Automobility in Brazil, Russia, India, and China

Quo Vadis?

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This paper introduces an innovative methodology to answer the question, Toward which levels of automobility are the BRIC countries (Brazil, Russia, India, and China) headed? The authors applied this methodology as an aid to understanding why long-term saturation levels for car travel differed across the countries of the Organisation for Economic Co-operation and Development study and what this difference meant for the saturation levels that the BRIC countries might attain. This approach factored out development of the gross domestic product (GDP) to focus on the ways in which other factors influenced specific paths of automobility in individual countries. The focus was on this question: Why were the long-term automobility saturation levels so much higher for some countries than for others, even at similar levels of GDP? The methodology drew on quantitative analysis of historical developments in four industrialized countries (the United States, Australia, Germany, and Japan) that served as case studies representing prototypical paths of automobility with extremely different levels of per capita automobility, in combination with qualitative data derived from an expert-based approach. The qualitative approach was used to transfer historical experiences about the ways in which (*a*) automobility evolution was shaped in industrialized countries and (*b*) these experiences might affect the future of automobility in the BRIC countries. On the basis of this analysis, Brazil proved the most car-oriented country of the BRICs, with a potential long-term level of automobility between those of Germany and Australia. Russia was the second most car-oriented country, also with a likely long-term level of automobility above that of Germany. China and India, in contrast, were heading toward lower levels of automobility, below that of Germany but higher than that of Japan.

In industrialized countries, the growth of car ownership and usage (i.e., automobility) has begun to slow. But a surge in automobility most likely lies ahead for numerous emerging economies, including the BRIC countries (Brazil, Russia, India, and China). The question of which levels of automobility the BRIC countries are headed toward is paramount for numerous reasons, not the least of which is that, while motorization in emerging economies brings opportunities for many, the negative consequences of it are daunting.

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This paper contributes to this important issue by introducing a novel methodology to answer the question about the levels of automobility toward which the BRIC countries are headed. This methodology draws on quantitative analysis of historic developments in four industrialized countries (the United States, Australia, Germany, and Japan) that serve as case studies representing prototypical paths of automobility with extremely different levels of per capita automobility, in combination with qualitative data derived from an expert-based approach. The latter approach was used to transfer historic experiences about the ways in which (*a*) automobility evolution was shaped in industrialized countries and (*b*) these experiences may affect the future of automobility in the BRIC countries. To describe the context for automobility as comprehensively as possible, the authors conducted an in-depth study of a small number of countries, by focusing on both qualitative and quantitative factors considered to be influential in automobility development.

For purposes of this study, "automobility" was defined as car travel (car kilometers per capita, for which a car is a four-wheeled passenger vehicle). This measure was selected instead of car ownership (cars per capita) because the authors observed more substantial levels of variation across the case study countries on the former measure. For example, car travel demand per capita in Japan in the past two decades has been about one-third of the U.S. level [compared at similar levels of gross domestic product (GDP) per capita], whereas car ownership in Japan has been about two-thirds that of the U.S. level. The authors believe that, because of its greater variance, car travel represents the big picture in relation to levels of automobility far better than do car ownership rates.

The paper is structured as follows. First, a brief overview of automobility trends in the four Organisation for Economic Co-operation and Development (OECD) case study countries. Next, the method, which draws both on quantitative and qualitative inputs, is described for estimating possible future levels of automobility. The final part of the paper presents the results of the study [i.e., possible future paths of automobility for the BRIC countries that are based on historical developments in the industrialized (or OECD) countries].

EVOLUTION OF PER CAPITA CAR TRAVEL IN OECD COUNTRIES

Figure 1 shows the historical evolution of per capita car travel versus GDP per capita in the OECD study countries as well as statistical models that were fitted to these historical time series (*1–7*). [The data for GDP per capita came from Bolt and van Zanden (*8*); the data are based on conversions that used purchasing power parity (PPP). A particular conversion developed for international comparisons,

