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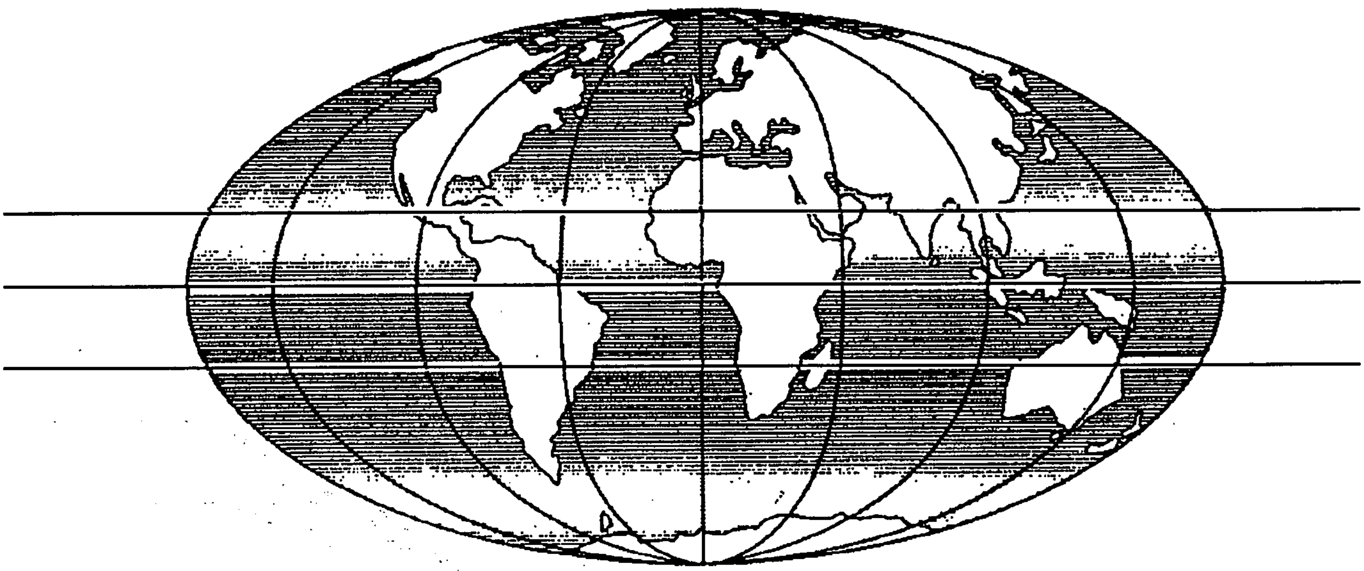

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Car ownership forecasts for low-income countries

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Introduction. Considerable efforts have been expanded over the years to develop sophisticated forecasting models of car ownership and use in developing countries[1]. Efforts to look at the probable growth patterns of vehicle ownership in the very low income countries of the World have been much more limited. Traffic is, however, growing in many of the World's poorer nations, albeit at very variable rates, and this has implications for both the countries themselves and, via potential environmental implications, for the industrialised world.

The implications for nations where growth is taking place are being felt not only in terms of pressures on the national road networks, but also through higher import bills for both vehicles and fuel[2]. This growth in vehicle ownership is also continuing hand-in-hand with rapid urbanisation, and the strains on many nations' transport infrastructure are particularly severe in cities[3]. Rising vehicle fleets also impose pressures on the vehicle maintenance facilities available and the administrative and planning structure required to police and regulate the road system. Since there are similar growth trends in commercial vehicle numbers and use, questions of road maintenance are compounded. More generally, there are questions of social equity and mobility associated with rising levels of personal car ownership and availability.

It is important, therefore, for these sorts of reason that both those involved in transport infrastructure planning and those responsible for the development of tractable land-use and economic policies, more generally, have reasonable car ownership and use forecasts together with robust forecasts of future commercial vehicle levels. Further, the major aid-giving agencies, such as the World Bank and Asian Development Bank, in order to allocate funds over time find it useful to know whether similar trends in vehicle ownership patterns occur across a range of low-income countries or whether wide divergences exist.

