David Hilling (1996) Transport and Developing Countries. London: Routledge, pp. 1-29.

1
TRANSPORT AND DEVELOPMENT

> Many factors contribute to economic and social progress, but mobility is especially important because the ingredients of a satisfactory life, from food and health to education and employment, are generally available only if there is adequate means of moving people, goods and ideas.
>
> (Owen, 1987)

This means transport. Few would disagree with Owen's broad conclusion regarding the relationship between transport and the development process although the precise nature of the interaction is far from clear. Much of the evidence from empirical sources is contradictory (Howe and Richards, 1984) and this has spawned considerable debate and a vast literature—'there are few clear statements of the ways in which the variable components of transport improvement and economic advance are related' (Pawson, 1979).

THE TRANSPORT GAP

It is easy to demonstrate that at the global level there are vast differences in the availability of transport, indeed, that there is a stark contrast between a relatively immobile Third World and the highly mobile advanced economies (Owen, 1964, 1987). Large parts of the Third World are characterised by lack of year-round mechanised transport and movement is by unreliable, high-cost, labour-intensive methods. Much of the infrastructure is poorly maintained and in disrepair and is inadequate for present needs without the complication of growth of demand in the future. The skills and resources necessary to upgrade the transport are usually lacking. The majority of the population live in spatially circumscribed local socio-economic systems and a relatively static state in which immobility and poverty are clearly related (Owen, 1987).

In the advanced economies recent years have seen a transport revolution with the advent of cheap, mass air travel, high and rapidly rising levels of personal mobility based on car ownership and containerisation of general freight with

associated concepts of intermodalism, just-in-time delivery and restructured distribution channels. All of this has encouraged new levels of internationalisation in industry and commerce and for the favoured the world has shrunk to village scale. For the villager in the Third World little has changed.

The global discrepancies in transport provision are represented in Table 1.1 from which it can be seen that the 'developed' regions of North America, Europe and Oceania have 26.0 per cent of the earth's land area, 15.1 per cent of the population but account for 60.2 per cent of the world's commercial vehicles, 74.6 per cent of the cars and 53.6 per cent of the rail freight. In sharp contrast, Africa, Central and South America and Asia have 57.5 per cent of the area, 79.4 per cent of the population but only 39.4 per cent of the commercial vehicles, 20.4 per cent of the cars and 22.5 per cent of the rail freight. Central and South America has vehicles roughly in proportion to its population but Africa emerges overall as an area of serious under provision. Japan accounts for 64 and 67 per cent respectively of Asia's commercial and passenger vehicles and excluded from the totals leaves that area with a grave deficiency

Table 1.1 The global transport gap, 1990 (% of world total)

	Area	*Population*	*Commercial vehicles*	*Passenger vehicles*	*Rail freight*
North America	16.1	5.2	40.1	35.2	40.9
Europe	3.6	9.4	18.2	37.4	12.2
Oceania	6.3	0.5	1.9	2.0	0.5
Former USSR	16.4	5.7	0.2	4.8	23.9
Central and South America	15.1	8.5	8.7	6.7	3.7
Africa	22.2	12.1	3.5	2.0	3.1
Asia (excluding Japan)	20.2	58.8	27.4 (9.7)	11.7 (3.8)	15.7

Source: United Nations Statistical Yearbook

Table 1.2 Vehicle stock growth rates (percentages)

	Commercial vehicles			*Passenger cars*		
	1951–1971	*1971–1990*	*1951–1990*	*1951–1971*	*1971–1990*	*1951–1990*
World	350	230	750	370	220	790
North America	210	220	480	230	150	350
Europe	320	190	630	1,050	230	2,360
Asia (excl. Japan)	560	500	2,830	740	440	3,290

	Commercial vehicles			*Passenger cars*		
	1951–1971	*1971–1990*	*1951–1990*	*1951–1971*	*1971–1990*	*1951–1990*
Central and South America	330	470	1,570	640	520	3,340
Africa	490	300	1,470	550	260	1,420

Source: United Nations Statistical Yearbooks

Between 1951 and 1990 (Table 1.2) the world total of commercial vehicles and cars grew by 750 and 790 per cent respectively, with rather slower growth in the second half of the period. Starting from a high base, growth in North America was well below the world average as was European growth in number of commercial vehicles. However, European car numbers expanded very rapidly, especially in the first two decades. Indeed, over the 40-year period the North American share of vehicles has declined, as has that of commercial vehicles in Europe. For all developing regions the growth in both categories has been far in excess of the world average and their share of the world total has also increased. Africa again emerges as the lagging region. Yet despite these growth rates, the gap between the mature economies and the Developing Countries is still vast and there is no prospect of this gap being narrowed significantly in the foreseeable future.

The gap is just as dramatic with respect to rail transport and while industrialisation in most of the developed countries was based on the expansion of railways there are many Developing Countries, especially in Africa, which will never have a 'railway age' in their development profile (Chapter 3).

Owen (1964) devised an index of travel and freight mobility which he applied to a range of countries for the late 1950s and this he updated for his later work on mobility and development (Owen, 1987). A selection of the countries is shown in Table 1.3. The index of freight mobility was based on length of rail line per 100 sq km, rail lines per 1,000 population, surfaced highways per 100 sq km, ton-miles per capita and commercial vehicles per capita. The passenger mobility index was based on passenger miles per capita, cars per capita and railways and highways as for the freight index. In each case Owen related the indices to a base of 100 for France. Owen concluded that over the 20-year period there had been a widening of the gap between rich and poor although there had been some increases in freight movement in countries near the bottom of the scale. There had been little or no improvement with respect to passenger mobility and it was on the basis of these calculations that Owen distinguished between the contrasting worlds of the mobile rich and the immobile poor.

An index of transport which combines aspects of passenger and freight movement and for comparative purposes retains the base of 100 for France

Plate 1.1 Transport is an all-pervasive input in the development process and in many Third World countries is labour intensive and the infrastructure is unsophisticated and poorly developed (Photo: Intermediate Technology).

(Table 1.3) shows that the relative position of the immobile poor has continued to decline although there has been increased mobility in countries such as South Korea, Brazil and Thailand which have been moving into the Newly Industrialising category. The available statistics are incomplete, far from accurate and produce anomalies but nevertheless suggest a broad relationship between levels of income and mobility especially at the upper and lower ends of the range. The figures for the earlier years also suggest that freight movement was being given greater emphasis than passenger transport and it can be argued that this was ignoring a critical ingredient in the development process. However, in many Developing Countries the distinction between freight and passenger transport is far from clear and for them this blurring provides justification for merging the indices for passenger and freight mobility, as has been done in Figure 1.1.