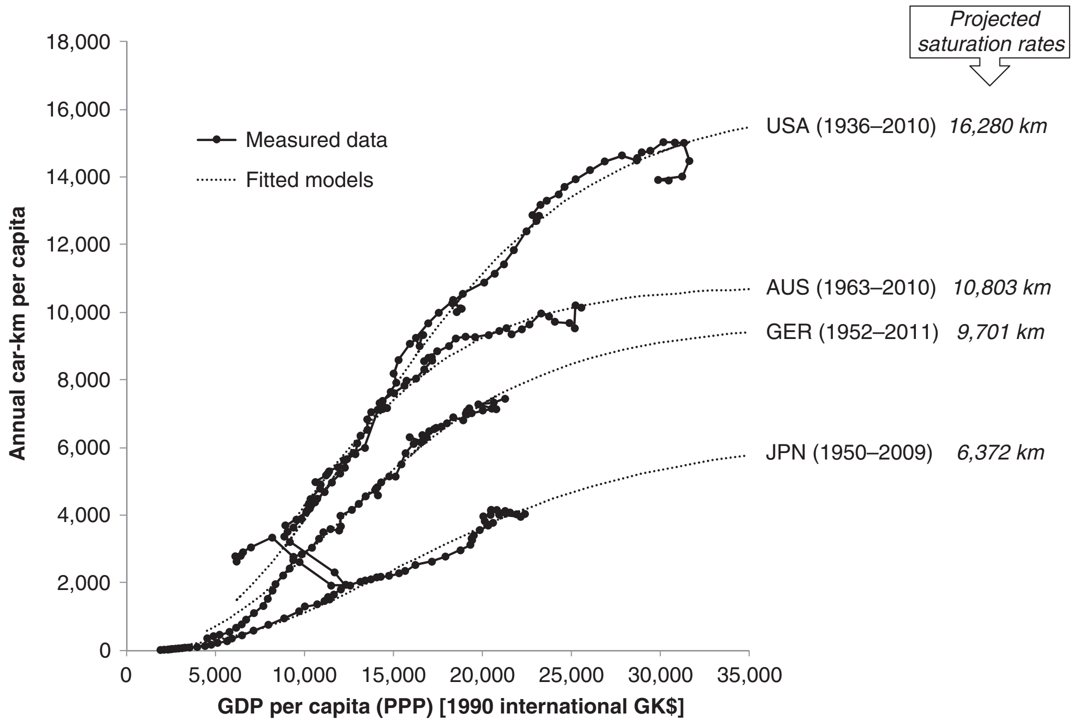

FIGURE 1 Observed and modeled levels of car travel for OECD study countries (*1–7*) (USA = United States of America; AUS = Australia; GER = Germany; JPN = Japan).

Geary–Khamis dollars (GK$), as opposed to exchange rates, was used (*8*).] While the fact that car travel increases with income is evident, Figure 1 also shows that, at given levels of GDP per capita, levels of car travel vary substantially across countries. This finding has also been uncovered by other researchers for indicators of both car travel (*9, 10*) and car ownership (*11–13*). From the authors' perspective, this finding indicates that GDP development falls short of fully explaining automobility development and that other factors must influence ultimate automobility levels.

Other researchers [e.g., Dargay et al. (*12*)] have found that car ownership grows nonlinearly with income, increasing more slowly at the lowest income levels and then more rapidly as incomes increase, and finally slowing as saturation is approached. As a result, car ownership trends tend to follow an s-shaped curve with income. Similarly, the authors observe that the evolution of car travel seems to follow an elongated s-shaped curve, as Figure 1 shows.

While a number of functional forms can describe such a curve, the authors chose to use a Gompertz function to model car travel, by using an approach similar to that used by Dargay et al. to model car ownership (*12*). Dargay and Gately argued that the Gompertz formulation is somewhat more flexible than the logistic model, particularly in allowing different curvatures at low- and high-income levels (*11*). Thus, for these models, the authors assumed that growth in car travel was a function of GDP. They then estimated models with three terms (α, β, and γ) describing the S-shaped curve for each OECD country. The resulting country-specific saturation levels γ are shown in Figure 1; the estimated country-specific growth terms β describe the speed of car travel evolution ($\beta_{AUS} = -0.178$; $\beta_{GER} = -0.148$; $\beta_{JPN} = -0.114$; $\beta_{USA} = -0.134$), where AUS = Australia, GER = Germany, JPN = Japan, and USA = the United States; and α defines the curvature at extremely low levels of GDP and is generic across countries ($\alpha = -5.495$). The adjusted R^2-value for this model was .985.

The estimated saturation levels for car travel (Figure 1) encapsulate the diverging historic paths of automobility in the OECD study countries. Therefore, this paper focuses on examining these estimated saturation levels. The study investigated the reasons why saturation levels for car travel differ across the OECD study countries, their meaning for automobility in the BRIC countries, and the ways in which such saturation levels might be estimated for the BRIC countries.

The authors emphasize that the saturation rates in Figure 1 should not be interpreted as future projections of automobility for the OECD countries because uncertainty in future conditions, technologies, and the like may influence automobility trends. In the context of this study, these saturation rates simply epitomize the historical paths of automobility that the OECD countries have been on until today.

Against the background of sound empirical evidence and an existing body of literature, the authors did not attempt to add to the discussion of how GDP development influences automobility evolution. Instead, the authors factored out the GDP development to focus on the ways in which other factors have influenced specific paths of automobility in individual countries. That is, the focus is on the question that previous models have left unanswered or answered only partially: Why are the long-term automobility saturation levels so much higher for some countries than for others, even at similar levels of GDP? The authors believe the answer to this question can be found in contextual factors other than GDP development. The remainder of the paper focuses on such contextual factors and the bearing they have on saturation levels for car travel.

METHODOLOGY OVERVIEW, ASSUMPTIONS, AND SPECIFICATIONS

Figure 2 shows an overview of the study focus and the approach used here for capturing the influence of context conditions on automobility evolution. This approach involved substantial expert participation in virtual and face-to-face workshops. In these workshops, factor scores were established to quantify relevant contextual factors in the study countries. In the case of the OECD study countries, these factor scores describe historical conditions; in the case of the BRIC study countries, the factor scores describe projected future conditions during the next decades. In addition, factor weights were established to describe the relative strength of each contextual factor's influence on automobility. The factor scores and factor weights were combined into a single automobility score that describes the relative conduciveness of an overall environment to automobility. The higher the score, the more likely that the given country has high rates of car travel. If the automobility scores are suitable representations of the fertile ground for automobility in the OECD countries, the scores should—for the OECD study countries—show a good correlation with the long-term evolution of automobility. In turn, projected automobility scores for the BRIC countries should provide good guidance on the direction of the evolution of automobility in these countries in the long run. Before this procedure is described in more detail, important assumptions and specifications that lay the groundwork for this approach are presented.

Assumption 1. Historical Paths of Automobility Evolution in OECD Countries Allow Calibration of Qualitative Model for Future Automobility in BRIC Countries

The authors assume that future automobility in the BRIC countries will be influenced by the same factors that were relevant in the OECD countries and that those factors will have similar impacts on automobility. This assumption always holds whenever models that have been calibrated with historical data are applied to projecting future developments. New, relevant factors may emerge in the future and shape the development in the BRIC countries. However, this study assumes that the same rules apply to the BRIC countries as the ones that were relevant in the OECD countries.

