BBVA RESEARCH

Economic Watch

EAGLEs

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Economic Analysis

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Emerging markets key for the automobile sector

A BBVA Research model for long-term automobile projections

- **Emerging and Growth-Leading Economies (EAGLEs)[1] will concentrate three quarters of the new Car Fleet**

  We expect the world car fleet to increase by 348mn between 2010 and 2020[2]. It is a larger growth than in previous decades and it is increasingly concentrated in emerging economies. EAGLEs will add 253mn and Nest countries 35mn compared with 31mn in the G7 countries. China will clearly dominate in absolute terms, contributing with a half of global growth in car fleet, followed by Latin America and India, where the increase in the number of autos widely exceed those in the G6 countries.

- **Car Fleet growth in emerging markets driven by higher purchasing power rather than demography**

  According to BBVA Research Model, high income growth, sustained over the medium term, will be boosting car demand in emerging economies during the current century. In Latin America, Turkey and the rest of Asia, demographics will also be a relevant factor. On the contrary developed markets are already at saturation levels both because of income per capita and demographic reasons with the exception of the US. Sales in these countries hang on car fleet depreciation and scrapping programs, waiting for a technological shock.

- **China is – and will continue to be- the most important player for the car industry during this decade**

  In 2000 the number of cars in China was lower than in Poland with a population 33 times higher. We now expect the Chinese car fleet to almost quadruple this decade and become the world largest due to the increase in car ownership. Brazil will reach Japan's size and Russia and India will get close, leaving behind the rest of G6 countries. Mexico will overtake Spain.

- **The boom in automobile ownership will continue for many years given the very low starting level**

  Average car ownership in emerging economies is 120 units per 1,000 people compared to around 500 units in developed markets. Considering population size and lower ownership ratios, potential is enormous in Asia. Latam, Russia and Turkey are more advanced in the demand curve but still in the high growth area.

- **High growth in car fleet will have positive spill-overs on other activities, such as road transportation, energy and finance will offer business opportunities**

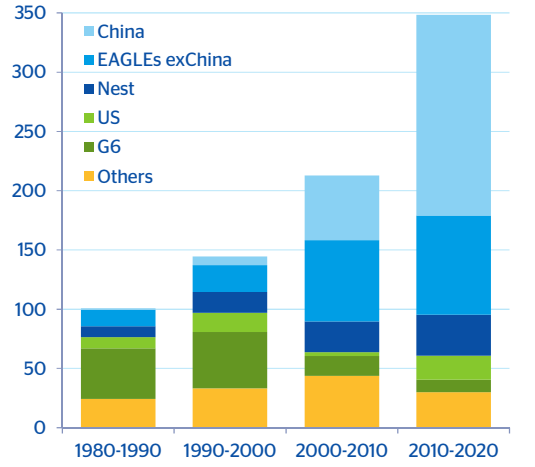
  New cars require building roads, improving road-safety, managing increasing traffic density and securing energy supply. At present transport is very oil-intensive, so we anticipate high demand pressure on this market and a further relative shift to Asia. On the business side, opportunities are present beyond auto makers and related activities. Higher car ownership entails a potential for automobile finance and insurance.

[1] Read more about the EAGLEs and Nest countries at http://www.bbvaresearch.com/KETD/ketd/ing/nav/geograficas/eagles/index.jsp
[2] The definition of car fleet doesn´t include light trucks for personal use, which are quite relevant in some cases. Among the largest markets we find the US, with a 50% share in total light vehicle retail sales.

Auto boom is already underway in the EAGLEs leaded by China this decade

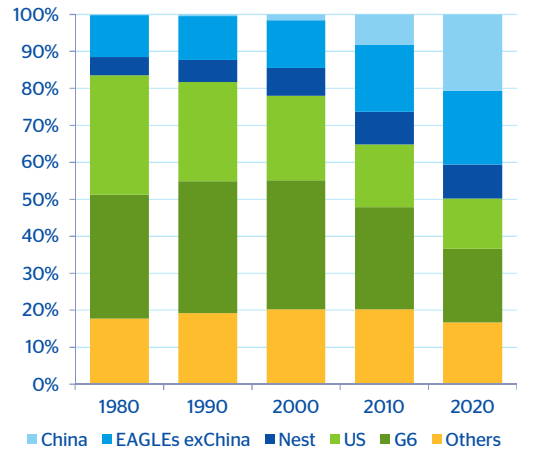
The number of drivers is quickly increasing in emerging economies, especially in low-income countries with large populations and persistent high economic growth. Under a more stable macro environment and leaving behind successive crisis, the car fleet of the EAGLEs accelerated its growth since the start of the current century. The change in the stock quadrupled and the number of cars more than doubled in one decade, leaded by China, Brazil and Russia. At the same time, car demand in developed markets started to lose momentum and it has fallen significantly due to the crisis[3]. At BBVA Research we have developed a long run panel data model to assess for changes in Car Ownership and fleet as a function of GDP per capita, urbanization, population density, financial deepening and road quality (see appendix for details).

Chart 1
Increase of world car fleet by decades (mn)



Source: BBVA Research

Chart 2
Distribution of world car fleet by decades (%)



Source: BBVA Research

According to projections from our model, we expect a reinforcement of this leading role of emerging economies in the auto market (Charts 1 to 6):

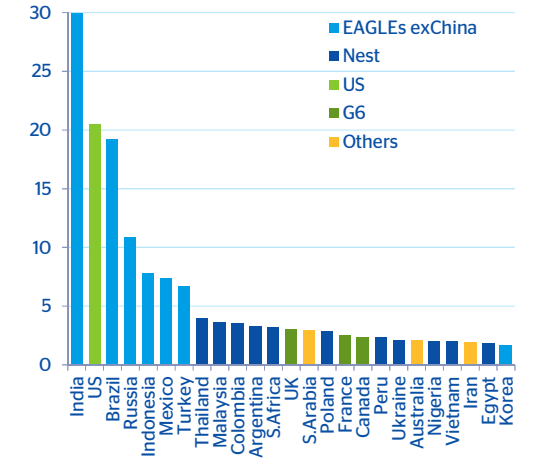
- The car fleet in the EAGLEs will more than double again this decade. The number of cars will reach more than 450mn units, widely exceeding those in the G7 countries. This will be the result of stock growing by more than 25mn cars per year. China will make the difference, accelerating growth to 17mn per year from less than 6m between 2000 and 2010. The car fleet will also increase faster in Indonesia, Turkey, Brazil and especially India. The change in stock may moderate somewhat in markets where car ownership is above average, like Korea, Russia and Mexico.
- The Nest countries will add 35mn autos to their car fleet this decade, reaching more than 100mn cars in 2020. The largest acceleration in stock growth will be recorded in Colombia, Philippines, Thailand, South Africa and Peru. On the other hand, Poland and Malaysia will expand their car fleet at a softer pace. These two countries have the highest ownership ratio and therefore face a lower elasticity to purchasing power.
- Among the G7 countries, the US will be the only one showing a recovery after the crisis with help of both income and population growth. On the contrary, the G6 members will

[3] A significant fall in demand is not fully accounted in car fleet variations. As explained in the methodology annex, elasticity to income per capita varies considerable in upturns and downturns. Furthermore, scrapping programs, like the ones implemented during the crisis, just substitute the stock but they don´t change it. In the case of emerging markets, where the car fleet is much younger, its change can be used as a proxy for gross sales with much less error.

likely extend their weak sales on subdued growth outlook and population contributing negatively in some countries[4].