That there is a link between levels of income and mobility would seem undeniable and it is but a short step to suggest that this is a causal relationship and that transport therefore has a special place in the development process. This was summed up in the oft-quoted contention that 'the material development of Africa may

Table 1.3 Indices of mobility for selected countries (base France 100)

	1957–8[a]			*1980*[b]			*1990*[c]	
	GNP per capita	*Travel mobility*	*Freight mobility*	*GNP per capita*	*Travel mobility*	*Freight mobility*	*GNP per capita*	*Transport index*
Canada	150	149	223	95	114	374	133	136
Sweden	131	93	105	119	96	151	108	81
France	100	100	100	100	100	100	100	100
West Germany	105	99	91	117	101	57	105	70
UK	104	86	94	63	78	47	97	64
Netherlands	77	58	69	101	83	42	94	67
South Korea	—	—	—	15	8	16	46	31
Egypt	9	8	9	5	5	13	22	12
Brazil	14	20	20	18	18	23	18	25
Mexico	23	23	28	15	14	42	17	16
Venezuela	—	—	—	31	24	36	17	26
Chile	32	36	38	—	—	—	15	21
Argentina	28	68	64	24	32	114	13	35
Colombia	21	9	11	11	6	47	10	14
Thailand	7	8	7	—	—	—	9	12
Bolivia	8	18	20	—	—	—	7	12
India	6	12	10	2	5	26	2	9
Ghana	15	10	10	—	—	—	3	3
Ethiopia	3	2	2	1	2	3	2	1
Bangladesh	—	—	—	1	2	3	2	2

Notes: a From Owen, 1964
b From Owen, 1987
c Based on surfaced roads per sq.km., vehicles per 1,000 population, rail travel per person per year, rail tonne-km freight per 1,000 population, domestic air km per person per year
Source: Based on United Nations Statistical Yearbooks

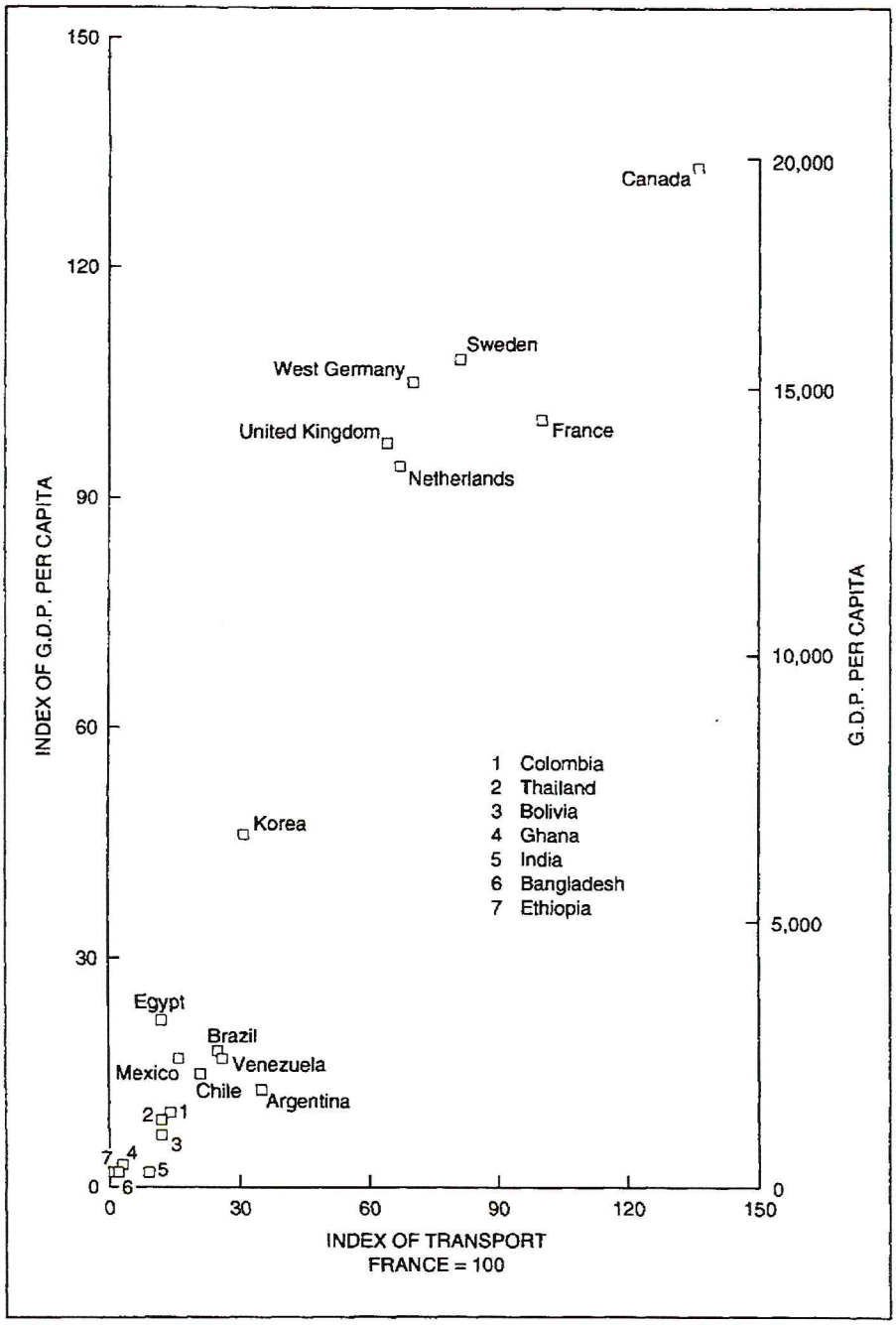


Figure 1.1 Indices of transport

Source: Calculated from UN Statistical Year Book (1990, 1991)

be summed up in one word—transport' (Lugard, 1922). Leaving aside doubts about the emphasis on material development, this simplistic interpretation of the role of transport undoubtedly found expression, post-1945, in international and national development strategies. For the United Nations transport provided 'the formative power of economic growth and the differentiating process' (Voigt,

1967) and a lack of transport was seen as 'a major deterrent to rapid economic growth and social progress' (United Nations, 1967).

In response, some 40 per cent of World Bank loans in the 1960s went to transport projects and in many Developing Countries in the 1950s and 1960s transport investment formed an even higher proportion of fixed investment (Bejakovic, 1970). Having designated the years 1968 to 1978 as World Development Decade, and possibly dissatisfied with the outcome, the United Nations then embarked on the Transport Decade (1978–1988). In 1994 transport was again selected for special treatment by the world body. There is almost daily evidence of the inadequacies of transport systems to deal with the special conditions created by drought, famine and political conflict but also a persistent feeling that a root cause of these conditions is lack of development and therefore the need for better transport. There is clearly a real danger that the argument becomes circular. At the heart of the debate is the question of which comes first —development or transport? To this chicken-egg argument it has been suggested that there is only one honest answer—'we do not know but probably both come first' (Lowe and Moryadis, 1975).

A more useful response may well be that the transport-development relationship is both time- and place-specific. There can be no universally applicable model but rather a range of local variants deriving from particular conditions of geography, history, politics, economics and culture.

DEMAND- AND SUPPLY-LED MODELS

To suggest that transport leads to development is to adopt a supply-led approach and there is a school of thought which argues that at early stages in the development process, and by implication in many Developing Countries, it is the provision of transport which leads to widening of markets, increased production and associated multiplier effects of an economic and social nature (White and Senior, 1983). This is the traditional view of transport although for many development planners transport became just one element in a range of 'infrastructure' which also included energy, health, housing and education—expenditure on such essentials being classed as Social Overhead Capital. This capital was invested in anticipation of the development which it was thought would follow.