On a broader front, transport is a major contributor to many of the emissions which are associated with both trans-border environmental damage (e.g. with acid rain) and with global warming. International responses to what are perceived to be mounting problems have tended to focus on the appropriate response in the industrialised countries (e.g. the fitting of catalytic converters to limit acid rain-associated emissions), but the parameters of these calculations are inevitably dependent, especially regarding the global warming issue, on the worldwide use of fossil fuels which, in turn, cannot be isolated from transport trends and developments in Third World nations.

The objective here is to look at car ownership in low-income countries and to seek to develop a forecasting model which offers some guidance as to what we might expect to happen in these countries into the next century. There is no pretence that the model used is by any stretch of the imagination sophisticated by modern econometric standards, but rather it seeks to be fairly general and robust with the minimum number of independent variables which themselves must be projected.

The current situation

What one means by 'low income' is to a large extent arbitrary, but in this study we define low-income countries as countries which enjoyed per capita incomes of US$3 000 or less in 1986. We also exclude, for practical reasons of comparability, small island states which because of their geography tend to have individualistic policies and patterns of car ownership. The available data, even those reported to the major international aid agencies, on vehicle ownership across low-income countries are, to put it mildly, extremely variable in their quality. In some cases they simply do not exist in a usable form which further reduces the number of countries examined or the observations for particular years are missing.

The main data employed here draw upon published sources for various years supplied in publications of the World Bank, the International Monetary Fund, the United Kingdom Society of Motor Manufacturers and Traders, the United States Department of Energy, and the International Road Federation. This is supplemented by data drawn from a variety of specific studies of trends in transport and the economies of low-income countries. The full list of countries in the forecasting exercise are set out in Table I together with details of per capita income in 1986 in $US, per capita car ownership levels and total commercial vehicle parks.

Much of the data used to develop the forecasting models relate to individual time series for each country dating back as far as 1967. Previous studies in the various fields of economic development indicate that there are significant differences in the nature of the low-income countries' economies and, therefore, a number of models subdividing the data-set are explored in the subsequent analysis[4]. This analysis itself also provides support for the stratification adopted. The countries examined are grouped into five categories which are themselves based upon car ownership rates and income levels in 1986. These are:

- A: less than 0.002 cars per person;
- B: less than 0.01 cars per person but more than 0.002, and a per capita GNP of less than $450;
- C: less than 0.01 cars per person but more than 0.002, and a per capita GNP of more than $450;
- D: less than 0.02 cars per person but more than 0.01; and
- E: more than 0.02 cars per person.

Inspection of the raw time series data for the various countries indicates that countries in categories A and B, those with very low current levels of car ownership and also low incomes, have experienced very limited growth in their car ownership per capita since the mid-1960s. In contrast, those countries which already had a somewhat higher level of per capita car ownership, and generally income, have also experienced a relatively rapid increase in the level of their per capita ownership.

This simple observation has implications for any forecasting model specification as well as highlighting the developments which are occurring in those low-income countries where income is growing more rapidly. The implications for the transport systems and the physical environments of countries in groups C, D and E is compounded when it is remembered that not only are their per capita car ownership rates increasing rapidly, but in addition their populations and cities are usually growing very rapidly as well.

The forecasting framework

Car ownership is normally seen as the main determinant of traffic growth in most low-income countries, although from an inter-urban road planning perspective freight transport can also be important. While the total car park is the key transport planning in this context, for technical reasons it is not the normal basis of forecasting models. Per capita car ownership is used as the dependent variable in the subsequent analysis both to permit easy comparisons with other studies where helpful, and also to limit the statistical problems of heteroskedasticity which can arise when employing data from countries of widely differing populations. For car-park forecasts, per capita projections can easily be grossed

Table I.