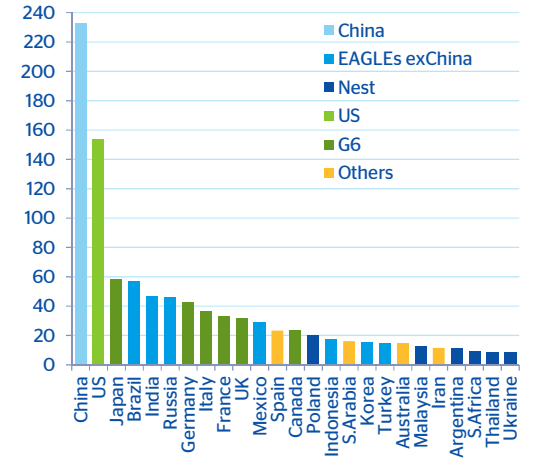
As a consequence of more dynamic auto stock building in emerging markets, shares of the world car fleet are changing quickly (Chart 2). The G7 economies accounted for around a 60% between 1980 and 2000, while the EAGLEs and Nest countries for a 20%. This picture started to change dramatically since the start of the current century. We expect the G7 countries to lose market share below a 40% by 2020 and EAGLEs and Nest countries to surpass this figure and increase it up to a 50%. China explains two thirds of this change.

Chart 3
Expected increase of car fleet in largest markets exChina between 2010 and 2020 (mn)



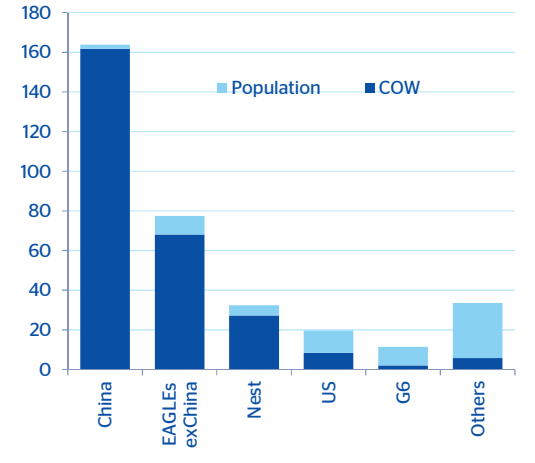
Source: BBVA Research

Chart 4
Car fleet of largest markets in 2020 (mn)



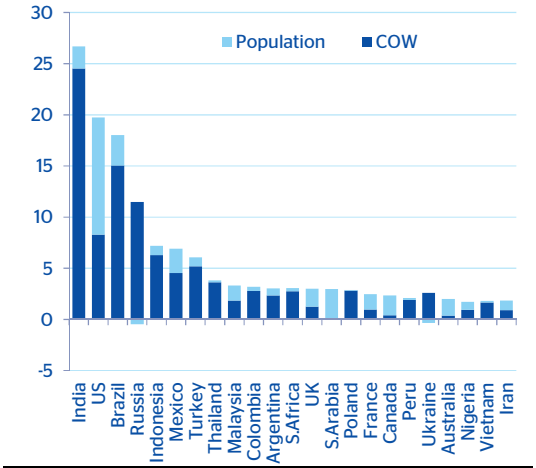
Source: BBVA Research

Chart 5
Expected increase of world car fleet between 2010 and 2020 by determinant (mn) (COW = car ownership)



Source: BBVA Research

Chart 6
Increase of car fleet in largest markets exChina between 2010 and 2020 by determinant (mn) (COW = car ownership)



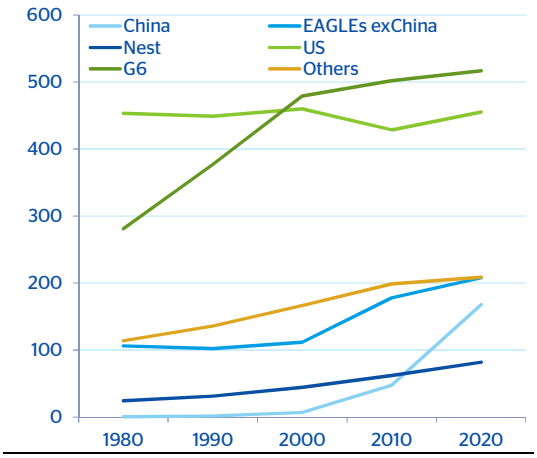
Source: BBVA Research

[4] Some other interesting factors are cited in this article by The Economist: http://www.economist.com/node/21563280

Potential is not exhausted as room for convergence is still huge

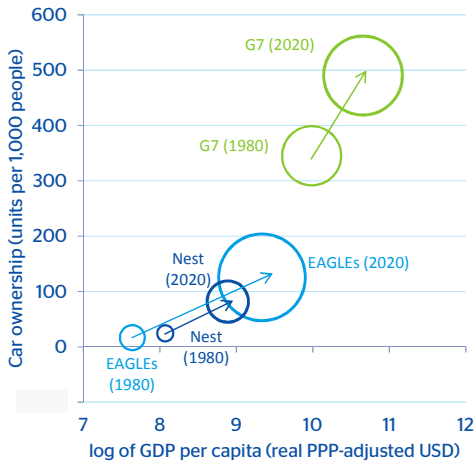
Growth in income per capita is pushing up car ownership in emerging markets, but levels are still far below those in developed markets. G7 economies are around 500 units per 1,000 people, while the average for EAGLEs and Nest is of 120 units (Chart 7). However, this aggregate figure hides a very heterogeneous situation (Chart 8). Variance is very relevant as a different elasticity applies for each level of income (Map 1) and population is obviously the key to determine absolute numbers.

Chart 7
Car ownership (units per 1,000 people)



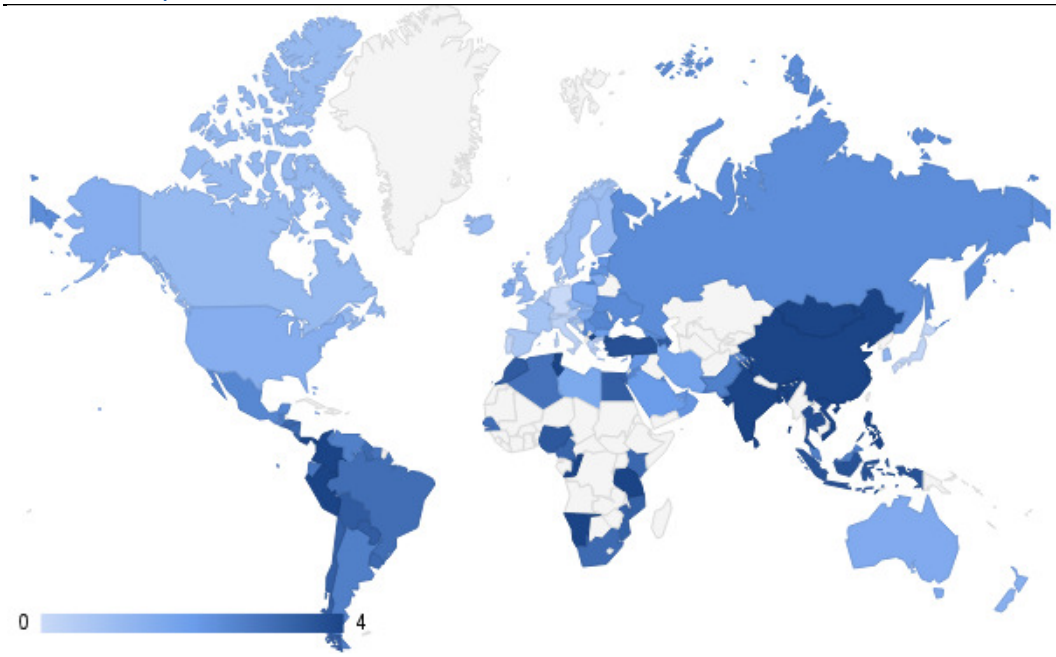
Source: BBVA Research

Chart 8
Income per capita (PPP-adjusted USD) and car ownership (units per 1,000 people) in 1980 and 2020 (bubble size is proportional to car fleet)