There are certainly many cases where development could be seen to follow the provision of transport—the new railway lines into the then Gold Coast (1903) and Northern Nigeria (1912) stimulated spectacular expansion of cultivation for export—cocoa in the case of the former and groundnuts in the latter (Mabogunje, 1980). Leinbach (1975) demonstrated the significance of transport for the stimulation of rubber cultivation and tin mining in Malaya while the opening up of Amazonia, for better and for worse, followed the construction of access roads into isolated forest areas and associated expansion of agriculture, forestry and mining (Kleinpenning, 1971).

An alternative view is that transport provision is invariably a response to demand and it is rarely developed except where there is a demand. Indeed, it can be argued that even in the supposedly supply-led situations cited above there was also a crucial and possibly more important demand factor operating. Demand for transport is of several distinct forms. Most obviously there is the *revealed demand* as expressed in the journeys that are actually made or the goods that are transported—the use that is being made of the existing infrastructure. However, at any place and at any point in time there is likely to be an element of *latent demand*—this comprises components of the existing demand which cannot be satisfied perhaps because of inadequacies in the infrastructure or prohibitive cost and which might be called delayed demand, and also completely new demand that may be created by additional or improved infrastructure. To revert to the previous examples, development followed transport because there was a latent demand—there was a market for the produce if the transport gap between producer and consumer could be closed.

What in fact is in question here is the existence or otherwise of what a number of writers have called prior-dynamism (Wilson, 1973; Leinbach, 1975). Pawson (1979), in a similar vein, refers to the set of conditions creating a need for transport innovation. These conditions could include the availability of readily exploitable natural resources, the existence of entrepreneurs and the absence of restrictions of a political or economic kind (Wilson, 1973)—overall, an environment in which economic opportunity can be exploited. In other words, transport will have its most obvious impact on development where there is some latent demand or prior dynamism.

It is for these reasons that the supply-led models of transport must now be viewed with some caution. The cyclical innovation theory of Schumpeter (1934) in which expansion was seen to follow great innovations (e.g. the steam engine) which were the prime movers in the growth process and Rostow's stages of growth theory (Rostow, 1960) in which railways were seen as the most powerful initiators of economic take-off, clearly elevated transport to a special, even unique, role in the development process. There can be no doubting the powerful impact of railway building on the development process in many countries (see Chapter 3) and many have argued for a causal linkage (Jefferson, 1928; Rostow, 1960). However, it has also been argued that the cost of rail transport in nineteenth century North America gave it little advantage over other modes and it was not therefore indispensable (Fogel, 1962) and that the development of the railways followed rather than led to growth in other sectors. Fishlow (1965) in contrast argued that the railway was the critical element in the economic transformation of North America.

As defined above there can in fact be few places where there is not some element of latent demand and where all demand is already satisfied. However, what is not clear is whether the existence of such demand is in itself an adequate reason for transport to be developed. We are possibly in error in viewing transport simply in terms of demand and economic activity. Long ago it was

pointed out that 'there can be no adequate theory of transport which has regard only to...the economic aspect...one must examine severally its relations to various social institutions— military, political, economic, ideal' (Cooley, 1894). Certainly in the case of some of the early African examples already noted the railways were built to penetrate hinterlands and so demonstrate the effective control required by the Congress of Berlin as a condition for laying claim to colonial territory and in a country such as Brazil improved transport has been a means of consolidating the political control by central government (Dickinson, 1983).

While transport provided in response to non-economic stimuli may well have been successful on its own terms the broader impact on economic development does in all probability depend on the existence of latent demand. Given the parsimony of most colonial regimes it was vital that even politically motivated transport developments should pay their way (Mabogunje, 1980) and not be a burden on the colonial government and there was invariably one eye on the potential traffic and revenue earning capacity. This was certainly true of Ghana's railway and it was a considerable element of latent demand which led to the rapid and profound economic impact of many of the early African railways.

In contrast, it is also the case that some of Africa's recent railway construction has been conspicuous for its lack of impact— Nigeria's Bauchi extension of the 1960s and the northern extension of the Cameroon railway in the 1970s provide obvious examples. It seems clear that transport of itself will not necessarily result in economic development, or as Owen (1964) has argued, it is a necessary but not sufficient factor. It has been claimed that this is equally true of many of the other ingredients in the development process (capital, technical ability, education, natural resources) and that it is not therefore a very helpful idea (Wilson, 1973). However, it is helpful in pointing to the idea that development is based on a range of inputs and is most likely to take place where these are considered not separately but as part of a package and planned in a coherent way. This is certainly how transport should be viewed because it is rarely an end in itself and the demand derives from other sectors of economic and social life.

Gauthier (1970) distinguishes three possible relationships between transport and development. The first he terms *positive*— where an innovation in transport is demonstrably responsible in a direct way for expansion of economic activity. The second is the *permissive* effect where transport does not itself stimulate economic growth but is such that it does not inhibit such growth when other stimuli are operating. The third relationship may be classed as *negative*—the situation in which the returns on investment in transport are less than from the same investment in directly productive activity with the possibility of an actual decline in per capita income. Transport projects can be very demanding of capital and with borrowed money, high interest rates and only very slow or even negligible generation of income they can very easily have a negative impact. It is of course for this reason that Developing Countries can ill afford mistakes in the provision of transport infrastructure.

Adler (1971) has argued along similar lines in classifying transport projects. There are cases where the transport is an integral part of a development project and in which the emphasis is on the whole project and the adoption of least-cost transport solutions. The development of the LAMCO railway in Liberia for the evacuation of iron ore to the exporting port provides an example (Chapter 3). There are also situations in which all other requirements are satisfied and only suitable transport is lacking—this is rather a case of prior dynamism. Finally, Adler identifies those situations in which transport is built into an area of promise and where other investments will have to take place if development is to follow. Arguably, such 'act of faith' transport provision will rarely be justified unless other investments are made.

A related idea is that all productive activity requires some infrastructure, including transport, before it can become operational and this either exists as surplus capacity or it must be provided. Development by surplus clearly equates with the supply-led situation described above and if there is some surplus capacity there is always the possibility that 'footloose' investments in economic activity can be accommodated. Arguably, it is always wise to ensure that there is just enough surplus capacity to provide for reasonable anticipated growth. In contrast, development by shortage depends on a build up in demand with the possibility that infrastructure is not provided until demand justifies it but directly productive activity is not established until the necessary infrastructure is available —another of the vicious circles which bedevil life in Developing Countries (Hilling, 1978). Pawson (1979) probably comes as close as anyone to providing a satisfactory explanation of the transport-development relationship. His starting point is a set of conditions which create the need for transport innovation. There then comes the adoption of a transport innovation which over time is likely to diffuse spatially. Without going into the reasons, this diffusion process is likely to be very uneven spatially—it is easy to find examples of this in canal, railway and surfaced road networks and technologies like containerisation. There will then be the impact of the transport in stimulating both forward and backward linkages. The forward linkages are the developments which result from transport innovation (e.g. farmers changing to cash crop production alongside a new or improved road) while the backward linkages are the multipliers resulting from the transport (e.g. the impact of railway construction on the demand for iron and steel, coal and engineering industries).