Country	Population (M) 1986	GDP (SDR) per head 1980* 1986	GNP per head ($U.S.)	Cars per head 1986	Commercial vehicles ('000) 1986
Ethiopia	43.5	84	120	0.00082	19.0
Burkina Faso	8.1	154	150	0.00198	14.0
Bangladesh	103.2	108	160	0.00048	35.0
Malawi	7.4	158	160	0.00189	17.5
Zaire	31.7	171	160	0.00284	80.0
Mali	7.6	—	180	0.00197	7.5
Burma	38.0	135	200	0.00163	45.0
Madagascar	10.6	269	230	0.00330	45.0
Uganda	15.2	1031	230	0.00211	15.0
Burundi	4.8	181	240	0.00202	7.5
Tanzania	23.0	217	250	0.00202	50.0
Togo	3.1	325	250	0.00726	12.0
Niger	6.6	346	260	0.00364	22.0
Benin	4.2	251	270	0.00417	12.0
India	781.4	199	290	0.00154	1000.0
Rwanda	6.2	177	290	0.00119	11.0
Kenya	21.2	343	300	0.00604	110.0
Zambia	6.9	513	300	0.01377	50.0
Sierra Leone	3.8	287	310	0.00612	11.0
Haiti	6.1	225	330	0.00492	14.7
Pakistan	99.2	225	350	0.00489	183.2
Ghana	13.2	1059	390	0.00417	45.0
Sri Lanka	16.1	197	400	0.00932	132.0
Senegal	6.8	382	420	0.01264	23.8
Liberia	2.3	465	460	0.00469	6.2
Indonesia	166.4	388	409	0.00628	1133.3
Philippines	57.3	565	560	0.00622	500.0
Morocco	22.5	633	590	0.02422	202.6
Zimbabwe	8.7	599	620	0.03046	80.0
Dominican Republic	6.6	956	710	0.01591	66.0
Papua New Guinea	3.4	703	720	0.00551	30.5
Côte d'Ivoire	10.7	940	730	0.01822	90.0
Honduras	4.5	541	740	0.00862	52.7
Thailand	52.6	560	810	0.01088	824.0
El Salvador	4.9	560	820	0.01990	65.0
Botswana	1.1	914	840	0.01493	24.5
Cameroon	10.5	561	910	0.00827	65.0
Paraguay	3.8	1107	1000	0.01608	30.2
Peru	19.8	653	1090	0.01964	214.9
Turkey	51.5	868	1110	0.01910	553.1
Tunisia	7.3	1029	1140	0.03714	159.0
Mauritius	1.0	935	1200	0.03512	12.0
Colombia	29.0	939	1230	0.02899	391.4
Chile	12.2	1941	1320	0.05230	263.0
Costa Rica	2.6	1684	1480	0.03269	68.0
Jordan	3.6	869	1540	0.04414	57.0
Syrian Arab Republic	10.8	1177	1570	0.01019	160.0
Brazil	138.4	1303	1810	0.07225	2100.0
Malaysia	16.1	1367	1830	0.07491	310.0
South Africa	32.3	2295	1850	0.09402	1179.9
Mexico	80.2	2078	1860	0.06484	2250.0
Uruguay	3.0	2129	1900	0.06667	100.0
Hungary	10.6	1639	2020	0.14518	189.1
Portugal	10.2	1879	2070	0.12118	525.0
Yugoslavia	23.3	1864	2250	0.12498	301.2
Panama	2.2	1469	2300	0.06364	43.6
Argentina	31.0	4087	2330	0.12574	1434.7
South Korea	41.5	1182	2350	0.01601	627.2
Algeria	22.4	1476	2370	0.03237	458.0
Gabon	1.2	2962	2590	0.01496	17.5
Greece	10.0	2991	3080	0.13011	625.0

*The 1980 GDP figures are expressed in the international unit of account, the Special Drawing Right (SDR), used by the International Monetary Fund to reduce the effects of floating exchange rates in international transactions. In December 1980 1 SDR was equivalent to US$1.28 or £0.53. In December 1986 1 SDR was equivalent to U.S$1.22 or £0.83.

up by applying forecasts of demographic changes.

Developing a forecasting framework for car ownership requires an initial analysis of the influences which affect ownership. The slow growth in car ownership in the lowest-income countries observed from the base data, coupled with the much more rapid rises in those countries which exhibit both higher existing levels of car ownership and of per capita income, suggests the use of a non-linear forecasting framework. A limited amount of work employing aggregate data looking at car ownership levels across various low-income countries, and also at differences between them and industrialised nations, has been conducted in the past using linear and log-linear specifications[5]. This type of specification, though, tends to ignore the ultimate saturation level towards which, following standard product-life cycle theory[6], the consumption of all commodities tends. A function which flattens out towards some asymptote is, therefore, preferred on these theoretical grounds in addition to the fact that it corresponds to the pattern which emerges from the categorised data discussed above.

