscidi 2015). As a result, the government also has very little interest in promoting EV penetration (Li 2016). This lack of support is further reinforced by the country's current economic situation. Due to Brazil's recession that has been ongoing since 2015, the government does not consider funding for EVs and charging infrastructure to be a priority (Li 2016).

Furthermore, unlike the Netherlands, Brazil is one of the largest automobile producers worldwide (OICA 2017b). Although the Brazilian automobile sector has recently been negatively affected by the economic crisis, production significantly grew, from the 1970s until 2013 to 2014, prior to the downturn. This led to a rise in liquid fuel consumption, from which the Brazilian economy has also greatly benefited (Baran and Legey 2013). Despite the country's plans to reduce GHG emissions, which can be achieved through a stronger EV penetration, the national

interest in EV technology investment is still low because of this (Domingues and Pecorelli-Peres 2013). Therefore, the dominance of the automobile and oil industries in Brazil steers governmental interests to some extent and contributes to the country's slow EV adoption process among consumers.

In contrast to the Netherlands, Brazil faces obstacles caused by various stakeholder interests, and political and economic challenges, all of which hinder more widespread consumer adoption of EVs. While some incentives were put in place by the government, more collaboration between different interest groups is required for consumers and stakeholders to fully understand the potential, economic, and environmental benefits of EVs and support stronger penetration (Marchán and Viscidi 2015). As Domingues and Pecorelli-Peres (2013) state, the government's public policies are very important, especially when combined with a collaborative effort from diverse sectors. Compared to the Netherlands, Brazil certainly faces a number of additional challenges due to its lower level of economic development, and its political and current economic situation. In addition, the level of support for EV penetration at the supranational level also creates quite different political landscapes for the Netherlands in the EU and Brazil in South America. This could cause the Netherlands to be more proactive than Brazil in terms of policy measures. For example, the EU has set mandatory targets to reduce carbon dioxide (CO<sub>2</sub>) emissions from passenger cars. Specifically, EU member countries must ensure that the average emissions level of new cars is 95 grams of CO<sub>2</sub> per kilometer by 2021 (European Commission 2018). This puts a certain amount of pressure on EU countries to proactively implement environmentally beneficial policies. On the other hand, Brazil does not face such supranational pressure, which may further explain the country's lack of support for EV penetration. Overall, the comparison between the Netherlands and Brazil highlights the importance of having a strong governance system in place that facilitates the collaboration between a country's various interest groups to raise EV market shares.

## 7.4 Implications and Conclusion

The comparison of policy measures supporting the penetration of EVs in 20 countries, on five continents, and the subsequent analysis of their impact on EV market shares highlights the importance of governmental incentives in promoting EVs. There are significant differences in the types and levels of incentives that different countries have implemented, as the study's comparative analysis demonstrates. Nonetheless, it can be concluded that monetary measures, infrastructure incentives, and traffic regulations all have a positive influence on EV market shares. In particular, monetary measures and strong support for developing a charging infrastructure have been proven effective. These results also support Lieven's (2015) finding that consumers appreciate financial incentives, but that sufficient charging networks are must-haves for individuals to be willing to purchase an EV.



Moreover, an analysis of successful and less successful governance systems for EVs, based on the case studies of the Netherlands and Brazil, further emphasizes the importance of having a collaborative system in place that supports EV penetration. Although governmental incentives can be very effective, substantial obstacles may arise if other key stakeholders do not contribute to, or strongly oppose, the adoption of EVs. For example, one of the key issues inhibiting widespread EV sales in Brazil is the dominance of the automotive industry and lobbying groups, which use their power to hinder EV implementation.

This implies that, while policy measures such as monetary incentives and infrastructure investments are important in promoting EVs, governments wishing to raise the EV market should also create a collaborative system and take further initiatives, such as establishing informative platforms about EVs or starting charging infrastructure projects. The Brazilian government should attempt to work with the automotive industry and lobbying groups that are opposed to EVs, rather than formulating policies that support these groups' interests. This requires a long-term perspective and strategic outlook, especially in times of economic downturns. Moreover, it is essential for key stakeholders, such as national and local authorities, automobile producers, importers, electricity producers, grid operators, and various others, to set common goals and work together to achieve them.

In addition to implementing measures such as financial incentives to strengthen EV market shares, governments may also find it effective to take general measures in support of electric mobility, as high EV market shares do not necessarily imply that electric mobility is also high. In fact, EV penetration merely indicates how many EVs are sold, but not how many people actually use electric cars. Governments may take further measures to raise their country's electric mobility. This includes, for instance, supporting carsharing projects with EVs, similar to Daimler's car2go system in Amsterdam (van't Hull and Linnenkamp 2015). Aside from promoting electric mobility more generally, this may also allow consumers who are not yet willing to purchase an EV to gain firsthand experiences and overcome potential barriers such as range anxiety. Ultimately, such projects may also lead to greater EV penetration over time.

Overall, this research provides important implications for both the public and private sectors. Nonetheless, there are also a number of limitations that should be taken into account for future research in this area. For example, the small sample size of 20 countries can be seen as problematic. Given the large quantity of data that was gathered for each country, the number of cases was nonetheless considered sufficient here. In addition, the potential sample-size issue was taken into account by calculating Cohen's effect size, which was independent of sample size, instead of  $t$  values in the structural equation model.

Moreover, this research only made a general distinction between monetary measures, traffic regulations, and infrastructure measures. As the comparative analysis of the 20 countries shows, various differences exist in the exact types of incentives that governments have implemented. Future research should investigate in detail which types of policy measures are the most influential for promoting EV penetration. In particular, having found that monetary measures and charging

infrastructure investments are the most effective incentives, focusing on these measures in future research may be a good means to produce findings that are even more actionable.

Finally, it is important to take into account that this research only represents a snapshot of the current EV market, using data from 2016. Since governmental incentives and the market itself have changed significantly over the past several years and are likely to continue to develop in the future, it is important to track these changes over time and continuously reconsider the current findings in light of these developments. In this way, it will be possible to provide valuable recommendations for the promotion of EVs among consumers over time.

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