Specification 1. Usage of Same Factors and Factor Weights for OECD and BRIC Countries

On the basis of the first assumption, the authors used not only the same nine factors and the same scale for the factor scores, but also the same factor weights for both the OECD study countries and the BRIC countries. Factor scores were developed to describe the different factor situations across countries, so the scores vary across countries. The factor weights, in contrast, were developed to capture the general influence of the factors on automobility, so the weights are the same across all countries.

Assumption 2. Changes in GDP per Capita Predominantly Influence Speed of Automobility Growth While Other Factors Are More Influential for Long-Term Saturation Levels

In light of the historical evolution of automobility in the OECD study countries (Figure 1), the authors assumed that factors other than GDP development were relevant for shaping the long-term saturation levels for automobility. Possibly, speed of GDP development or alternating periods of recession and growth will affect not only the speed with which automobility develops, but also its direction in the long run. As an example, Japan has shown extremely fast economic development since the 1960s but has low automobility. In the authors' view, this influence of fast GDP development on saturation levels has been mitigated by other factors such as land use. So GDP

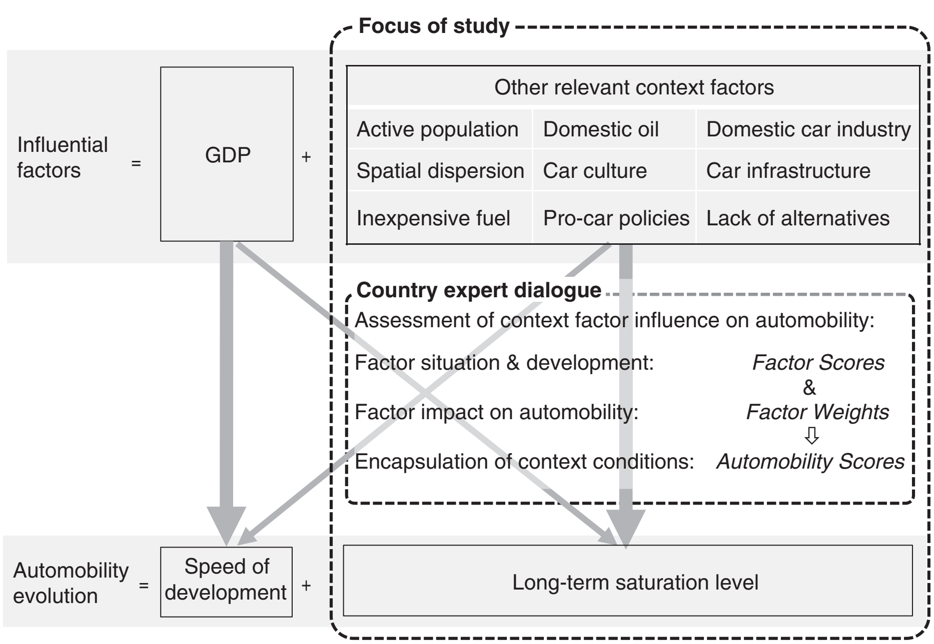

FIGURE 2 Study focus and methodology overview.

development has a contributing (not direct) influence only on long-term saturation levels for automobility. Thus, when investigating the shapes of these saturation levels, the authors have concentrated on the impact of these other factors (which in turn are likely to influence the speed of automobility growth).

Specification 2. Identification of Nine Contextual Factors (Other than GDP)

The objective here was to cover a broad range of relevant quantitative and qualitative factors adequately. On the basis of a literature review and expert consultation, nine factors were derived, including some that can be quantified and others that almost completely elude quantification. They fall broadly into two categories: (*a*) transport policy factors, which are directly or quickly influenced by transport policy, and (*b*) exogenous factors, which, by and large, are shaped by other background developments and on which transport policy has only a second-order bearing. These nine factors are described next.

Transport Policy Factors

Transport policy factors account for four of the nine contextual factors, as follows:

1. Car infrastructure comprises all infrastructures for automobility, including the quality and quantity of roads and parking supply.
2. Inexpensive fuel describes the degree to which the pump price for fuel (including all taxes, etc.) is low relative to income.
3. Procar policies comprise noninfrastructural policies and regulations in relation to car ownership and use. These range from vehicle registration taxes and vehicle inspection regulations to car usage fees and city access restrictions.
4. Lack of alternatives describes the supply of alternative modes of transport in quantity and quality.

Exogenous Factors

Exogenous factors account for the remaining five contextual factors:

5. Active population describes the share of the population in a life stage with high mobility rates. This share includes both demographic effects (i.e., age cohorts in which mobility is typically high) and work-force participation (i.e., the share of the working age population that actually works).
6. Domestic oil describes the availability of oil from domestic sources as opposed to reliance on foreign oil.
7. Domestic car industry describes the relevance of a domestic car industry to the national economy and the country's policies.
8. Spatial dispersion describes the degree to which settlement patterns require people to rely on motorized transport. This factor includes the level of sprawl of urban environments as well as the proportion of people who live there.
9. Car culture describes the degree to which the overall cultural environment is conducive to automobility. A strong car culture is one in which cars are important (*a*) to feeling independent and individual, (*b*) for personal space and privacy, (*c*) in expressing certain attitudes and beliefs, (*d*) as a social norm, (*e*) as a hobby, (*f*) as personal living space, and (*g*) in popular culture.

Assumption 3. Context Conditions That Prevail During Period of Strong Growth of Automobility—at Intermediate Levels of GDP Development—Set Course for Long-Term Development of Automobility

Automobility tends to grow over several decades. In light of the finding that automobility grew most strongly at intermediate levels of GDP per capita, the authors concluded that this intermediate stage of economic development was the crucial period for focus. Therefore, they assumed that the conditions that prevail during the period of strong automobility growth set the course for the long-term development of automobility. These conditions might have been in place before the start of strong growth in automobility, but they exert their most significant influence on the development of automobility during that period.