A variety of possible sigmoid-shaped functions could be applied to meet the general requirements of the model. The main modelling thrust employed here uses the aggregate quasi-logistic approach which has in the past been used for both local and national level forecasting in industrialised countries. The model is easy to calibrate, flexible and relatively straightforward to interpret. It has also proved useful in earlier work in less developed countries conducted at the national, case-study level[7].

If we take P as the probability of an individual owning a car, S as the ultimate saturation level of car ownership per capita, $X_1, X_2, \ldots X_n$ as a set of socio-economic influences on ownership and $a, b_1, b_2 \ldots b_n$ as parameters, then the model can be depicted as:

$$P = \frac{S}{1 + e^{-a} X_1^{-b_1} X_2^{-b_2} \ldots X_n^{-b_n}} \quad \ldots (1)$$

Manipulating and converting Equation (1) into logarithmic form yields the operational model set out as Equation (2). Values of P for estimating purposes become the actual levels of per capita car ownership for each country. The values of the parameters can then be determined by linear regression procedures, i.e. applying least-squares techniques[8] to:

$$ln\left(\frac{P}{S-P}\right) = a + b_1 lnX_1 + b_2 lnXn + \ldots b_n lnXn \quad \ldots (2)$$

While the saturation level has been the subject of a number of different theoretical interpretations over the years, here it is seen as no more than a technical aid to improving the quality of the ultimate forecasts generated. Surveying the work which has been conducted in industrialised countries one finds levels of saturation ranging from 0.4 to 0.7. Before adopting these, or similar figures, for low-income countries one should note that there is considerable evidence that different countries, and indeed regions within countries, seem ultimately to be heading for different saturation levels[9].

When modelling car ownership for the five groups of countries various saturation levels are adopted. These are based on both examination of the existing patterns of growth and on techniques for estimating saturation developed by Tanner[10]. Since the ultimate saturation level is some distance away, especially in the lowest-income countries, the level of uncertainty involved in estimating long-run saturation is large. Further, for forecasting one also needs to take into account the fact that the data suggest the saturation level moves up with time. Therefore, levels in the range 0.3 to 0.45 per capita are assumed for S and estimations of other parameters, together with subsequent forecasts, are based upon this range.

Turning to the other explanatory variables, there are empirical reasons to suspect that the relationship between car ownership and the major causal variables is not stable through time. This is consistent with the findings, based on a large sample of developing countries, of a shift in the linear relationship between per capita car ownership and per capita GNP between 1965 and 1973[11]. Strictly comparable updatings of these calculations are not possible; however, taking the data-set for the countries in this study and repeating similar linear regressions in constant 1980 prices for the years 1967, 1973 and 1983 provides evidence that this shift has continued. In technical terms it suggests that some variable (or variables) is being omitted from the analysis. Identification and quantification of this variable poses intractable practical problems. In order to capture some of its effect, however, a time trend *(T)* is included in the forecasting models used here (with T=1 for 1967).

Cross-sectionally countries vary in many ways which are impossible to quantify. But even if one could isolate variables which capture this national uniqueness, it is unlikely that their future values could be predicted and hence used directly in a car ownership forecasting context. In order to take account of these specific, national features a set of dichotomous, dummy variables *(D)*, one for each country, is included in the model. These take the values of unity if an observation relates to a country and zero otherwise.