Source: BBVA Research

Map 1.
World markets according to annual growth of the car fleet between 2010 and 2020 (0=minimum up to 1%, 1=1-2%, 2=2-4%, 3=4-7%, 4=above 7%)



Source: BBVA Research

We can group emerging economies according to their market growth potential, which is defined by the elasticity of car ownership to changes in income per capita[5]. Using as a reference the long-term income[6] results are summarized in Table 1. We highlight that Asian countries are close to or in the explosive area. They are also very largely populated countries, making therefore larger their potential demand. Turkey and Latin American economies lie as well on high-growth areas. On the contrary, Poland and Korea are the most mature markets with car ownership ratios close to developed standards.

Table 1.
Potential for car ownership expansion according to long-term income per capita

Growth Area	Long-term income per capita (in real PPP-adjusted USD)		Sensitivity of car ownership to income per capita*		Countries and Groups
	From...	...to	From...	...to	
Accelerating Growth	1,100	4,600	1	2.5	Bangladesh, Pakistan, Nigeria, Vietnam, Philippines, India
Explosive Growth	4,600	12,500	2.5	3.1 (max)	Indonesia, Egypt, Ukraine, Thailand, Colombia, China, S.Africa, Peru, Brazil
Strong Growth	12,500	15.800	1.75	2.5	Turkey, Mexico
Growth	15.800	19,900	1	1.75	Malaysia, Chile, Russia, Argentina
Moderate Growth	19,900	24,400	0.5	1	Poland
Saturation	24,400	+	min»0	0.5	Korea, G7

**Change of car ownership (units per 1,000 people) to a change of 100 USD in income per capita*
Source: BBVA Research

Economic challenges are big but business opportunities too

The expansion of the car fleet is bringing very relevant challenges for emerging economies:

- One of the implications of the increasing car fleet is the urgency for infrastructure improvement. The average density of the road network in emerging economies is around a third of the one in G7 countries with 40km and 150km per 100km^2 respectively. The use ratio is also lower but the gap is not so large, with an average of 30 cars per km of road in emerging countries and 40/km for developed economies. Thus, saturation and potential bottlenecks are a serious possibility[7]. Among the EAGLEs, Mexico would be facing the most stressful situation as the road network is not very extensive and the use ratio is above average. Traffic congestion is already a problem in Korea as it presents a road density comparable to developed standards and one of the highest use ratios in the world (more than 100/km). Urban traffic management is also a headache at present in many capitals in emerging economies[8]. In terms of quality, the average of paved roads is around 60% in emerging economies in comparison with close to a 90% in the G7 countries. Among the EAGLEs, Turkey has the highest ratio around developed standards, followed by Russia and Korea (80%). Indonesia, India, China and Mexico have the lowest readings (40-60%).

- The increasing number of autos in the world is entailing a significant challenge for energy demand. Road sector energy consumption per capita in emerging markets is now about a fourth than in developed economies. Considering the ongoing converging process and the amount of population living in the emerging world, the forecast is not to fail if technology doesn´t boost efficiency. In fact China and India, the most populated countries on earth, present at the same time very low energy consumption ratios. According to a recent International Energy Agency report "without strong new policies, road transport sector fuel use will double between 2010 and 2050"[9] and our own estimations point that energy consumed in the transport sector will increase by a 50% during this decade[10]. At present,

[5] A different elasticity stems from the shape of the curve relating income per capita and car ownership; i.e. the Gompertz curve, which is explained with detail in the methodology annex.
[6] A 15-year moving average of income per capita is the key variable for defining car ownership developments.
[7] In fact, our model estimations show that the saturation level of each country also depends on the quality of infrastructure level and thus, improvements in this field may further boost the growth of the car fleet in emerging markets.
[8] Beijing, Sao Paulo, Bangkok, Moscow, Mexico City, Mumbai, Manila, Seoul, Lagos, Jakarta, Caracas and Cairo are usually cited in rankings referred to the most traffic congested cities in the world.
[9] "Technology Road Map, Fuel Economy of Road Vehicles", IEA (2012): http://iea.org/publications/freepublications/publication/FuelEconomy_2012_FINAL_WEB-1.pdf
[10] We estimate a linear function between log values of GDP per capita in PPP-adjusted USD and log values of the per capita energy consumption in transport.

energy used in transport is more oil intensive than in other sectors (90% and 25% respectively). Thus, in absence of a significant technological progress in the short term, oil prices will continue under pressure.

On the opportunity side, we find relevant implications beyond the auto sector, related activities and FDI&trade flows. The opportunities stems from coping the challenges:

- Road infrastructure needs in developing economies are estimated at around USD 7-8tn until 2030[11] and they require diverse sources of finance, such as Public-Private Partnerships (PPP) or pension funds. Additionally, city traffic congestion may bring a shift in urban planning, requiring the development of extensive public transport systems. On energy demand, both increasing transport efficiency and the development of electric and hybrid vehicles have been identified as key opportunity areas[12]. In this sense, the IEA (2012) warns that "although many fuel-saving technologies are already commercially available and cost-effective, particularly when considered over the lifetime of vehicles, their market penetration is often low because of a range of barriers".

- In the financial sector, consumer credit and car insurance are the areas with more potential. At present financial deepening is low in most emerging economies and a sustained auto demand should boost this finance segment[13]. This potential should be higher if social welfare is extended and precautionary and retirement savings abate.

- On the fiscal side, a strong auto demand, both trough new stock and replacement on depreciation, could help to increase usually low tax collection in emerging economies. As informality is high, registration of new cars would be then the key item, being also collection easier and less costly than taxation on income. Two other potential sources of fiscal revenues are the removal of oil subsidies and road tolls. All these additional fiscal revenues could help to finance road infrastructures.

[11] The following are the commonly cited references on this issue: "Strategic Transport Infrastructure Needs to 2030", OECD (2012) and Booz Allen Hamilton, *Strategy & Business*, no. 46, 2007.
[12] "Mobilizing for a resource revolution", McKinsey Quarterly, January 2012: http://www.mckinseyquarterly.com/Strategy/Strategic_Thinking/Mobilizing_for_a_resource_revolution_2908
[13] In addition to this demand factor, our model shows that improvements in the level of financial deepening could reinforce the increase of car ownership in emerging countries.