It was these backward linkages which persuaded Rostow (1960) of the leading role of railways in the take-off to sustained growth in countries such as the United States, Britain and Russia. However, even in these countries the railways never consumed more than about 20 per cent of the iron produced (Pawson, 1979) and it is now generally accepted that the Rostow stages of growth model is a far from satisfactory basis for explaining the progress of development in the Third World. The conditions of nineteenth century Britain are not replicated in Developing Countries—most obviously they may have to import everything that they need to build a railway system and this greatly reduces, although does not

necessarily eliminate, the possibility of backward linkages. India is one of the few Developing Countries in which railways have had a considerable backward linkage effect, and is now able to sell its expertise and technology to other countries.

In practice there are few Developing Countries with railway systems of a size to justify the development of substantial backward linkages even if they have the technology and resources to do so. It is worth noting at this point that in contrast road transport has been more successful in this respect and in many Developing Countries there is a considerable 'shade-tree mechanics' industry and a number of countries have moved into vehicle assembly with varying degrees of local production of components of the more basic type and in suitable environments have started rubber cultivation to feed rubber and tyre producing factories—Ghana has done this.

Given the global trading situation it is not now easy for Developing Countries to create backward linkages of the type and on the scale which followed railway construction in what are now the developed countries although the possibilities in activities related to road transport hold out more promise. The main hope must rest with the forward linkages and these in effect constitute what has been identified as latent demand.

TRANSPORT AND FORWARD LINKAGES

It is relevant in this context to ask what is meant by development? For all too many, development has been synonymous with *economic growth* and measurable in terms of indices such as per capita income. Growth may simply mean more of the same and says nothing about change in structures whether economic, social or political. Many others have concentrated on *modernisation,* an idea espoused particularly by geographers who could map the diffusion of modernising behaviour—often emphasising material possessions such as telephones, televisions, radios and cars or the use of banks, schools, cinemas, medical or educational services (Leinbach, 1976). Some saw this as an undesirably Eurocentric approach to development questions and argued that development should be concerned with equity and *distributive justice* at all scales (Mabogunje, 1980). This clearly involves the idea of regional planning to bring about more even benefits from development. Some go further to argue that what is needed is a *socio-economic transformation* of the whole mode of production, an approach favoured by Marxist theorists, and involving the breakdown of colonialism, dependency and capitalism. This places a new emphasis on human issues, full mobilisation of society and the redefinition of a country's external relations. The idea of under-development turns the focus on subjugation to, and dependency on, external forces, removal of independence and loss of self-reliance (Mabogunje, 1980).

It does not take much effort to see that behind all these ideas about development there are considerations of distribution, movement, contact,

Plate 1.2 Until Band Aid money made possible a temporary bridge, an inadequate ferry across the Chari river provided land-locked Chad with its principal route for external trade and drought relief aid.

diffusion and spatial interaction, in a word, transport. While in detail the complex relationship between transport

Table 1.4 Transport and development

	Market consequences	*Extra-market consequences*
1	For users of transport services	
	Vehicle size, character	Tourism
	Transport operating costs	Recreational, amenity
	Cost of time	Improved safety
	Financial position of transport firm	Integration
	Reliability, speed of transport	Improved information
	Commodities carried	
	Freight flows—volumes, direction	
	Passenger flows—numbers, direction	
	Changed distribution channels (handling, warehousing, inventory)	
	Price changes for commodities	
2	For non-users in zone of influence of transport facility	
	Changes in cost of public services	Impact on general well-being of community, region
	Changes in value of land for all uses	Sequent occupance—extensive/intensive
	Changes in value of crops and natural resources	Emergence of entrepreneurial capacity
	Changes in rural land use	

	Market consequences	*Extra-market consequences*
	Changes in urban land use	
3	Wider regional/national impact	
	New patterns of investment	Changing patterns of internal/ external links
	Changes in employment opportunity	Changing relative significance of settlements, regions, sectors
	Changing patterns of income distribution and level	Demographic changes— structure, migration
	Changes in balance of trade, terms of trade	Changing investment criteria
	Spread of money economy	Changing political alliances, structures
	Changing patterns of public finance — taxation, revenue	

Source: Modified from Stokes (1968)

and the development process may not be fully understood it is not difficult to identify some of the ways in which transport may have an influence on productive and social activities.

Any new, extended or improved transport infrastructure will affect the range, capacity and the cost of movement, effectively providing positive changes in mobility and accessibility which will potentially enhance economic and social opportunity. There is no guarantee that local communities will respond to such opportunities (Wilson, 1973) and the empirical evidence suggests very considerable variations in the manner and extent to which they do so. Reactions are not readily predicted and the economic consequences allow for little more than speculation (Howe, 1984).

The variety of responses to transport improvement can be appreciated in terms of the range of possible consequences, many of them interrelated but few of them inevitable. An attempt is made in Table 1.4 to classify some of the main consequences of transport improvement as they affect the users of the transport, the non-users in the zone of influence of the transport facility and the wider regional or national impact (Stokes, 1968). The compartmentalisation implied in the table does not reflect reality in which distinctions may be far from clear but it does draw attention to a variety of non-economic considerations which some feel have been given too little attention in many studies of transport and development (Leinbach, 1976) and which are implicit in the definitions of development considered above.

CONSEQUENCES FOR USERS

Many of the consequences of transport improvement derive from the reduced cost of transport services. The first beneficiaries will be the transport operators themselves, who, with better roads or rail track are able to use larger units with reduced costs. The cost benefits are likely to be greater with the first major development (e.g. new surfaced road) and rather less with each successive minor

improvement. This explains why the impact of similar transport improvements in developing and developed economies is generally far more obvious in the former. A study of agricultural production in Argentina concluded that road improvement did not have the impact of a new road (Miller, 1973) and a study in Sabah suggested that production was not very sensitive to small reductions in cost (Bonney, 1964). This could well reflect the fact that transport costs are often only a relatively small proportion of the final cost of many products. Also, one cannot be sure that reduced costs to the operator will be passed on to the shipper and the trickle down effect to the farmer might be slight or possibly take a long time to have any effect. Howe (1984) has argued that even where vehicle operating costs are reduced substantially the impact on, say, crop production, is not likely to be great in conditions in which either the farming or the transport services are arbitrarily regulated or under monopoly control rather than subject to market forces.

In cost-benefit analysis of transport projects in mature economies the value of time can often be a critical factor yet there is often the implication that this is less important in Developing Countries both in contrast to developed countries and also relative to other factors involved. While it is certainly difficult to calculate (low wage values, non-productive use of lost time) there are certainly situations in which an attempt at evaluation could usefully be made (Howe, 1984).