Having taken these factors into account, the resultant pooled equations relate per capita car ownership for all countries in the data-set and for all years to the GDP of the countries at constant prices *(Y)*, a dummy variable *(D)* which takes up the effect of specific national deviations from the general car ownership income relationship, and a time trend. The operational form of the model thus becomes:

$$ln\left(\frac{P}{(0.3\sim0.45)-P}\right) = a + \sum b_j lnY_j + \sum c_k lnD_k + t lnT \quad \ldots (3)$$

The main independent variable influencing per capita vehicle ownership at the national level is income. There is some evidence that income changes may exert a lagged effect on vehicle ownership [12], but, given the problems of specifying the appropriate lag structure, current income is used in the model. Additional variables which may influence vehicle ownership include: the price of fuel, the level of urbanisation and the degree of industrialisation. The importance of such variables are explored, but there are inevitable problems of multicollinearity. They are, therefore, generally excluded from the main forecasting models.

Parameters

The income variable employed is adjusted to 1980 prices and standardised to allow for exchange-rate effects. Current income levels are used and no lagged structures are included. A simple tabulation by category of per capita income against per capita car ownership for all the countries in the study over the period (Table II) confirms the positive relationship which has been found in most other studies of car ownership be they in industrialised or in developing countries.

Using per capita income in the pooled quasi-logistic model (i.e. Equation (3)) for the five categories of low-income countries defined above confirms the importance of income. The result equations are set out in Table III (excluding the set of values for the country-specific dummy variables, D_i). The explanatory power of all the models is high, the coefficients are significant and all coefficients take the expected sign. Further, comparisons between the quasi-logistic specification and an alternative log-linear model indicates a considerable degree of similarity. This suggests that the saturation levels adopted are unlikely to be dominating the quasi-logistic results.

Table IV provides details of the coefficients associated with the D_j variable in the quasi-logistic specification. These indicate the degree to which the quasi-logistic relationship differs between countries. For forecasting purposes, when predicting per capita car ownership for any individual country the appropriate dummy is added to the constant term in the quasi-logistic model.

In addition to income a variety of other variables may be thought to exercise some influence on the magnitude and pattern of car ownership and some comments are offered regarding a number of these.

The parameters estimated for the quasi-logistic equations set out in Tables III and IV include a time variable as well as income (with T=1 in year 1967). The variable proves to be statistically significant at the 5 per cent level and to exert a positive effect on car ownership, i.e. it conforms to the empirical findings of earlier Transport and Road Research Laboratory work and to the linear cross-section results cited above. The broad implication of this, in the context of the specific specification of the time trend effect included in the model, is that over time car ownership at each income level will rise, although the marginal effect of this time factor decreases with the years. One should caution against

Table II.

Cars per capita	Gross Domestic Product per capital (Special Drawing Rights)									
	<101	101-250	251-500	501-750	751-1000	1001-1501	1501-2000	2001-2500	2501-5000	>5001
>0.0220				39	29	99	97	39	114	14
0.0200-0.0100			22	80	56	27	10		4	14
0.0100-0.0067		22	67	44	12	15		2		3
0.0067-0.0050		9	54	26	9	13	1	1	3	
0.0020-0.0030		37	23	16	1	6				
0.0030-0.0025		33	15		2	1	4			
0.0025-0.0020		38	4	2	4	10	2			
0.0020-0.0013	4	53	3	2		1				
0.0013-0.0001	7	46	1							
<0.0001	10	29	1							

Table III.

Country grouping	Constant (a)	Income* (b)	Time (T)	Assumed saturation level	Adjusted coefficient of multiple determination
A	–8.70 (0.982)	0.571 (0.191)	0.109 (0.026)	0.30	0.84
B	–8.24 (0.431)	0.699 (0.076)	0.103 (0.015)	0.35	0.90
C	–9.83 (0.039)	0.943 (0.066)	0.088 (0.000)	0.35	0.82
D	–11.80 (0.887)	1.100 (0.138)	0.261 (0.032)	0.40	0.67
E	–10.74 (0.741)	1.160 (0.112)	0.244 (0.023)	0.45	0.90

*Income is GDP per capita expressed in 1980 constant prices in SDRs for Time, $T = 1$ in year 1967

Table IV.