Annex: data by country and aggregates

		COW (units per 1000 people)					Population (mn)					Car fleet (mn)					Change in car fleet (mn)				Annual change in car fleet (%)			
		1980	1990	2000	2010	2020	1980	1990	2000	2010	2020	1980	1990	2000	2010	2020	1980-1990	1990-2000	2000-2010	2010-2020	1980-1990	1990-2000	2000-2010	2010-2020
EAGLEs	Brazil	88,5	101,2	114,8	191,8	268,9	121,7	149,7	174,4	194,9	210,4	10,8	15,1	20,0	37,4	56,6	4,4	4,9	17,4	19,2	3,5	2,8	6,4	4,2
	China	0,6	1,6	7,0	47,3	167,9	983,2	1145,2	1269,1	1341,3	1387,8	0,6	1,9	8,9	63,5	233,0	1,3	7,1	54,6	169,5	13,0	17,0	21,7	13,9
	India	1,5	3,1	5,8	13,4	33,4	700,1	873,8	1053,9	1224,6	1386,9	1,1	2,7	6,1	16,4	46,3	1,6	3,5	10,2	29,9	9,8	8,6	10,3	11,0
	Indonesia	4,2	7,1	14,2	40,6	66,7	150,8	184,3	213,4	239,9	262,6	0,6	1,3	3,0	9,7	17,5	0,7	1,7	6,7	7,8	7,5	8,8	12,3	6,1
	Korea	6,7	48,3	175,8	284,6	309,0	37,5	43,0	46,0	48,2	49,8	0,2	2,1	8,1	13,7	15,4	1,8	6,0	5,6	1,7	23,6	14,6	5,4	1,2
	Mexico	57,4	81,1	109,9	189,4	229,4	68,8	84,3	100,0	113,4	125,9	3,9	6,8	11,0	21,5	28,9	2,9	4,1	10,5	7,4	5,6	4,9	6,9	3,0
	Russia	N/A	N/A	139,7	244,0	324,3	138,7	148,2	146,8	143,0	141,0	N/A	N/A	20,5	34,9	45,7	N/A	N/A	14,4	10,9	N/A	N/A	5,5	2,7
	Turkey	16,8	30,5	69,5	110,5	181,8	44,1	54,1	63,6	72,8	80,8	0,7	1,6	4,4	8,0	14,7	0,9	2,8	3,6	6,6	8,3	10,4	6,2	6,2
Nest	Argentina	106,8	131,2	145,9	201,2	259,2	28,1	32,6	36,9	40,4	43,9	3,0	4,3	5,4	8,1	11,4	1,3	1,1	2,7	3,2	3,6	2,3	4,2	3,4
	Bangladesh	0,2	0,4	0,7	2,3	4,0	80,6	105,3	129,6	148,7	167,3	0,0	0,0	0,1	0,3	0,7	0,0	0,0	0,3	0,3	13,3	7,4	15,0	6,8
	Chile	40,2	53,8	86,5	131,1	200,4	11,2	13,2	15,4	17,1	18,5	0,4	0,7	1,3	2,2	3,7	0,3	0,6	0,9	1,5	4,7	6,5	5,3	5,2
	Colombia	18,2	31,2	49,0	67,5	127,8	26,9	33,2	39,8	46,3	52,2	0,5	1,0	1,9	3,1	6,7	0,5	0,9	1,2	3,5	7,8	6,5	4,8	7,9
	Egypt	9,5	18,5	25,1	33,9	48,3	45,0	56,8	67,6	81,1	94,8	0,4	1,1	1,7	2,7	4,6	0,6	0,6	1,0	1,8	9,4	4,9	4,9	5,2
	Malaysia	120,7	111,8	195,1	327,1	391,8	13,8	18,2	23,4	28,4	33,0	1,7	2,0	4,6	9,3	12,9	0,4	2,5	4,7	3,6	2,0	8,4	7,4	3,4
	Nigeria	N/A	0,6	8,6	17,2	23,2	75,5	97,6	123,7	158,4	203,9	N/A	0,1	1,1	2,7	4,7	N/A	1,0	1,7	2,0	N/A	33,6	9,9	5,7
	Pakistan	2,5	5,0	7,4	10,5	12,2	80,5	111,8	144,5	173,6	205,4	0,2	0,6	1,1	1,8	2,5	0,4	0,5	0,8	0,7	10,9	6,7	5,5	3,3
	Peru	17,9	17,0	27,7	54,2	119,9	17,3	21,7	25,9	29,1	32,4	0,3	0,4	0,7	1,6	3,9	0,1	0,3	0,9	2,3	1,7	6,9	8,2	9,5
	Philippines	14,4	17,4	27,9	14,5	24,8	47,1	61,6	77,3	93,3	109,7	0,7	1,1	2,2	1,3	2,7	0,4	1,1	-0,8	1,4	4,7	7,3	-4,6	7,3
	Poland	67,0	138,2	260,8	440,3	514,5	35,6	38,1	38,3	38,3	38,4	2,4	5,3	10,0	16,9	19,7	2,9	4,7	6,9	2,9	8,2	6,6	5,4	1,6
	S.Africa	82,8	97,8	93,2	116,7	171,8	29,1	36,8	44,8	50,1	52,6	2,4	3,6	4,2	5,9	9,0	1,2	0,6	1,7	3,2	4,1	1,5	3,4	4,4
	Thailand	9,5	21,4	42,2	68,4	120,9	47,5	57,1	63,2	69,1	72,1	0,5	1,2	2,7	4,7	8,7	0,8	1,4	2,1	4,0	10,4	8,1	5,9	6,3
	Ukraine	35,6	65,1	107,4	144,3	201,3	50,0	51,6	48,9	45,4	43,0	1,8	3,4	5,3	6,6	8,7	1,6	1,9	1,3	2,1	6,6	4,6	2,2	2,8
	Vietnam	6,2	3,6	6,1	16,5	35,4	54,0	67,1	78,8	87,8	96,4	0,3	0,2	0,5	1,4	3,4	-0,1	0,2	1,0	2,0	-3,1	7,0	11,7	8,9
G7	Canada	418,3	455,7	549,8	613,8	625,8	24,5	27,7	30,7	34,0	37,2	10,3	12,6	16,9	20,9	23,3	2,4	4,2	4,0	2,4	2,1	2,9	2,2	1,1
	France	355,1	415,3	475,2	491,0	506,4	53,9	56,7	59,0	62,8	65,9	19,1	23,5	28,1	30,8	33,4	4,4	4,5	2,8	2,5	2,1	1,8	0,9	0,8
	Germany	296,2	387,9	520,2	512,1	523,2	78,3	79,1	82,3	82,3	81,0	23,2	30,7	42,8	42,1	42,4	7,5	12,2	-0,7	0,2	2,8	3,4	-0,2	0,1
	Italy	302,4	482,4	571,8	582,9	592,9	56,2	56,8	57,0	60,6	61,3	17,0	27,4	32,6	35,3	36,3	10,4	5,2	2,7	1,0	4,9	1,7	0,8	0,3
	Japan	198,4	285,7	419,5	451,9	467,0	115,9	122,3	125,7	126,5	124,8	23,0	34,9	52,7	57,2	58,3	11,9	17,8	4,4	1,1	4,3	4,2	0,8	0,2
	United Kingdom	277,4	375,5	425,8	462,3	482,5	56,3	57,2	58,9	62,0	65,8	15,6	21,5	25,1	28,7	31,7	5,9	3,6	3,6	3,1	3,2	1,6	1,4	1,0
	United States	453,3	449,0	459,9	428,5	455,3	229,8	253,3	282,5	310,4	337,1	104,2	113,8	129,9	133,0	153,5	9,6	16,2	3,1	20,5	0,9	1,3	0,2	1,4
Other developed and emerging markets	Algeria	40,8	58,0	55,4	76,4	99,5	18,8	25,3	30,5	35,5	40,2	0,8	1,5	1,7	2,7	4,0	0,7	0,2	1,0	1,3	6,7	1,4	4,8	4,0
	Armenia	N/A	N/A	74,9	87,7	112,5	3,1	3,5	3,1	3,1	3,1	N/A	N/A	0,2	0,3	0,4	N/A	0,0	0,0	0,1	N/A	N/A	1,6	2,7
	Australia	394,4	448,8	509,3	551,5	568,0	14,7	17,1	19,2	22,3	25,2	5,8	7,7	9,8	12,3	14,3	1,9	2,1	2,5	2,1	2,8	2,4	2,3	1,6
	Austria	297,7	389,9	511,8	519,5	531,7	7,5	7,7	8,0	8,4	8,5	2,2	3,0	4,1	4,4	4,5	0,7	1,1	0,3	0,2	2,9	3,2	0,6	0,4
	Azerbaijan	23,9	36,1	40,9	79,2	121,0	6,2	7,2	8,1	9,2	10,2	0,1	0,3	0,3	0,7	1,2	0,1	0,1	0,4	0,5	5,9	2,5	8,2	5,5