The reliability and speed of transport is critical for a range of goods and becomes more important as one moves from basic, bulk commodities to consumer products which may be perishable, have short shelf life or have restricted market windows. Howe (1984) gives examples of improved roads in Swaziland and St Lucia which reduced damage to citrus and bananas, respectively, and brought benefit to producers. The enhanced capacity for air freight in recent years has opened up a wide variety of new long distance trades in perishable products from Developing Countries to European and North American markets—for example, fruit, vegetables, flowers and sea food (see Chapter 4).

Changes in the range of commodities carried is therefore a normal consequence of transport improvement often accompanied by an increase in the volume. It may also be that the directional balance of movement is altered and while better transport allows local people to move their produce to markets it also enables goods from outside to be brought in more easily—this could be both to the advantage and possibly the disadvantage of the local economy and a factor in the process of under-development.

As a general rule the ability to move goods more quickly and with the assurance that delivery time will be short allows for a reduction in stock carrying and lower inventory costs. A possible consequence will be centralisation of warehousing facilities. With components air freighted from France to its assembly plant in Kaduna, Northern Nigeria, the Peugeot car company was assured daily deliveries and while an eventual change to container transport by

sea and rail reduced transport costs it provided a less reliable and vastly longer delivery time for components.

A number of writers (Blair, 1978; Hay, 1973b) have pointed to the significance of roads for the movement of people and while in many Developing Countries it is impossible to distinguish clearly between passenger and freight transport (many vehicles are adaptable to variable combinations of the two (e.g. Ghana's 'mammy wagons') it does often appear that road transport is dominated by the former. A possible change of attitude on the part of operators is evidenced by reports from Zimbabwe of bus drivers showing increasing reluctance to take farmers' produce, especially of a bulky kind (J.A.Smith, 1989). In time, and as quantities to be marketed by individual farmers increase, there may well be the need for a sharper distinction in provision for passengers and freight movement or farmers will acquire small commercial vehicles for their own use.

Transport improvements can produce a rapid response in passenger numbers. Many of these people will be carrying trade goods because personal marketing of produce is normal in many Developing Countries. A study in Sabah (Bonney, 1964) suggested that in smallholder economies the facility with which people can be moved is of greater importance than movement of freight. Others will be travelling to medical centres, schools or to visit friends and relatives (Jones, 1984). In many African countries where kinship bonds are strong it is customary to return 'home' for religious and family festivals and improved transport facilitates and encourages this.

Almost inevitably there will be a time lag before economic activity responds to transport improvement and this is related to production cycles in agriculture and the often lengthy lead time for establishing new agricultural or industrial enterprises. On a priori grounds one might therefore expect 'pure' freight transport to respond more slowly than passenger numbers and any survey undertaken soon after transport improvement has been made may well not show any marked increase in freight movement.

With respect to the Rigo road improvement in Papua New Guinea there was noted a considerable increase in vehicle ownership and growth in all forms of traffic with new commodity movements and commuting patterns (Ward, 1970). In this case, and it could be fairly typical, the growth of road traffic was high initially and then slowed down. It is quite normal for diffusion following an innovation to conform to a flattened 'S' formgradual growth at first, then accelerated and finally a slowing down as possibilities for response are exhausted. This has been well illustrated by the spread of containerisation.

In addition to the consequences in the transport market *per se* there are a number of extra-market effects. These could include tourist and recreational travel and the social travel already noted, and there will be cost savings with respect to the time devoted to such travel and for all users the cost benefit of improved safety. Far more difficult to quantify in monetary terms are the benefits to users of being able to communicate more effectively, of having more information available and being better integrated into political, social and cultural

processes. It could certainly be argued that these are at the heart of development in any wider sense of the term. Wilbanks (1972) noted that the improved information flow resulting from better access contributed more to agricultural development than reduced transport costs.

CONSEQUENCES FOR NON-USERS AND WIDER REGION

Development is not simply concerned with those who in a direct way use the transport facilities provided—of great importance will be the wider consequences in the zone of influence and these are likely to show decay with distance away from the facility itself. Some of the consequences in this category represent the more obvious geographical manifestations of the development process in action—the changing economy, landscape and welfare of the people living adjacent to the new or improved transport infrastructure. Indeed, much of the research into the impact of transport on development has been concerned with attempts to measure just such changes and Howe (1984) has provided a valuable review of the literature as far as rural roads are concerned, although many of the works cited provide insights into the wider transport-development relationship.

The reduced cost of transport implicit in improvements to infrastructure should be reflected in the cost of many goods and also the cost of providing a range of public services which will benefit not only the direct users of the transport but also the non-users. This is probably a main factor in the opening up of new land but is of considerable significance in extending the amenities and services which are such an important part of the overall well being of the people involved—educational, health and agricultural extension services come immediately to mind. Such social benefits should not be under estimated.

The value of land is a function of the uses to which that land can be put and improved access and lower transport costs can have a profound effect. Access to wider regional or international markets has been a main factor stimulating the change from subsistence to cash cropping with resultant changes in land values. In Zimbabwe a rural roads programme resulted in great expansion of farmer participation in marketing and big increases in cash crop production both of staple food crops (the country has even become a net exporter) and industrial cash crops such as cotton (J.A. Smith, 1989). While there are some exceptions, most of the evidence points to increases in cash crop production consequent upon road improvement with lower-value subsistence crops replaced by higher-value market crops. The extent of this change would certainly appear to be related to distance from the transport facility and also possibly the distance from main centres of population, commerce and external market links.

With intensification of production, land rents and values will rise and in areas of communal land holding but personal usufruct, as in much of Africa, there will be growing competition for land which will increasingly enter into the

commercial market often with mounting litigation over issues of ownership. Changes in land use and land values consequent upon transport improvement are certainly not restricted to rural, agricultural areas although in many Developing Countries this is likely to be the most obvious impact.

To the extent that transport increases the utility of resources which may have no value to the community in whose area they are located it is able to increase the value of a whole range of natural resources. The iron ore deposits of Mount Nimba in remote northern Liberia only assumed 'value' on the opening of the railway and port which allowed mining and export to commence. The same would be true for the forest resources along the line of rail and some of the roads constructed in the east of Liberia. In the Amazonas area of Brazil there has been an all too rapid increase in forest clearance both for timber production and also to make way for new agriculture. In the same region mineral exploitation has been associated with road construction (Kleinpenning, 1971, 1978).

A detailed questionnaire examination of the consequences of rural road improvement in selected areas of peninsular Malaysia (Leinbach, 1976) suggests a very wide range of impacts and variety of persons affected. There were indications of rising land values, expanded range of buying and selling opportunities for local and imported produce, growth of small businesses, formation of growers' cooperatives and the creation of new economic opportunities (logging, vending). The improved roads stimulated inward and outward migration, increased access to medical services, increased acceptance of family planning, establishment of new postal services and a general increase in the availability and exchange of information. Journey making and transport ownership has been encouraged. While Leinbach is cautious regarding the precise relationship between the road improvements and the changes described there can be no doubting its significance.