Group A		Group B		Group C		Group D		Group E	
Ethiopia	0.464	Malawi	–0.564	Liberia	0.156	Zambia	0.910	Morocco	–0.271
Burkina Faso	0.337	Zaire	–0.351	Indonesia	–0.436	Dominican Republic	0.420	Zimbabwe	0.059
Bangladesh	–0.910	Madagascar	0.085	Philippines	0.046	Côte D'Ivoire	0.320	Mauritius	–0.544
Burundi	0.134	Uganda	–1.950	Papua New Guinea	–0.501	El Salvador	0.755	Chile	–1.033
Burma	0.248	Tanzania	–0.653	Honduras	–0.23	Peru	0.995	Costa Rica	–0.870
India	0.000	Togo	–0.041	Thailand	0	Turkey	0.000	Brazil	0.000
Rwanda	–0.123	Niger	–1.040	Botswana	–0.435	Tunisia	0.720	Malaysia	–0.280
		Benin	–0.148	Cameroon	–0.296	Colombia	0.630	South Africa	–0.150
		Kenya	0.000	Paraguay	–0.42	Jordan	0.875	Mexico	–0.712
		Sierra Leone	0.420	Syrian Arab Republic	–0.745	Algeria	0.141	Uruguay	–0.520
		Haiti	–0.110			Gabon	–0.720	Hungary	0.030
		Pakistan	–0.473					Portugal	0.380
		Ghana	–1.060					Yugoslavia	0.063
		Sri Lanka	0.603					Panama	–0.310
		Senegal	0.399					Argentina	–0.660

reading more into the coefficients than this since the nature of the specification was selected for purely statistical reasons — i.e. to provide a good fit to the historic data — and the results are sensitive to the year chosen to be set equal to unity.

In the past a number of commentators have observed that much of the growth in car ownership in developing countries occurs in urban areas[13]. In terms of the percentage of population living in urban areas, the statistical analysis of low-income countries reveals no consistent overall relationship with per capita car ownership. What one does find, however, is that for many individual countries there does seem to exist a positive, linear relationship between car ownership and level of urbanisation. Technically it is possible to extrapolate, using these linear models, future levels of car ownership in relation to urban growth for countries which have in the recent past exhibited a consistent relationship between the two. Caveats should, however, be attached if this is to be done. First, the link between car ownership and urbanisation emerges as being very location-specific and, hence, questions of its generality and temporal stability arise. Second, in higher-income countries there is evidence that urban areas exhibit lower car ownership levels than in rural areas, suggesting that a linear relationship may flatten out and possibly turn down as development progresses[14]. Third, levels of urbanisation are themselves extremely difficult to predict in the medium and long term and they are highly correlated with other factors such as income levels, which can lead to problems of multicollinearity in more extended models of car ownership.

The progressive shift away from agriculture to manufacturing and service industries is changing the aspirations and attitudes of many people in low-income countries. For modelling and forecasting purposes, however, the high correlation of the industrial mix of the labour force with such variables as income and urbanisation makes it difficult to isolate its specific impact. Also, graphical examination of the data-set suggests that in practice the correlation between car ownership and industrial mix is, in any case, in practical terms very small.

Forecasts

Forecasting involves making use of the model developed above and feeding into it predicted values of the independent variates (i.e. income and time). Here, for reasons of tractability, we focus on only the forecasts for a selection of countries from the total database.

The major exogenous variable in all forms of vehicle ownership forecasting is income. This is itself, however, difficult to predict with any accuracy even for a short period. Bodies such as the World Bank, Asian Development Bank and other agencies provide periodic forecasts of the anticipated future growth rates for low-income countries, but, because they are regularly updated and modified, no single projection represents a stable input for transport forecasting purposes.

The approach adopted is, therefore, to employ sensitivity analysis and to offer a range of projections of future growth in per capita car ownership based upon alternative scenarios of how income may change in the future. The assumed rates of growth in per capita income are 0 per cent, 1 per cent, 2 per cent, 3 per cent and 4 per cent. These cover the range of predictions made by the major international institutions in recent years, with figures in the 2 to 3 per cent range being regularly given.