	Belgium	336,6	383,5	459,4	483,7	501,0	9,8	9,9	10,2	10,7	11,0	3,3	3,8	4,7	5,2	5,5	0,5	0,9	0,5	0,3	1,4	2,1	1,0	0,6
	Bolivia	2,6	17,9	28,2	41,9	61,3	5,4	6,7	8,3	9,9	11,6	0,0	0,1	0,2	0,4	0,7	0,1	0,1	0,2	0,3	23,8	7,0	5,9	5,5
	Bulgaria	92,1	149,3	248,9	342,5	446,2	8,9	8,8	8,0	7,5	7,0	0,8	1,3	2,0	2,6	3,1	0,5	0,7	0,6	0,6	4,9	4,2	2,6	2,0
	Cameroon	5,6	8,7	7,4	10,5	13,7	9,1	12,2	15,7	19,6	24,1	0,1	0,1	0,1	0,2	0,3	0,1	0,0	0,1	0,1	7,6	0,9	5,9	4,9
	Congo	11,1	10,9	9,6	N/A	N/A	1,8	2,4	3,1	4,0	5,0	0,0	0,0	0,0	N/A	N/A	0,0	0,0	N/A	N/A	2,7	1,4	N/A	N/A
	Costa Rica	37,6	55,0	87,3	140,9	209,1	2,3	3,1	3,9	4,7	5,3	0,1	0,2	0,3	0,7	1,1	0,1	0,2	0,3	0,4	6,7	7,3	6,7	5,3
	Croatia	133,4	176,0	249,7	350,8	386,9	4,4	4,5	4,5	4,4	4,3	0,6	0,8	1,1	1,5	1,7	0,2	0,3	0,4	0,1	3,1	3,5	3,2	0,8
	Cyprus	134,2	233,5	284,1	432,2	436,5	0,7	0,8	0,9	1,1	1,2	0,1	0,2	0,3	0,5	0,5	0,1	0,1	0,2	0,1	6,9	4,1	5,9	1,1
	Czech Republic	169,4	229,8	335,8	427,6	471,0	10,3	10,3	10,2	10,5	10,7	1,7	2,4	3,4	4,5	5,1	0,6	1,1	1,0	0,6	3,1	3,8	2,7	1,2
	Denmark	271,3	309,3	347,2	367,4	383,0	5,1	5,1	5,3	5,6	5,7	1,4	1,6	1,9	2,0	2,2	0,2	0,3	0,2	0,2	1,4	1,5	1,0	0,7
	Dominican Rep.	16,2	20,6	53,1	90,9	124,6	5,8	7,2	8,6	9,9	11,1	0,1	0,1	0,5	0,9	1,4	0,1	0,3	0,4	0,5	4,6	11,9	7,1	4,4
	Ecuador	8,2	16,2	27,2	41,5	53,4	8,0	10,3	12,3	14,5	16,4	0,1	0,2	0,3	0,6	0,9	0,1	0,2	0,3	0,3	9,8	7,3	6,0	3,8
	El Salvador	21,5	13,4	34,2	49,2	70,7	4,7	5,3	5,9	6,2	6,6	0,1	0,1	0,2	0,3	0,5	0,0	0,1	0,1	0,2	-3,3	11,0	4,1	4,4
	Estonia	85,6	154,4	338,5	400,8	503,4	1,5	1,6	1,4	1,3	1,3	0,1	0,2	0,5	0,5	0,7	0,1	0,2	0,1	0,1	6,7	6,7	1,5	2,2
	Finland	256,5	388,9	412,7	452,7	485,2	4,8	5,0	5,2	5,4	5,5	1,2	1,9	2,1	2,4	2,7	0,7	0,2	0,3	0,3	4,7	1,0	1,3	1,0
	Georgia	51,5	88,3	51,6	131,1	182,9	5,1	5,5	4,7	4,4	4,1	0,3	0,5	0,2	0,6	0,7	0,2	-0,2	0,3	0,2	6,3	-6,5	8,8	2,7
	Greece	89,1	170,9	290,8	457,3	467,7	9,6	10,2	11,0	11,4	11,6	0,9	1,7	3,2	5,2	5,4	0,9	1,5	2,0	0,2	7,3	6,3	5,0	0,4
	Guatemala	34,8	33,4	33,7	37,3	40,8	7,0	8,9	11,2	14,4	18,4	0,2	0,3	0,4	0,5	0,7	0,1	0,1	0,2	0,2	2,0	2,4	3,5	3,4
	Guyana	41,4	33,1	43,6	63,1	96,0	0,8	0,7	0,7	0,8	0,8	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	-2,9	2,9	4,1	4,5
	Honduras	10,2	11,0	10,6	27,8	36,5	3,6	4,9	6,2	7,6	9,2	0,0	0,1	0,1	0,2	0,3	0,0	0,0	0,1	0,1	3,8	2,1	12,3	4,7
	Hungary	94,7	187,5	231,6	302,5	361,2	10,7	10,4	10,2	10,0	9,8	1,0	1,9	2,4	3,0	3,5	0,9	0,4	0,7	0,5	6,7	2,0	2,5	1,6
	Iceland	376,9	471,0	565,4	635,3	630,5	0,2	0,3	0,3	0,3	0,4	0,1	0,1	0,2	0,2	0,2	0,0	0,0	0,0	0,0	3,4	2,9	2,5	1,0
	Iran	57,5	58,7	76,7	129,5	142,0	38,6	54,9	65,3	74,0	81,0	2,2	3,2	5,0	9,6	11,5	1,0	1,8	4,6	1,9	3,8	4,5	6,7	1,8
	Ireland	215,9	227,4	350,7	425,1	443,3	3,4	3,5	3,8	4,5	5,0	0,7	0,8	1,3	1,9	2,2	0,1	0,5	0,6	0,3	0,8	5,2	3,6	1,5
	Israel	110,8	180,5	236,4	289,8	299,9	3,7	4,5	6,0	7,4	8,7	0,4	0,8	1,4	2,1	2,6	0,4	0,6	0,7	0,4	6,9	5,8	4,2	1,9
	Jamaica	36,0	58,2	99,6	138,7	148,2	2,1	2,4	2,6	2,7	2,8	0,1	0,1	0,3	0,4	0,4	0,1	0,1	0,1	0,0	6,0	6,5	4,0	1,0
	Jordan	34,8	50,4	53,0	112,9	128,3	2,3	3,4	4,8	6,2	7,4	0,1	0,2	0,3	0,7	0,9	0,1	0,1	0,4	0,2	8,0	4,1	10,6	3,1
	Kenya	7,0	6,7	7,8	13,2	16,0	16,3	23,4	31,3	40,5	52,6	0,1	0,2	0,2	0,5	0,8	0,0	0,1	0,3	0,3	3,3	4,5	8,1	4,6
	Kuwait	260,4	228,0	319,5	399,1	436,2	1,4	2,1	1,9	2,7	3,4	0,4	0,5	0,6	1,1	1,5	0,1	0,1	0,5	0,4	2,9	2,7	5,8	3,1
	Latvia	66,1	106,2	233,6	394,9	519,8	2,5	2,7	2,4	2,3	2,2	0,2	0,3	0,6	0,9	1,1	0,1	0,3	0,3	0,2	5,5	7,0	4,8	2,4
	Lebanon	346,5	301,2	366,4	424,4	470,1	2,8	2,9	3,7	4,2	4,5	1,0	0,9	1,4	1,8	2,1	-0,1	0,5	0,4	0,3	-0,9	4,4	2,7	1,7
	Libya	139,4	103,4	105,1	218,5	231,0	3,1	4,3	5,2	6,4	7,1	0,4	0,4	0,6	1,4	1,6	0,0	0,1	0,8	0,2	0,5	2,1	9,7	1,7
	Lithuania	72,0	133,4	334,9	513,7	623,5	3,4	3,7	3,5	3,3	3,2	0,2	0,5	1,2	1,7	2,0	0,2	0,7	0,5	0,3	7,2	9,0	3,8	1,5
	Luxembourg	354,2	480,0	624,6	646,4	661,0	0,4	0,4	0,4	0,5	0,6	0,1	0,2	0,3	0,3	0,4	0,1	0,1	0,1	0,1	3,6	4,0	1,9	1,5
	Macedonia	93,1	121,0	149,3	N/A	N/A	1,8	1,8	1,8	1,8	2,1	0,2	0,2	0,3	N/A	N/A	0,1	0,1	N/A	N/A	2,7	2,1	N/A	N/A
	Mongolia	23,1	23,1	23,3	53,2	157,0	1,7	2,2	2,4	2,8	3,2	0,0	0,1	0,1	0,1	0,5	0,0	0,0	0,1	0,4	2,6	1,0	10,1	13,1
	Montenegro	N/A	N/A	130,5	193,2	262,3	0,6	0,6	0,6	0,6	0,6	N/A	N/A	0,1	0,1	0,2	N/A	N/A	0,0	0,0	N/A	N/A	4,0	3,2
	Morocco	22,0	27,0	42,1	58,1	89,8	19,6	24,8	28,8	32,0	35,1	0,4	0,7	1,2	1,9	3,1	0,2	0,5	0,6	1,3	4,5	6,1	4,4	5,4
	Mozambique	3,6	1,6	3,2	9,2	12,2	12,1	13,5	18,2	23,4	29,2	0,0	0,0	0,1	0,2	0,4	0,0	0,0	0,2	0,1	-6,6	10,3	13,9	5,1
	Namibia	N/A	21,1	28,9	53,4	111,2	N/A	1,4	1,9	2,3	2,7	N/A	0,0	0,1	0,1	0,3	N/A	0,0	0,1	0,2	N/A	6,3	8,3	9,3