Specification 3. Identification of Relevant Study Periods per Country

The authors defined the relevant study period as beginning when GDP per capita reached $5,000 PPP and ending when GDP per capita reached $20,000 PPP. This definition was based partly on empirical evidence (Figure 1) and partly on practical considerations. On the one hand, the authors needed historical data for the time when the OECD study countries surpassed the lower limit. On the other hand, they felt that this lower limit should also be within reach of the BRIC countries today. For example, the United States passed the lower threshold ($5,000 PPP) in the first decade of the 20th century, and India is likely to pass it within the next decade. For the upper limit, the authors selected $20,000 PPP because Japan and Germany are just above that level.

These study periods lie in the past for the OECD study countries. But three of the four BRIC countries are in the study period now as their current GDP per capita exceeds $5,000 in PPP. In a dialogue with country experts, the authors arrived at estimates of approximately when the BRIC countries would reach the $20,000 PPP GDP thresholds. The decades during which the BRIC study countries passed or are likely to pass the respective lower or upper GDP per capita limit are shown in Table 1.

EXPERT INPUT TO ESTABLISH FACTOR SCORES, FACTOR WEIGHTS, AND AUTOMOBILITY SCORES

Participation of Country Experts in Virtual and Face-to-Face Workshops

Each of the eight study countries was represented by national experts: one for each OECD country and teams of two or three for each BRIC country. These country experts were transportation scholars with practical experience and who were recruited from renowned transportation research institutions in the respective countries (see the section on acknowledgments). The difference in the number of representatives for the OECD and BRIC countries reflects the challenges in assessing the factors for these countries. For the OECD countries, the availability of information was generally better, partly because, for those countries, only historical and current information were needed. For the BRIC countries, in contrast, projections for the factors were

TABLE 1 Results from Establishing Factor Scores, Factor Weights, and Automobility Scores

	Transport Policy Factors				Exogenous Factors					
Factor	Car Infrastructure	Inexpensive Fuel	Pro-Car Policy	Lack of Alternatives	Active Population	Domestic Oil	Domestic Car Industry	Spatial Dispersion	Car Culture	Automobility Score
Factor Scores for OECD Countries After Final Rating										
Australia										
1910s	–1.2	0.5	1.2	0.1	0.1	1.3	–0.8	–0.8	0.7	.46
1990s	1.4	0.9	0.6	0.9	1	0.2	–0.1	1.8	1.2	
Germany										
1950s	–0.2	–1	0.1	–0.9	–0.9	–1.8	0.9	–1.3	0.6	–.26
2000s	0.9	–0.3	–0.7	–1.7	0	–1.5	1.8	–0.5	0.2	
Japan										
1960s	–1.3	–1.1	0.5	–0.8	0.4	–1.8	0.7	–1.8	0.6	–.51
1990s	0	–0.2	–1.3	–1.7	0	–1.4	1.6	–0.9	–0.1	
United States										
1910s	–1.1	1.3	1.8	0.1	0.4	1.8	1.4	–0.8	1.1	.87
1980s	1.8	1.7	0.9	1.5	0.9	0.1	0.4	1.7	1.4	
Factor Scores for BRIC Countries, Using Same Scale, After Final Rating										
Brazil										
1980s	–0.5	–1	0.8	0	1.1	1	0.8	–0.2	–0.1	.23
2030s	0.2	–0.2	1.1	–0.5	1.5	1.4	1.4	0.3	–0.4	
China										
2000s	–0.8	–1	0.3	0.3	1.2	–0.2	0.3	–1.7	–0.6	–.35
2030s	0.4	–0.2	–1.2	–1.3	1.5	–0.6	0.9	–1.1	0	
India										
2010s	–1.4	–1	0.2	1	–0.3	–0.6	–0.8	–1.4	–0.6	–.49
2040s	–0.2	–0.2	–0.6	–0.6	0.8	–0.9	0.3	–1	0	
Russia										
1990s	–0.1	0.3	1.2	–0.8	0.6	1.8	–0.8	0.1	–0.2	.03
2030s	0.2	–0.2	–0.2	–1.2	0.4	1.6	–0.2	–0.2	0.5	
Factor Weights that Describe How Strongly Contextual Conditions Impact on Automobility (1 = low impact, 2 = medium impact, 3 = high impact)										
Final expert rating	3	2	2	2	1	1	2	3	2	

NOTE: Factor scores describe contextual conditions for automobility on a scale from –2 (not conducive to automobility) to +2 (very conducive to automobility) for two points in time: the beginning of the period of strong growth of automobility (GDP per capita of $5,000 PPP) and the end of the period of strong growth of automobility (GDP per capita of $20,000 PPP).

necessary—at least to describe the situation at a level of GDP per capita of $20,000 in PPP. In determining the number of experts involved in such a process, a tradeoff was required between the possible influence of subjectivity of the expert judgments (which possibly is larger with only a few experts) and keeping the number manageable in a workshop. The authors believed that the latter was an important issue because the possibility of a lively workshop discussion across country contexts was crucial to this approach and that the selected number of experts per country struck a sensible balance here.

The authors conducted virtual and face-to-face expert workshops in which information was elicited to establish the factor scores and factor weights [i.e., to describe historical (OECD) and future (BRIC) context conditions for automobility and their impact on its evolution]. The term "virtual workshop" refers to iterations of e-mail discussions about specific topics that were initiated by circulating a set of slides with information and a task for country experts to complete. The 2-day face-to-face workshop with experts from all countries took place in Berlin in April 2013. Table 2 shows an overview of the three-stage process (i.e., preparation, elaboration, validation) for establishing the factor scores.