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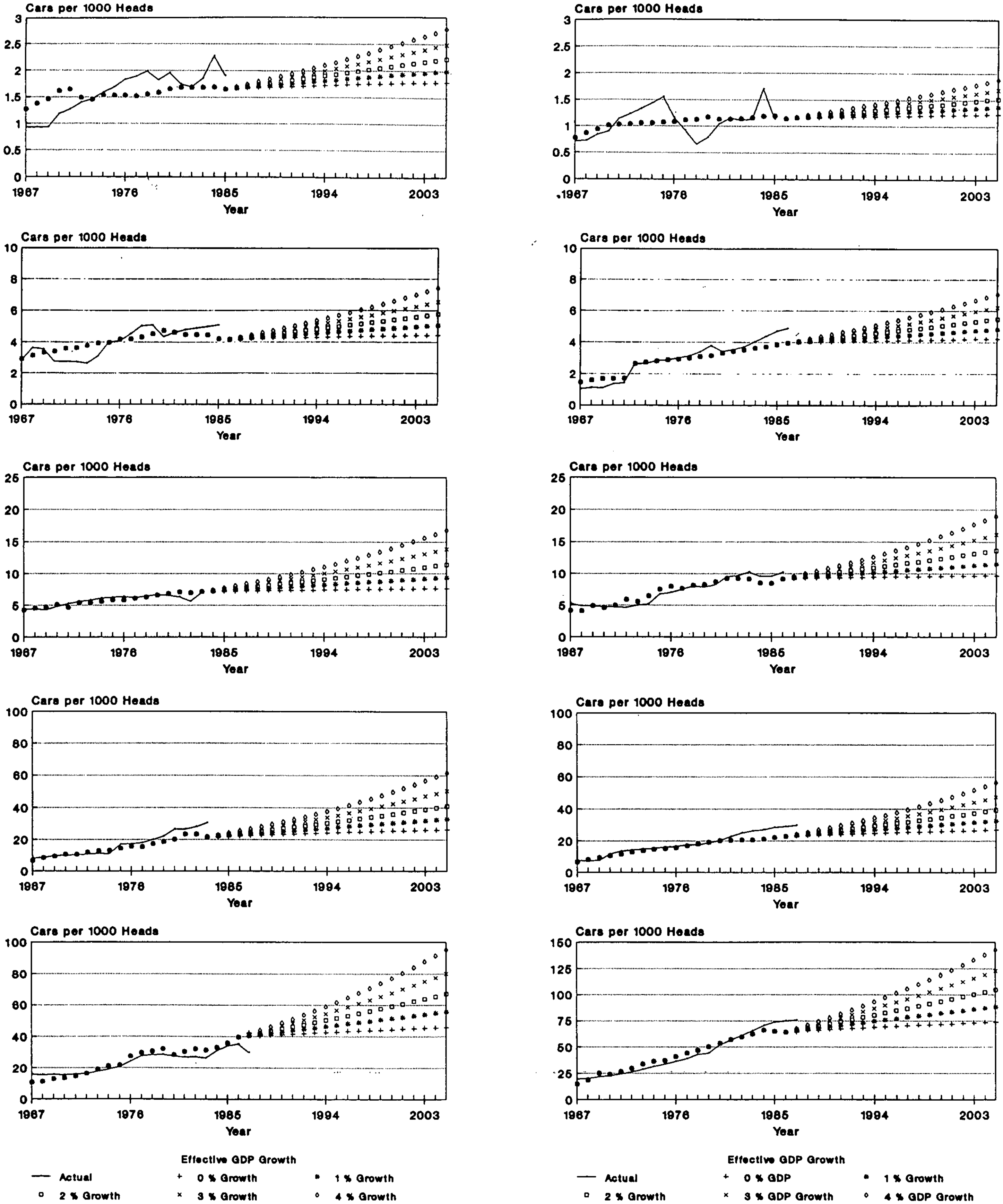

Fig 1. Plots of actual, modelled and forecast levels of cars per 1 000 head of population for these selected countries:

- *Burkina Faso*
- *Rwanda*
- *Haiti*
- *Pakistan*
- *Cameroon*
- *Syrian Arab Republic*
- *Algeria*
- *Colombia*
- *Mauritius*
- *Malaysia*

Forecasts are based upon assumed growths in GDP of 1, 2, 3 and 4 per cent.

The results for a selection of countries (including representatives from each of our five broad groupings) set out in terms of cars per thousand population are seen in the various components of Fig 1. Actual car ownership levels per thousand head of population for the period from 1967, together with the levels predicted by the model, are also shown for comparative purposes.