	Netherlands	292,7	343,7	399,9	435,2	443,5	14,1	14,9	15,9	16,6	17,0	4,1	5,1	6,3	7,2	7,6	1,0	1,2	0,9	0,3	2,2	2,2	1,3	0,4
	New Zealand	467,9	499,3	558,4	596,1	617,7	3,1	3,4	3,9	4,4	4,8	1,5	1,7	2,2	2,6	3,0	0,2	0,5	0,4	0,4	1,4	2,4	1,9	1,4
	Nicaragua	11,7	9,7	14,4	18,8	25,6	3,2	4,1	5,1	5,8	6,6	0,0	0,0	0,1	0,1	0,2	0,0	0,0	0,0	0,1	0,5	6,2	4,1	4,5
	Norway	301,8	380,1	412,4	462,5	470,0	4,1	4,2	4,5	4,9	5,2	1,2	1,6	1,9	2,3	2,5	0,4	0,2	0,4	0,2	2,7	1,4	2,0	0,9
	Oman	46,6	76,6	151,9	174,1	186,7	1,2	1,9	2,3	2,8	3,3	0,1	0,1	0,3	0,5	0,6	0,1	0,2	0,1	0,1	10,0	9,2	3,5	2,4
	Panama	50,2	55,1	75,4	111,4	202,1	2,0	2,4	3,0	3,5	4,0	0,1	0,1	0,2	0,4	0,8	0,0	0,1	0,2	0,4	3,1	5,3	5,8	7,6
	Paraguay	18,5	38,9	77,9	43,4	61,9	3,2	4,2	5,3	6,5	7,6	0,1	0,2	0,4	0,3	0,5	0,1	0,3	-0,1	0,2	10,8	9,7	-3,9	5,3
	Portugal	106,6	211,4	418,4	497,2	508,1	9,8	9,9	10,3	10,7	10,6	1,0	2,1	4,3	5,3	5,4	1,1	2,2	1,0	0,1	7,2	7,5	2,1	0,2
	Qatar	288,8	223,8	338,4	385,6	404,6	0,2	0,5	0,6	1,8	2,2	0,1	0,1	0,2	0,7	0,9	0,0	0,1	0,5	0,2	5,2	6,6	13,0	2,8
	Romania	54,5	55,7	125,2	205,8	283,7	22,2	23,2	22,2	21,5	21,0	1,2	1,3	2,8	4,4	5,9	0,1	1,5	1,6	1,5	0,7	8,0	4,8	3,0
	S.Arabia	211,1	306,7	401,5	480,8	481,8	9,8	16,1	20,0	27,4	33,5	2,1	5,0	8,0	13,2	16,2	2,9	3,1	5,1	3,0	9,1	5,0	5,1	2,0
	Senegal	10,7	12,7	17,8	16,0	18,6	5,4	7,2	9,5	12,4	16,0	0,1	0,1	0,2	0,2	0,3	0,0	0,1	0,0	0,1	4,7	6,3	1,7	4,1
	Serbia	107,2	146,8	137,5	185,5	240,8	8,9	9,6	10,1	9,9	9,7	1,0	1,4	1,4	1,8	2,3	0,4	0,0	0,4	0,5	3,9	-0,1	2,8	2,5
	Slovakia	N/A	166,2	235,7	306,8	347,7	5,0	5,3	5,4	5,5	5,5	0,8	0,9	1,3	1,7	1,9	0,1	0,4	0,4	0,3	0,6	3,8	2,8	1,4
	Slovenia	227,6	304,7	437,2	520,9	561,0	1,8	1,9	2,0	2,0	2,1	0,4	0,6	0,9	1,1	1,2	0,2	0,3	0,2	0,1	3,5	4,0	2,0	0,9
	Spain	201,6	308,5	433,1	476,0	479,0	37,5	38,9	40,3	46,1	48,7	7,6	12,0	17,4	21,9	23,3	4,4	5,5	4,5	1,4	4,7	3,8	2,3	0,6
	Sri Lanka	8,0	10,0	17,9	35,1	72,8	15,1	17,3	18,7	20,9	22,3	0,1	0,2	0,3	0,7	1,6	0,1	0,2	0,4	0,9	3,7	6,8	8,1	8,3
	Suriname	71,1	88,5	130,7	227,6	307,3	0,4	0,4	0,5	0,5	0,6	0,0	0,0	0,1	0,1	0,2	0,0	0,0	0,1	0,1	3,3	5,4	6,9	3,9
	Sweden	346,9	420,7	451,4	461,3	481,1	8,3	8,6	8,9	9,4	9,9	2,9	3,6	4,0	4,3	4,8	0,7	0,4	0,3	0,4	2,2	1,1	0,8	1,0
	Switzerland	356,5	447,3	494,6	521,1	528,3	6,3	6,7	7,2	7,7	7,9	2,2	3,0	3,5	4,0	4,2	0,7	0,6	0,4	0,2	2,9	1,7	1,2	0,5
	Syria	8,1	10,2	11,4	36,3	38,5	8,9	12,3	16,0	20,4	24,1	0,1	0,1	0,2	0,7	0,9	0,1	0,1	0,6	0,2	5,8	3,7	15,1	2,3
	Tanzania	5,9	2,9	2,7	4,6	7,5	18,7	25,5	34,0	44,8	61,1	0,1	0,1	0,1	0,2	0,5	0,0	0,0	0,1	0,3	-3,9	2,2	8,4	8,3
	The Bahamas	254,2	264,8	291,6	277,8	288,2	0,2	0,3	0,3	0,3	0,4	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,0	2,4	2,5	0,9	1,5
	Trinidad&Tobago	145,6	164,5	178,0	222,2	223,2	1,1	1,2	1,3	1,3	1,4	0,2	0,2	0,2	0,3	0,3	0,0	0,0	0,1	0,0	2,5	1,4	2,6	0,3
	Tunisia	29,1	30,6	54,7	82,2	152,3	6,5	8,2	9,5	10,5	11,5	0,2	0,3	0,5	0,9	1,8	0,1	0,3	0,3	0,9	2,9	7,5	5,2	7,4
	UAE	128,9	124,4	245,6	276,6	285,9	1,0	1,8	3,0	7,5	9,2	0,1	0,2	0,7	2,1	2,6	0,1	0,5	1,3	0,5	5,6	12,7	10,8	2,4
	Uruguay	75,5	122,2	201,9	193,1	290,2	2,9	3,1	3,3	3,4	3,5	0,2	0,4	0,7	0,7	1,0	0,2	0,3	0,0	0,4	5,6	5,8	-0,3	4,5
	Venezuela	100,2	80,4	54,5	100,8	121,4	15,0	19,7	24,3	29,0	33,3	1,5	1,6	1,3	2,9	4,0	0,1	-0,3	1,6	1,1	0,5	-1,8	8,2	3,3
AYYreYates	EAGLEs	17	19	27	61	126	2245	2683	3067	3378	3645	37	52	82	205	458	15	30	123	253	3	5	10	8
	EAGLEs exChina	106	102	112	178	208	1262	1537	1798	2037	2257	37	50	73	142	225	14	23	68	84	3	4	7	5
	Nest	24	31	44	62	82	642	803	958	1107	1263	16	25	43	69	103	9	18	26	35	5	6	5	4
	EAGLEs&Nest	18	22	31	61	114	2887	3485	4025	4485	4909	53	77	125	274	561	24	48	149	288	4	5	8	7
	Asia	3	5	12	35	91	2195	2667	3099	3455	3771	6	13	37	122	343	7	24	85	221	8	11	13	11
	China&India	1	2	6	31	101	1683	2019	2323	2566	2775	2	5	15	80	279	3	11	65	199	11	13	18	13
	Asia exChina&India	8	13	29	48	64	512	648	776	889	996	4	9	22	42	64	4	14	20	21	7	10	7	4
	LatAm	69	85	103	168	230	274	335	392	441	483	19	28	40	74	111	9	12	34	37	4	4	6	4
	EEMEA	68	74	88	132	164	418	483	534	589	654	28	36	47	78	107	7	11	31	30	2	3	5	3
	G7	345	405	471	471	490	615	653	696	739	773	212	264	328	348	379	52	64	20	31	2	2	1	1
	G6	281	377	479	502	517	385	400	414	428	436	108	151	198	215	225	42	47	17	10	3	3	1	0
	EAGLEs&Nest&G7	76	83	96	119	165	3502	4139	4721	5224	5682	265	342	453	622	940	76	111	169	318	3	3	3	4
	Other DMs&Ems	114	136	166	199	209	503	600	689	797	903	57	82	115	158	188	24	33	44	30	4	3	3	2
	Aggregate	**81**	**89**	**105**	**130**	**171**	**4004**	**4739**	**5410**	**6021**	**6584**	**323**	**423**	**568**	**780**	**1129**	**101**	**144**	**213**	**348**	**3**	**3**	**3**	**4**