Establishing Factor Scores

The authors needed an assessment scheme for their nine factors that was able to (*a*) describe all quantitative and qualitative elements in a comparable manner and (*b*) capture changes in the factor situation over time. Simultaneously, the factor assessment scheme had to be manageable in a workshop.

These requirements resulted in a visually orientated, intuitive scheme that the workshop participants nicknamed the "flag game." Figure 3 shows this assessment scheme for one of the nine factors. For each country, the figure shows two flags along a horizontal axis. The left-most position of this axis represents a situation in which one would expect automobility to be low, while the right-most position shows a situation conducive to increased automobility. The position of one flag represents the factor situation at the beginning of the period of strong growth of automobility (i.e., the decade when the country reached or will reach the $5,000 PPP threshold); the position of the other flag shows the factor situation at the end of the period of strong growth of automobility (i.e., the decade when the country reached or will reach the $20,000 PPP threshold). The direction and the length of the arrows between the flags represent the changes that

TABLE 2 Three-Stage Process with Expert Participation for Establishing Factor Scores and Factor Weights

Stage	Establishing Factor Scores	Establishing Factor Weights
1. Virtual workshop: preparation	Study team provided factor fact sheets and initial solutions for factor scores among experts. Experts provided initial feedback on fact sheets and factor scores.	Study team asked experts to identify influential factors. Experts provided list of influential factors.
2. Face-to-face workshop: elaboration	Study team presented updated factor fact sheets and revised factor scores. Experts discussed and adjusted factor scores with focus on factor projections for the BRIC countries.	Study team presented starting solution for factor weights. Experts discussed and adjusted factor weights.
3. Virtual workshop: validation	Study team circulated updated factor scores supplemented with additional information, statistics, and comments that challenge the factor scores. Experts validated final factor scores.	Study team circulated updated factor weights from face-to-face workshop. Experts provided final judgment on factor weights.

have taken place during the (expected) period of strong automobility growth. Eventually, the positions of the flags were translated into factor scores, numbers between −2 (for the left-most position) and +2 (for the right-most position) that quantify the expert judgment about this factor.

The strength of the flag game was that it allowed experts to compare the situation for the different factors—at two crucial points in time—across countries. The factor scores should not be interpreted as absolute scores. Instead, factor scores should be seen as relative scores that describe the historical, current, or future situation in the countries compared with one another and over time.

Generally, the experts had international experience and were able to compare situations across countries. Nevertheless, expert judgments remained subjective, and thus supporting their factor assessment with objective and comparable information made sense. Therefore, the authors prepared fact sheets (available upon request) for each factor showing statistics and descriptive information for the study countries to facilitate the experts' factor scoring. Some factors (e.g., fuel price and active population) can be captured suitably by quantitative information. For these factors, time series data were prepared to cover the respective study periods as comprehensively as possible. Other factors have a strongly qualitative component (e.g., the quality of public transport supply as opposed to its mere quantity). In these cases, selected statistics for only single cross-sectional years were prepared so as to provide a baseline for comparisons across countries. Aside from that, the focus was deliberately placed

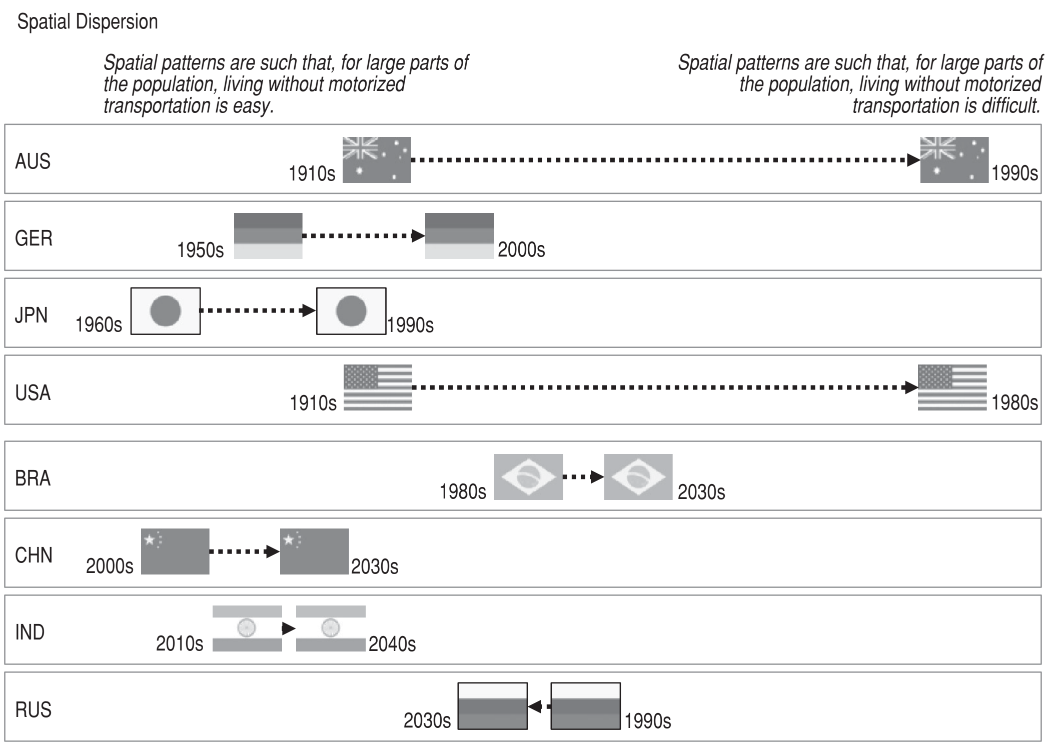

FIGURE 3 Example of the factor assessment scheme (flag game) used in expert workshops to capture situation and dynamics of contextual factors during study periods.

on descriptive information because of the authors not wanting the significance of statistical figures to eclipse qualitative information.