Noting the scale on the vertical axes, the overall picture which emerges is that even on fairly conservative assumptions regarding income growth, many low-income countries in our groups C, D, and E will experience very considerable growth in per capita car ownership in the medium term. In contrast the very poorest countries, using similar assumptions regarding income growth, will

Table V.

Country	Assumed annual rate of per capita income growth	Index of total national car park (1986=100) 1986	2000	2025
Burkina Faso	1%	100	143	286
	4%	100	183	394
Rwanda	1%	100	177	499
	4%	100	224	951
Togo	1%	100	149	335
	4%	100	205	751
Haiti	1%	100	96	161
	4%	100	128	351
Pakistan	1%	100	148	340
	4%	100	196	739
Cameroon	1%	100	162	440
	4%	100	255	1309
Gabon	1%	100	215	632
	4%	100	355	1922
Algeria	1%	100	141	341
	4%	100	232	1000
Mauritius	1%	100	146	209
	4%	100	219	544
Malaysia	1%	100	149	284
	4%	100	216	628

have much less dramatic rises in per capita car ownership[15].

In terms of national car parks, projections of population levels need to be applied to the national per capita car ownership forecasts. Demographic forecasting for low-income countries is as difficult as car ownership forecasting and a variety of forecasts could be adopted. Here we use World Bank predictions of populations for the years 2000 and 2025 to provide a feel for the actual implications for the transport systems of the growth in vehicle numbers. The results of applying these projections to our models produce the car ownership forecasts, with 1986 as a base, for selected countries, shown in Table V.

As can be seen, the countries with relatively high car ownership levels at present can expect, by historic standards, fairly rapid increases in their parks even if their income rises by quite modest amounts (i.e. 1 per cent per capita per annum) in the medium term. A substantial part of this trend comes from the projected increase in population levels which, in some cases, exert a stronger influence on the car-park forecasts than does the predicted rise in per capita ownership. The projected tripling of the population of Gabon by the year 2025 and a more than tripling for Rwanda are examples of the importance of the demographic factor in national car park forecasting.

While presenting the sample forecasts in index form offers insights into differing growth rates it does tend to obscure the actual magnitude of the pattern which emerges. If one makes the relatively conservative assumption of a 1 per cent annual growth in per capita income to the year 2000, for example, Malaysia will have an extra 0.59M cars, while if annual income per capita rises by 4 per cent, slightly above the Asian Development Bank's prediction, it will have 1.63M extra cars. The Cameroon, on the same basis, would find its car park rising from 0.09M vehicles to 0.14M on a 1 per cent annual income rise assumption and to 0.22M on a 4 per cent annual income rise assumption. Given their transport infrastructures, these are very significant numbers of cars for these countries to cope with, especially since their numbers are forecast to rise relatively rapidly.

Conclusions

Simple examination of trends over the past 20 years shows clearly the rapid increase in car ownership which is emerging in many low-income countries as their prosperity gradually begins to grow and the aspiration of their populations for cars grows even faster. While at the lowest income per capita vehicle ownership is static or falling, at high income levels it appears to be following the classic sigmoid-shaped growth path which has been observed in industrial states. The increase in the overall car park moves ahead of the rate of increase in per capita car ownership as populations expand.

Surprisingly little detailed study has been made of the exact nature of the underlying relations influencing both vehicle numbers and their use in low-income countries. One of the major difficulties in this type of work is to establish a reliable and consistent database. This has been attempted here, although it is clear that deficiencies exist in both the coverage and quality of the data employed and this must be taken into account when assessing the forecasts.

Notwithstanding the data limitations the study has generated model results which are both intuitively reasonable and cross-reference well with the limited work conducted elsewhere. It indicates that as low-income countries become more prosperous there is an inevitable and rapid rise in their car ownership rates. Reinforcing this income effect there is also a separate temporal effect as car ownership levels at any given level of income rises over time. This may be due to a variety of factors and is not fully understood but, from a forecasting and transport planning perspective, it inevitably adds to the ultimate growth in traffic volume.

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