Annex: methodology and estimation results

We follow the empirical framework used by Dargay, Gately and Sommer (2007) and we extend it in several ways in order to obtain our own long-term estimation of the car ownership ratio and of car sales for several countries around the world until 2020. We are thus able to get an approximation of the future structure of the car industry in both developed and developing markets.

The underlying model exploits the relationship between car ownership levels and income per capita follows a non-linear function (S-shaped) that can be well approximated by the Gompertz curve. Car ownership levels are very low at very low levels of per capita income. However, car ownership takes off around medium-low levels of income and it grows very fast until it starts approaching a certain saturation level associated to high-income levels, before which it slows down its growth rate.

The empirical model is based on the idea that vehicle saturation levels may differ across countries and across time, given that such saturation levels may depend on different structural determinants, such as demographic factors. The model extends previous empirical works by including the level of financial development and an infrastructure quality indicator as determinants of each country saturation level.

The model also deviates from Dargay et al. (2007) because we use all the cross-country variability of the different dependent variables as part of the main determinants of the saturation level and we refrain from using the lagged value of the dependent variable to model short-term dynamics.

Some authors such as Chamon, Mauro, and Okawa (2008) have claimed that there is no empirical justification for assuming the existence of saturation levels, although they note that there is empirical evidence of an income threshold above which car ownership goes off. However, if we plot the logarithm of the car ownership ratio of several countries vs. the logarithm of income per capita in PPP values as in Chart A1 (2004 values), we can see that indeed there seems to be an initial fast increase in car ownership ratios at very low levels of income, followed by a decrease in growth rate at higher levels of income per capita, and thus, we can clearly see a smooth S-shaped relationship that justifies the estimation of a Gompertz-curve type of relationship. Only if we were to plot the car ownership ratio vs. the log of GDP per capita (in PPP) the graph would suggest that no saturation level is ever reached.