Eventually, the three-stage expert dialogue shown in Table 2 was used to establish the factor scores. The repositioning of flags (i.e., readjustment of the factor scores) in the third stage of the process was minimal. Therefore, the authors believe that these three rounds of expert participation provided sufficient iteration to arrive at agreed-on factor scores. Ultimately, the positions of the flags were translated into 18 (two periods × nine factors) numeric scores per country that describe each factor at two points in times on a scale from −2 to +2. The final scores for each factor are shown in Table 1.

For a clarification of the results in Table 1, one may consider the spatial dispersion factor—one of the two factors eventually considered most influential (see next section)—shown in Figure 3. This factor captures two countervailing developments that usually accompany increasing prosperity: (*a*) rising levels of urbanization leading to larger proportions of the population living in urban environments and thus relying less on motorized transportation and (*b*) increasing living space per person (i.e., increasing sprawl within urbanized environment, which in turn leads to larger proportions of urban populations relying on motorized transport). The net impact of these two trends on automobility was judged to have developed strongly positive over time for the United States (factor score increasing from about −0.8 to about +1.7) and Australia (factor score increasing from about −0.8 to about +1.8). In Germany and Japan, the net results of those two countervailing developments were judged to have become less automobile-oriented over time because their urban areas managed to maintain higher densities. The experts expected similar development for the BRIC countries. For Russia, the automobile orientation of the spatial patterns was even expected to decrease in coming decades. As shown in Figure 3, the level in Russia in the 2030s is expected to be far below its peak in the 1990s. The reason for this trend was that new urban housing continued to be built in high-density condominiums.

Of course, the spatial-dispersion factor can vary strongly within countries, say between the American Northeast and Southwest. This issue of intracountry heterogeneity also applied to other factors (e.g., the procar-policies factor for which local city ordinances often have strong impact). In these cases, the authors attempted to determine an average factor score for the entire country by making estimates about the proportion of the population affected by certain circumstances (e.g., policies or spatial conditions).

Establishing Automobility Scores and Factor Weights

Next, these 18 factor scores per country were combined into one automobility score per country to summarize the country's factor conditions. The authors assumed that the factors had differing levels of influence on automobility. To take account of this assumption, three possible weights (a three-point scale was used, with 3 representing the strongest influence on automobility and 1 the lowest influence) were introduced to capture the variance of influence across factors. (Also considered was the possibility that the impact of factor conditions on automobility differs in strength over time. To account for this consideration, additional weights for the two points in time, the beginning and end of the study period, were introduced. However, these time weights were discarded because the country experts did not deem them necessary.)

As with the factor scores, establishing the factor weights relied on the judgment of the experts, who discussed them in the three-stage procedure shown in Table 2. The final set of factor weights is an arithmetic mean of the expert judgment in the last virtual workshop rounded to the nearest integer. At this point, the experts' judgment on the weights had converged such that no individual judgment differed from the weight that was finally assigned to the factor by more than 1. The final weights for each factor are shown in Table 1.

Eventually, the automobility score per country was derived by computing the weighted average of all factors scores by using the respective factor weights.

DISCUSSION OF RESULTS

Overall Evolution of Factor Conditions for Automobility

Figure 4 provides an overview of the paths of the study countries in relation to the context conditions for automobility separated by transport policy factors and exogenous factors. In the figure, the start and end positions of the country arrows are defined by the weighted combination of the factors that constitute the exogenous ones (*x*-axis) or the transport policy ones (*y*-axis) for the start and end of the study period. Therefore, the arrows show the paths that the countries have taken or are projected to take with respect to the two sets of factors throughout the respective study period.

In regard to the exogenous factors, Japan and the United States represent the extremes among the OECD countries. What distinguishes these two countries the most is the prevalence of sprawl, the availability of domestic oil, and the demographic setup. While the domestic car industry is important in both countries, it has become more relevant over time in Japan but lost relevance in the United States. The other two OECD countries, Australia and Germany, are between these extremes. Among the BRIC countries, Russia and Brazil exhibit relatively favorable exogenous conditions for automobility—both have domestic oil—and in Brazil, the car industry and the demographic setup add to that favorability. China and India, in contrast, lack domestic oil and have much denser cities such that exogenous conditions for automobility are overall less advantageous. It was not a big surprise that all study countries moved toward conditions that are more amenable to automobility over time. The increase of spatial dispersion that generally tends to accompany increasing incomes plays an important role here. In addition, the increasing importance of the car industry and rising shares of active population in many countries influence this trend substantially.

Furthermore, with respect to the transport policy factors, the United States and Japan represent two extremes. The United States is in the top box, mostly because of the quantity of its car infrastructure and the affordability of fuel. The combination of tough regulation, good alternatives, and historically limited car infrastructure puts Japan at the other extreme.

The trends for the transport policy factors are more heterogeneous than for the exogenous factors. A look at the past for the OECD countries shows that, in Germany and particularly in Japan, the increasing affordability of fuel and the extension of the car infrastructure have been kept in check by tougher regulations and expansion of alternatives. These conditions were not the same in Australia and the United States, where policy contributed to increasingly favorable conditions for automobility. Among the BRIC countries, Brazil was the one that exhibited the most favorable policy conditions for automobility and continues to develop in that direction.