It can be suggested that what is initiated for the wider region is a process of 'sequent occupation' in which there is likely to be a shift along the continuum from self-sufficiency to dependency, from a non-money to a money economy, from isolation to incorporation, from extensive to intensive activity and from rural to urban. There will be increasing scope for those with entrepreneurial ability to capitalise on their skills.

By extension from the above the wider region may well see new patterns of investment and the spread of the money economy which with increased employment opportunities will enlarge the base for revenue collection for local and central government. With time the whole pattern of trade could change with respect to the commodities involved, the markets and relative monetary values. There is considerable evidence to indicate changing patterns in income levels and distribution. The whole pattern of the region's or nation's external links could change, as they did with railway penetration routes of the colonial era, and internally there are likely to be changes in the relative significance of specific locations and settlements, regions and economic sectors.

Plate 1.3 In many Developing Countries there is no clear distinction between passenger and freight transport and vehicles are chosen for their flexibility of function.

Transport can at the same time stimulate both dispersion and concentration of people and activities. Settlements at favoured transport nodes will attract population and services. Improved transport links draw people to them and bring in-migration but by the same token make it easier for population to migrate outwards—the net effect being different from place to place.

`DISBENEFITS' AND COSTS

It would be all too easy to conclude from the above that transport improvement in some ill-defined way is able to stimulate a chain of benefits at all levels. Indeed, the emphasis on transport in much earlier development planning was based on this very assumption and the definition of development merely in simple economic growth terms. In some cases even economic growth did not take place yet the wider reality is that the effects of transport improvements are often very different from those envisaged and in all too many cases undesirable or harmful in terms of the process of change initiated and the impact on equity and social justice in the community concerned. Transport can have a negative impact in a far wider sense than defined economically by Gauthier (1970) or Adler (1971).

As Pirie (1982) has suggested with respect to the railways in Southern Africa while they did bring capitalist development and promoted growth in some localities they also had some debilitating effects and acted as agents of

underdevelopment as well as development. Particularly, this was reflected in greater indebtedness, greater dependency, the promotion of wage labour and proletarianism and the facilitation of migrant labour and the social problems this created. In different degrees much of this is true for most transport developments.

Some of these negative impacts will now be considered but one can but agree with Brookfield (1975) when he argues that it is impossible to separate the positive from the negative consequences of change and evaluation must be based on the defined goals in each situation. At the very broadest level it can be argued that the transport improvement of the colonial era was fundamental to the underdevelopment of the colonial territories resulting in regional imbalance, core-periphery relations, chains of exploitation and dependency (McCall, 1977). The interests of the local population were often secondary to the economic advantage of the mother country and there was the tendency for capitalism to be reinforced (Edwards, 1978). The colonial penetration produced export orientation and the emergence of the colonial economy characterised by a small range of primary exports and heavy dependence on imported consumer goods and, increasingly, foodstuffs. A possible effect of this was the stifling of traditional economic activities. This was certainly true for the 'cottage' industries in many parts of Africa and India (Dickenson, 1978) and food crop farming in areas in Africa.

A similar effect of transport improvement, albeit different in scale, may be identified at the national or local level. Transport improvement is, by definition, highly selective spatially, and its impact is bound to be spatially differentiating—the higher the technological level the more marked this will be. Motorway style roads and high-capacity rail links make up but a small fraction of the networks of which they are a part and numerous studies have pointed to the concentration of economic activity and benefit along narrow corridors or in 'islands' favoured by the higher capacity facilities (Taaffe *et al.*, 1963; Hoyle, 1983, 1988). In the hierarchical development of transport networks there is implicit a spatial inequality—those near the facility benefit more than those in the surrounding area, those in the city more than those in town and village.

It is possible to go on from this to suggest that improved transport may be a factor in social stratification, widening income differentials and greater inequality (Elmendorf and Merrill, 1977) with centralisation reducing the possibility of spreading benefits (Howe, 1984). There is evidence to suggest that increased cash cropping leads to increased income inequality, differential increases in land values, sharpened land competition, concentration of land in hands of relatively more prosperous members of the community and possibly increased unemployment. While overall income may rise the distribution may be worsened and poorer farmers may even be forced out. It has been suggested that in some cases, especially in remoter areas, new roads may have a harmful impact on minority groups, some of the Indian groups of Amazonia provide the obvious examples, and possibly even lead to their elimination. In contrast, as Howe (1984) has noted, where a minority group has control of local economic activity,

such as the Lebanese or Indians in parts of Africa or the Chinese in parts of South East Asia, they may benefit disproportionately. In Nepal, Blaikie *et al.*, (1977) noted that new opportunities consequent upon road improvement tended to be taken up by the already advantaged and these were often 'outsiders'.

Where the existing transport involves labour-intensive technology the effect of improvement may well be reduced employment in the transport sector itself and resultant increases in hardship. In rural areas the elimination of head porterage could have this effect as could the change from pedal rickshaws to modern transit in urban areas (see Chapter 7). Likewise, a change from labour-intensive to mechanical construction and maintenance methods, especially for roads but also to some extent for other transport facilities, will mean reduced employment and demand for skills that are not available locally and may have to be imported at great cost. It is open to debate whether or not it makes sense in situations of abundant cheap labour and high levels of unemployment to change to methods which consume scarce capital which could possibly be used to better purpose in other areas of development.

It is certainly the case that transport improvement has a profound impact on the distribution of population and the migratory forces that shape this distribution (McMaster, 1970) and in Southern Africa allowed the widening of labour markets so that an area such as southern Mozambique became little more than compounds for workers in the Rand (Pirie, 1982). The whole process of rural-urban migration, a main problem in many Developing Countries, is undoubtedly facilitated, although not necessarily caused, by improved transport.

It must also be noted that both in its construction and operational phases transport can have serious implications for the environment (Farrington, 1992), to which must be added the environmental degradation which may result from the economic activities initiated by or associated with the transport infrastructure. The environmental impact may be local in scale such as drainage impeded by a transport route, soil creep and land slips on bare slopes, but can be global as in the case of large scale forest clearance in Amazonia, tropical Africa and parts of Asia.

TRANSPORT AND SPATIAL ORGANISATION

The idea that transport is fundamental to spatial organisation is developed in many standard texts and in a variety of ways (Lowe and Moryadis, 1975; Taaffe and Gauthier, 1973). One of the best-known theories of transport (Ullman, 1974) revolves around the idea that geographical reality (climate, resource endowment) results in natural *complementarity* between places and that this will result in interaction or exchange if problems of transfer can be overcome. This *transferability* will be a function of the availability and cost of transport. This is not greatly different from the classical economist's concept of comparative advantage and the emergence of trading patterns based on division of labour and specialisation at varying levels from local through regional to global. The idea

that such a spatial specialisation would ultimately lead to an equalisation of incomes has been shown not to be realistic and growing disparity is the all too frequent outcome.

This concept of transferability is closely associated with the idea of *mobility,* the ability of people and goods to move or be moved or the capacity to change place *(Oxford English Dictionary)* and it is facility of movement to particular places which determines their *accessibility*. Mobility and accessibility are at the heart of any consideration of the organisation of space and the means by which ends in other sectors are accomplished (Owen, 1987).