Given the kind of function displayed in Chart A1 and the non-negative nature of the dependent variable, we estimate a model taking the natural logarithm to both sides of the equation. The model is estimated by maximum likelihood using a non-linear estimator with robust standard errors. The equation that we finally estimate is the following:

$$
\begin{aligned}
lnCAROW_{it} = ln\Big\{&\big(\alpha + \beta_1(\overline{GDPPC}_{it}^{5yMA} - \overline{GDPPC}_{it}^{15yMA}) + \beta_2(DENS)_{it}^{>US} \\
&+ \beta_3(DENS)_{it}^{<US} + \beta_4(URB)_{it}^{>US} + \beta_4(URB)_{it}^{<US} + \beta_6\overline{(ROADSQ)_i} \\
&+ \beta_7\overline{PCRED}_{it}^{5yMA}\big) * \exp\Big[\gamma * \exp\Big(\beta_8\big(\overline{GDPPC}_{it}^{15yMA}\big)\Big)\Big] \\
&+ \beta_9\big(GDPPC_{it} - \overline{GDPPC}_{it}^{15yMA}\big) \\
&+ \beta_{10}(GDPPC_{it} - \overline{GDPPC}_{it}^{15yMA})^{GDP<0}\Big\}
\end{aligned}
$$

Where:

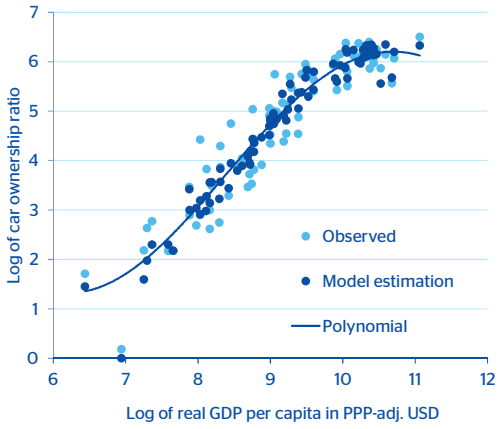
- $lnCAROW_{it}$ is the natural logarithm of car ownership.
- α is the constant "maximum" saturation level. If there were no other variables in place, this is the level that a country will approach as long-term per capita income tends to infinity.
- γ is the parameter that defines the curvature of the Gompertz curve.

- $\overline{GDPPC}_{it}^{15yMA}$ is the 15 years moving average of the GDP per capita in PPP terms. Thus, γ and β_8 are the parameters that account for the long-term relationship between income per capita and the observed car ownership level.
- $(\overline{GDPPC}_{it}^{5yMA} - \overline{GDPPC}_{it}^{15yMA})$ is the difference between the medium-term per capita income (5 years moving average of GDP pc PPP) and the long-term per capita income (15 years moving average of GDP pc PPP).
- $(DENS)_{it}^{\geq US}$ is a variable equal to a country's population density if it is higher than contemporaneous US' density and zero otherwise. $(DENS)_{it}^{<US}$ is zero in the complementary case.
- $(URB)_{it}^{\geq US}$ is a variable equal to a country's population urbanization level if it is higher than contemporaneous US' level and zero otherwise. $(URB)_{it}^{<US}$ is zero in the complementary case.
- $\overline{(ROADSQ)_i}$ is the average over time of each country indicator of the quality of their roads infrastructure. The indicator is a principal component of the ratio of roads per square km and the ratio of roads per inhabitants.
- $\overline{PCRED}_{it}^{15yMA}$ is the 15 years moving average of the ratio of Credit to Private Sector to GDP. The variable is included as the difference between its value and a threshold level of financial development (100% of GDP). If the variable is above the threshold, its value is made equal to zero. We thus assume that when the credit market development is above the given threshold, the country will approach the maximum saturation level.
- $\left(GDPPC_{it} - \overline{GDPPC}_{it}^{5yMA}\right)$ is the difference between the observed income per capita in a given period of time and the medium-term income per capita deviations ($\overline{GDPPC}_{it}^{5yMA}$). Thus β_9 accounts for the effect of cyclical changes in income per capita on the observed car ownership level. $(GDPPC_{it} - \overline{GDPPC}_{it}^{15yMA})^{GDP<0}$ is the same variable, but it is different from zero only in recessions periods. Thus β_{10} accounts for the differential effect of cyclical changes in income per capita during recession's periods.

In Table A1 we can observe the model's estimated parameters and results. Most of the variables turn out to be highly significant including the parameters that define the Gompertz curve. Importantly, both the financial development level and the roads quality indicator are also highly significant and their signs indicate that the saturation level of countries with very low infrastructure and financial development levels will be much lower than what their income per capita would indicate on its own.

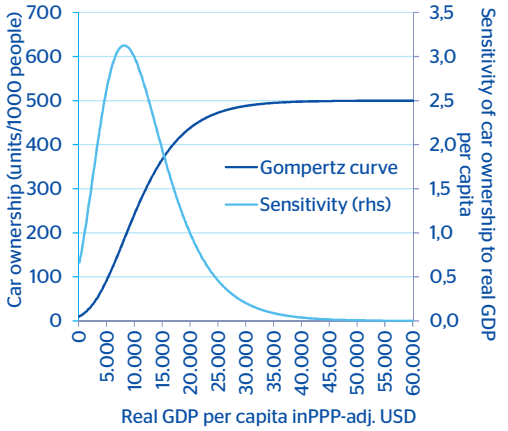
In Chart A2 we can see the Gompertz curve defined by the estimated parameters. This Gompertz curve would define the saturation level that a country would have if we had only taken into account its per capita income (long-term level). In the same panel we can also see the implied sensitivity of the Car Ownership ratio to a change in real income of 100 US dollars (2005 constant dollars in PPP terms). We can see that the model indicates that the sensitivity is initially very low, it reaches a maximum at around 8,000 dollars and decreases continuously afterwards until it gets close to zero around 45,000 dollars and beyond.

Chart A1.
Car ownership ratio and real GDP per capita in PPP-adjusted USD (2004)



Source: BBVA Research

Chart A2.
Car ownership and real GDP per capita in PPP-adjusted terms (Gompertz curve and Sensitivity)



Source: BBVA Research

Table A1.
Estimated regression results

		Variable	Coefficient
Saturation Level determinants	Long-term per capita income	α (max. constant Saturation Level)	499.9***
		γ (Gompertz curve shape)	-3.95***
		β (real GDPpc PPP-adj. 15y MA)	-0.00017***
	Other structural determinants	Real GDPpc PPP-adj. deviation 5yMA-15yMA	0.007***
		Population density (above US)	-0.18***
		Population density (below US)	-0.19
		Urbanization rate (above US)	2.259***
		Urbanization rate (below US)	-1.06*
		Roads quality Indicator	90.86***
		Credit to private sector	1.152***
Short-Term determinants		Real GDPpc PPP-adj. dev. Obs.-5yMA	0.009***
		Real GDPpc PPP-adj. dev. obs.-5yMA (in recessions)	-0.01***
		Adjusted R^2	0,991
		Number of Observations	2.001
		Number of Countries	92

**** indicates significance at a 1% confidence level, ** at a 5% level and * at a 10% level*

Table A2.
Variable definitions and sources

Variable	Definition	Source
Car ownership	Passenger cars per 1,000 people	World Bank and UN
GDP per capita	Real GDP per capita in PPP-adjusted USD 2005 constant terms)	IMF and BBVA Research
Population density	Population per km^2 of area	United Nations
Urbanization	Percentage of urban population	United Nations
Road density 1	Road kilometers per km^2 of area	World Bank
Road density 2	Road kilometers per capita	World Bank
Private credit	Private credit to non-financial institutions to GDP ratio	World Bank, Haver and BBVA Research

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Dargay, J., Gately, D. Sommer, M. (2007), "Vehicle Ownership and Income Growth, Worldwide: 1960-2030", The Energy Journal, 28, 4, 163–90.

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