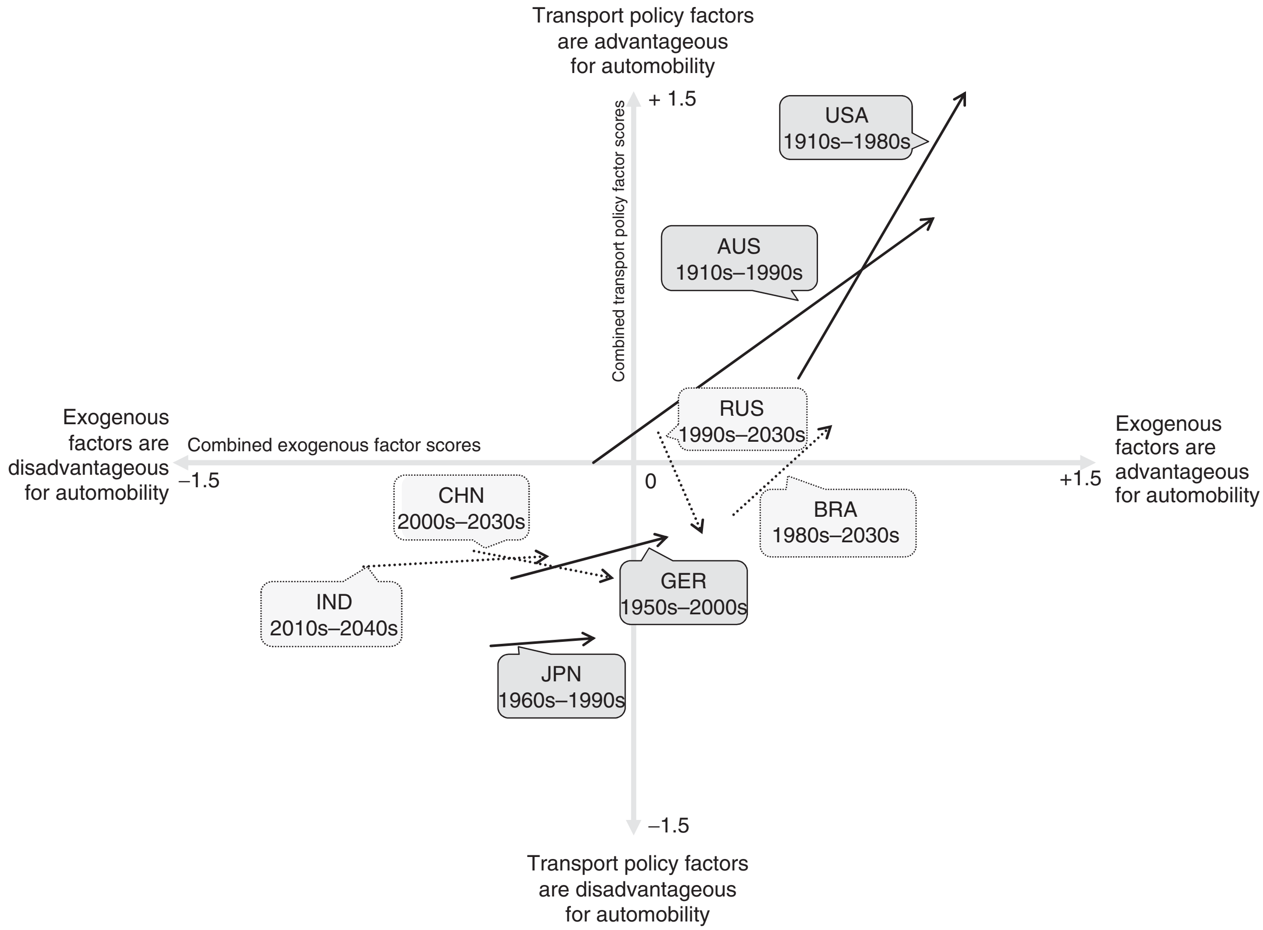

FIGURE 4 Historical and projected trends for development of transport policy factors and exogenous factors in study countries.

China and India seemed to follow the German path, while in Russia policy conditions were expected to get tougher—mostly because the favorable tax treatment for cars and fuel in that country is not expected to continue.

In Figure 4, the countries are, by and large, positioned along the diagonal from the lower left to the upper right—and many even move in that direction. This orientation indicates that transport policy factors and exogenous factors are correlated, or—in other words—that transport policy often follows a course that is set by exogenous driving forces.

Automobility Scores and Estimates of Future Automobility in BRIC Countries

The projected future paths for automobility in the BRIC countries raise the question of how this translates into levels of automobility. To answer this question, the authors established automobility scores to encapsulate all context conditions for automobility in a given country. The automobility score for each country was computed as a weighted mean of all factors per country, by using the weights for the factors shown in Table 1.

Next, the authors applied a simple linear regression that modeled car travel saturation levels by using the automobility scores as the independent variable (Figure 5). The regression was calibrated by means of data for the OECD study countries and applied to the BRIC countries.

Figure 5 shows that the automobility scores resulting from the expert dialogue bear a strong correlation with long-term automobility trends for the OECD study countries. The scores explain 86% of the variation in car travel saturation levels for the OECD countries (for the OECD countries, these saturation levels were projected by using only historical car kilometer per capita and GDP per capita time series).

After assuming that the automobility scores in the BRIC countries will, on average, have similar impacts as in the OECD study countries, the authors applied the regression equation to the projected automobility scores of the BRICs. This procedure provided an indication of the direction of automobility in the long term in these countries. Given the discussion of the paths of context conditions above, the authors are not surprised that—according to this projection—long-term levels of per capita automobility for India and China are between the Japanese and German levels, while those for Russia and Brazil are between the German and Australian levels.