Mabogunje (1980) has suggested that the process of development is in effect one of spatial reorganisation—new social goals require new types of spatial action and transport is the means by which these actions are integrated. Many of the models of transport development (Taaffe *et al.,* 1963; Hoyle, 1973; Rimmer, 1977) are effectively designed to identify phases in the evolution of spatial organisation. While earlier models such as those of Taaffe may not deal effectively with issues of modal interlinkage and spatial integration and say little about important questions of control and therefore power (Mabogunje, 1980), more recent models have gone much further in attempting to incorporate transport into a wider political, administrative and even social context (Rimmer, 1977).

In Rimmer's model the starting point is a *pre-contact phase* in which there are no overseas, external links and there is an unmodified traditional system of production and circulation whose character is determined by the culture of the people and resources of the area concerned. Movement will be by low capacity tracks and possibly waterways. In the *early colonial phase* there were the first contacts by sea between the more and less advanced territories, establishment of trade and the gradual spread of this trading influence inland from the coastal points of contact. Yet for the most part the Europeans themselves did not penetrate inland, their coastal footholds were tenuous and usually by courtesy of the coastal inhabitants (Hilling, 1969a) and there was minimal adaptation in the traditional societies.

This was to change with the gradual emergence of what might be called *full colonialism* when the core territories consolidated their dominance over the periphery. This was reflected in the building of roads, railways and ports, establishment of political control, new administrative settlements and the diversification of economic activity. There was considerable spatial restructuring as new settlements were created, as mining and plantation agriculture were established, as rural-urban migration was initiated and as Europeans, in varying numbers and degree of permanence depending on the environment, set up their homes. There emerged a structural and behavioural dualism (Brookfield, 1975) which in much simplified terms may be considered as traditional and modern. In terms of economic activity and transport the dualism was well defined with the externally imposed transport developed for the export oriented 'modern' sector and integrated into the global economy, and built with scant regard for, and

having little in common with, that which served the traditional sector based on local production, marketing, technology and circulation.

Political independence for the colonies was not always followed by the economic independence which the Developing Countries might have wished for and this was reflected in a phase of *neo-colonialism* with the continuation of the established core-periphery dependency relations, albeit in a more subtle and possibly more invidious form. However, in the Developing Countries more positive approaches to development planning brought a call for improved infrastructure and transport services better adapted to demand. In Sierra Leone the old colonial railway was eventually abandoned and many Developing Countries embarked on rural road schemes (Chapter 5). It has been claimed with some justification that in practice there have been few radical changes to inherited transport networks (Hoyle and Smith, 1992) and there is still an all too sharp distinction, one might say a gulf, between the transport that has been externally imposed and that which is needed at the local level. This is a point which will be developed at a number of places in later chapters of this book.

It has been suggested that a *mature independence* situation can be identified (Hoyle and Smith, 1992) in which longer periods of political independence lead to meaningful domestic decision making, a more varied range of external links and the intensification of the domestic infrastructure. Australia and Canada could be cited as examples but it is not easy to identify Developing Countries that have as yet reached this stage—when they become 'developed'.

TRANSPORT TECHNOLOGY AND DEVELOPMENT

For the most part this discussion of transport and development has been couched purposely in very general terms. In practice, the impact of transport on wider development issues will be a function of a number of interrelated considerations and where transport does not produce the anticipated development it may be that it is the transport itself which is at fault. For example, *timing* is critical and inappropriate timing in relation to demand or the provision of associated services and inputs to other sectors may be counter productive. Likewise, the *location* of each new transport facility in relation to the overall geography of demand is important and this could range from macro-scale decisions regarding the siting of new airports or seaports or the location of new rail links and motorways, to the micro-scale detail of road or rail alignment and location of small wharves on rivers.

It is also critical that the decision makers are appropriate and that decisions regarding transport are made for the right reasons—there have certainly been cases in many Developing Countries where decisions have been made by politicians for wholly personal gain or the perceived advantage of their home region irrespective of the real merits or likely development impact of the transport facility concerned.

Possibly of even greater significance will be questions related to the technology selected for the transport provided and considerable emphasis will be given to this in the modal chapters which follow. If transport is to have any impact on development it must be appropriate, in the fullest sense of that term, to the desired development goals. It must be the most suitable mode and level of technology and in the right place at the right time—all too often transport developments have failed to satisfy these conditions and it is hardly surprising that the resultant impact has not measured up to expectations.

Table 1.5 represents a hypothetical evolutionary scheme for an agricultural development project (Deschamps, 1970). At each stage the character of the demand can be identified and appropriate transport adopted. At the *feasibility stage* the demand will be mainly from small groups of 'expert' surveyors (hydrologists, pedologists, agronomists, anthropologists, etc.), probably from overseas aid agencies or consultancy firms, who will need to move around 'in the bush' and off-track. This demand is likely to be met by the use of four-wheel-drive, rugged vehicles or in certain conditions by helicopters or boats. There is unlikely to be any real track construction although there may be some ground clearance.

Having produced a scheme acceptable to government it is possible that the *extension services* will be involved in education and demonstration to encourage local acceptance and participation.This could involve larger numbers of personnel, possibly with local knowledge and understanding, travelling widely, visiting villages and farmers and possibly setting up trial schemes. This may require a larger range of vehicles, could involve the use of some 'traditional' transport technology and could be constrained by issues of vehicle availability, operational costs and limited budgets. It is unlikely that track construction will be necessary

Table 1.5 Agricultural development and transport demand

	Stage	*Transport demand*	*Transport technology*
1	*Feasibility* Field surveys	Small numbers of persons Some equipment Off track	Helicopter, boats, rugged four-wheel drive vehicles
2	*Extension* Education Demonstration	Larger numbers of staff Mobility at local level Access to farms, villages	Horse, cycle, moped, smaller four-wheel drive vehicles
3	*Input* Implementation	Movement of imported equipment, machinery Movement of workers One-off demand	Improved port facilities Improved access roads Heavy lorries, low loaders Rail link (?) Buses (?)
4	*Output*	Movement of produce (volume, nature of commodity, regularity, seasonality) Export markets	Improved regional road links Specialised vehicles (tankers, refrigerated) Rail transport

	Stage	*Transport demand*	*Transport technology*
		Domestic markets	Water transport Upgraded port facilities Terminal, storage facilities
5	*Income*	New patterns of consumer demand— imports, domestic production New levels of personal mobility —education, health, social, work Local re-investment— new industries, expanded agriculture Settlement growth Expanded services and amenities	Upgraded distribution channels Warehouse, transit facilities Specialised vehicles Sophisticated port facilities Air transport expansion Higher capacity roads Rising car ownership Increased demand for public transport

Soure: Modified from Deschamps (1970); Hilling (1976)

although some improvements may be needed to allow movement of larger vehicles or possibly give year-round access.