CONCLUSIONS

This paper contributes to the discussion about future automobility in the BRIC countries by examining the long-term direction that the evolution of automobility is taking in these places. By taking

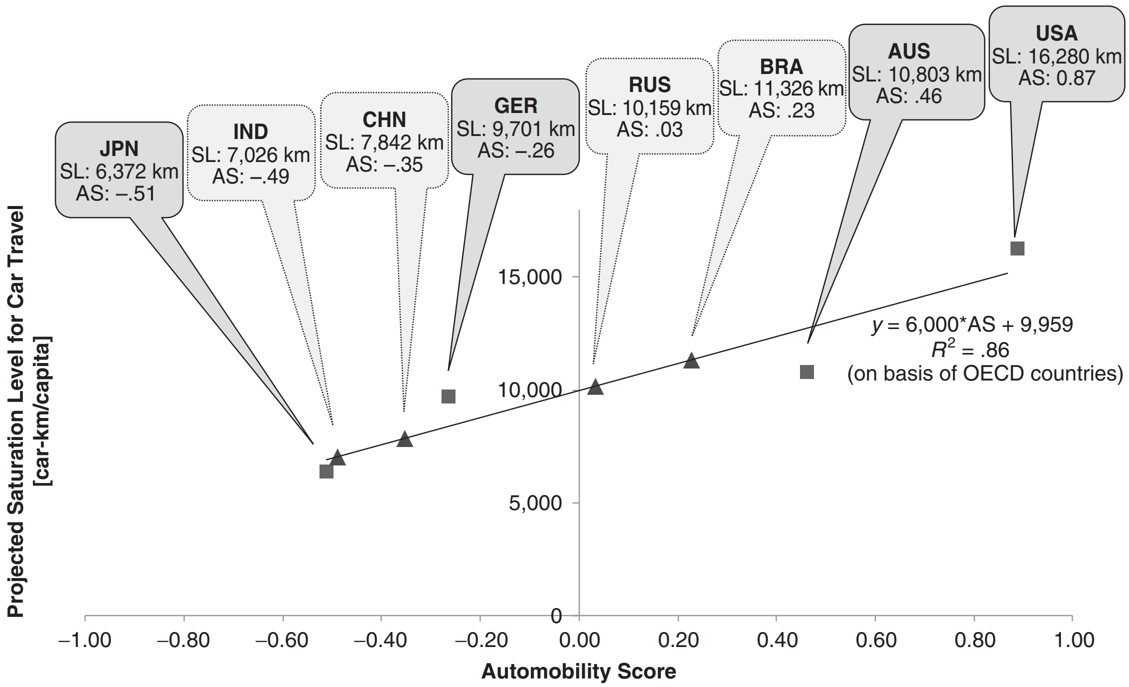

FIGURE 5 Saturation levels (SL) for car travel projected on basis of historical data for OECD study countries and estimated on basis of automobility scores for BRIC countries and automobility scores (AS) as established for OECD study countries and as projected for BRIC countries (IND = India; CHN = China; RUS = Russia; BRA = Brazil).

this long-term perspective, the authors factored out the development of GDP per capita as an influential factor for automobility. As reasons for doing so, the authors assumed that income growth predominantly determines the speed of automobility development but has less of an impact on saturation levels. Instead, the authors quantified the impact of nine other influential factors and then compared projected future paths of the BRIC countries in relation to these factors with the historical paths that four OECD study countries have taken. To account for the broad range of quantitative and qualitative information that is necessary to assess these paths comprehensively, this approach drew heavily on the participation of country experts in several virtual and face-to-face workshops.

On the basis of these inputs, the authors derived estimates of long-term saturation levels of car travel (per capita) in the BRIC countries. Analysis shows that Brazil proves to be the most car-oriented country among the BRIC countries, with levels of automobility between those of Germany and Australia. Russia places second, also with a likely long-term level of automobility above that of Germany. China and India, however, are heading toward lower levels of automobility, below that of Germany but higher than that of Japan.

The approach applied in this study is novel in that it compared historical and projected trends, combining quantitative and qualitative elements. The authors are well aware of the caveats of the approach, including the subjectivity of the expert judgments in assessing the factors themselves or their influence on automobility. The authors would like to develop this approach further to substantiate the expert ratings and to give more validity to the overall approach. In relation to the next steps to extend the presented methodology, the authors plan to combine the projected saturation levels for car travel with GDP forecasts to develop concrete projections for particular points in time. Moreover, the intent is to derive car ownership projections for the BRIC countries. Generating such projections will first require differentiating the diverging influence of GDP (or average income levels) on car travel on the one hand and car ownership on the other. However, car ownership projections will, in turn, improve the ability to compare projected development with the part of the automobility journey that the BRIC countries have already taken (i.e., their historical evolution of car ownership and mobility to today).

However, the authors recognize that attempting to overcome the existing shortcomings of this approach to attain greater accuracy in the predictions may be pointless. The greater uncertainty about the future of automobility in the BRIC countries (as well as in the OECD countries) probably lies in the emergence of new factors, for example, the impacts of information and communications technology on mobility. In addition, the recent indication of stagnation in car travel in many industrialized countries—discussed in separate studies as the "peak car" hypothesis—possibly renders the projected saturation levels for the OECD study countries obsolete. As a result, the projected saturation levels for the BRIC countries may also be too high.

The authors perceive this method simply as one attempt among many to illuminate the path that lies ahead for automobility in the BRIC countries. However, the authors also believe that this approach can be adapted to include new, emerging factors. Thus, the approach can serve as a platform for discussing the evolution of mobility more generally by comparing historical experiences and likely future trends. This ability for comparison may prove to be the real potential of the methodology.

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