In what may usefully be called the *input phase* more radical innovation may be needed. Depending on the precise location of the project area, access may have to be greatly improved. There may be the need for earth-moving equipment, pumps, generators, irrigation pipes and construction materials, all of which may have to be imported, thereby creating a demand for improved port facilities and regional link routes of all-weather capability and higher capacity than already exists. The construction of these new routes and facilities will themselves require equipment and access. Special vehicles such as low loaders or cement transporters may be needed and fuel will be required in larger quantities. However, it is worth noting that many of the inputs and the movements that they generate are one-off in character and the track and vehicles may be redundant on completion of the project works. The relative merits of the different modes will certainly be an issue to be carefully considered in relation to the nature of the movements generated and anticipated future growth of traffic. Thus, railways are likely to have a far higher 'import' element than roads and are not suitable for one-off movements of 'out-of-gauge' equipment. However, they may well be thought suitable if the expected output of the operational project is to be regular movement of large volumes of produce on a year-round basis.

This brings one logically to the *output phase* when the scheme starts producing the commodities for which it was planned. These may be for domestic or export markets, the volume and character of the goods and the production cycle over time will be different for each commodity, and the required transport and handling facilities may well be specific to each. Short-life perishables (flowers from Kenya, seafood from Côte d'Ivoire) will require transport with very different characteristics from bananas or pineapples or large volumes in bulk such as cocoa, coffee, palm produce and latex. Speed may be the critical

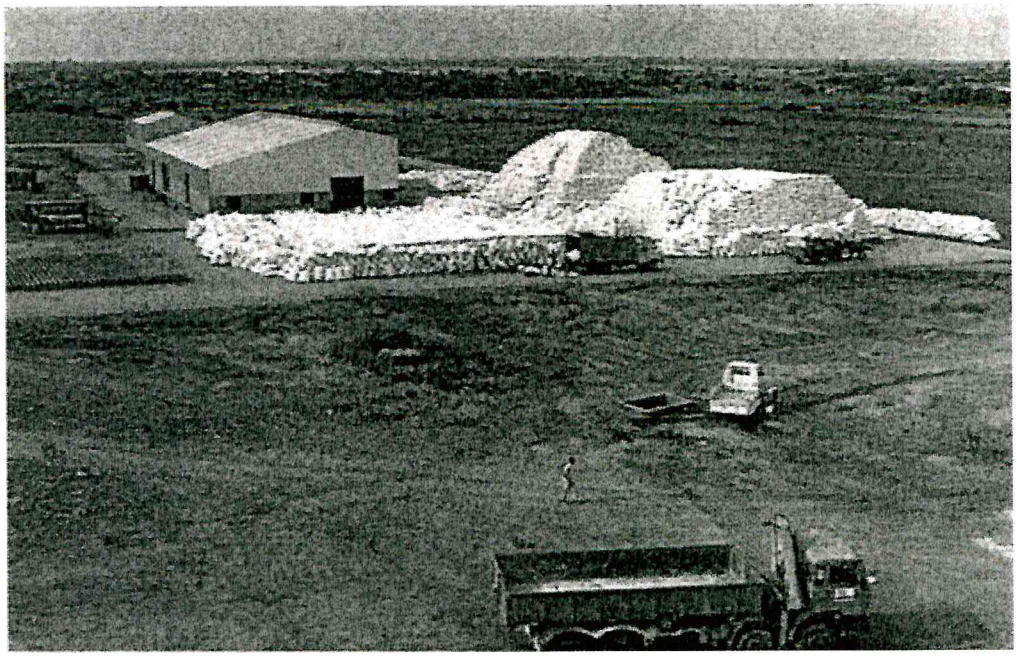


Plate 1.4 A cotton ginnery opened at Lalago, Tanzania, in 1994, is dependent on road transport over poor roads but reduces long hauls for the farmers and is a boost to local cotton production and income (Photo: Cargill plc).

requirement or specialised vehicles (refrigerated, tanker, side-loading, top-loading, container) may be necessary. Decisions will have to be made regarding mode and suitable technology and higher capacity track, whether road, rail or water, may have to be provided to accommodate larger, regular flows of traffic.

The outcome of all this new production, hopefully, will be *income* both personal and public, and new patterns of trips will be generated (educational, medical, social) and new forms of consumption demand created (foods, cars, household goods) which may have to be met by imports or more desirably by new or expanded domestic industries. Either way there is likely to be demand for port facilities of greater capacity or sophistication (Chapter 7) and a possible increase in international air transport (Chapter 4). There may well be a demand for high capacity interregional links. The impact of these changes may well be reflected in urbanisation and the need to upgrade urban transport systems (Chapter 6) and there is likely to be a growing disparity between the transport provision in the core and peripheral regions.

While this example is concerned with an agricultural project the underlying logic would be just as applicable in the context of an industrial scheme, and more importandy, it illustrates a vital principle that has been ignored in much of the theorising about and also the actual planning of transport. It is not enough to think only of transport in general terms but essential that careful consideration is given to the *when* (timing), *where* (location), and *what* (technology) in each

particular case. In effect these must be related to the overall development objectives—this is a demandled approach but always with realistic anticipation of future growth and likely changes. It is an emphasis on transport that is appropriate for each situation and set of conditions.

THE ELEMENTS OF TRANSPORT

In the more detailed examination of transport which will follow certain main elements should be borne in mind. All transport involves a *way, terminals, vehicles* and *energy*. These vary in significance between modes, between different levels of technology, between places and with time.

The *way* may be natural (sea, air), improved natural (dredged river channel) or artificial (road, railway, canal). The construction and maintenance costs depend on the type of way and range from Zero in the case of oceanic routes to massive for high technology roads and railways. The extent to which the costs are passed on to the user depends on whether the way is common user, as in the case of most roads, or single user as for most railways.

In a broad sense a *terminal* is any point at which there is access to a way or at which interchange between modes is possible—what might be called an intermodal interchange. Terminal facilities vary greatly in size, design and level of sophistication as between modes and also for any particular mode—there is a world of difference between, say, a simple fishing port and Rotterdam, but both effectively perform transfer functions between the land and sea modes. Often very complex in design (large airports or seaports), the terminal may be multi-functional and in addition to the obvious transfer function may provide storage, processing and servicing facilities.

The *vehicle* is the unit of carriage and can vary greatly in capacity, speed, degree of specialisation, flexibility and propulsion and ranges from simple carrying aids for human porters, through the variety of road and rail vehicles to large planes and ships. The movement of any vehicle will consume *energy* in some form and this is the most obvious way in which the cost of transport reflects the effort of overcoming the friction of the earth's surface.

In combination, the way, terminals and vehicles determine both the *flexibility* of the overall transport system and also its *capacity*. In any consideration of the role of transport in stimulating spatial interaction and development these are vital questions for the transport planners. As we shall see in later chapters, road and rail transport differ greatly in their flexibility and capacity but so do different types of road and different designs of railway.

It has been suggested (Lowe and Moryadas, 1975) that geographic space consists of points (nodes) at each of which different types of activity take place and as human needs can rarely be satisfied at any one point there is need for interaction between points. Our ability to effect this interaction will be in part a function of distance but also a reflection of the transport that is available. Transport networks evolve through a process of node connecting which may in

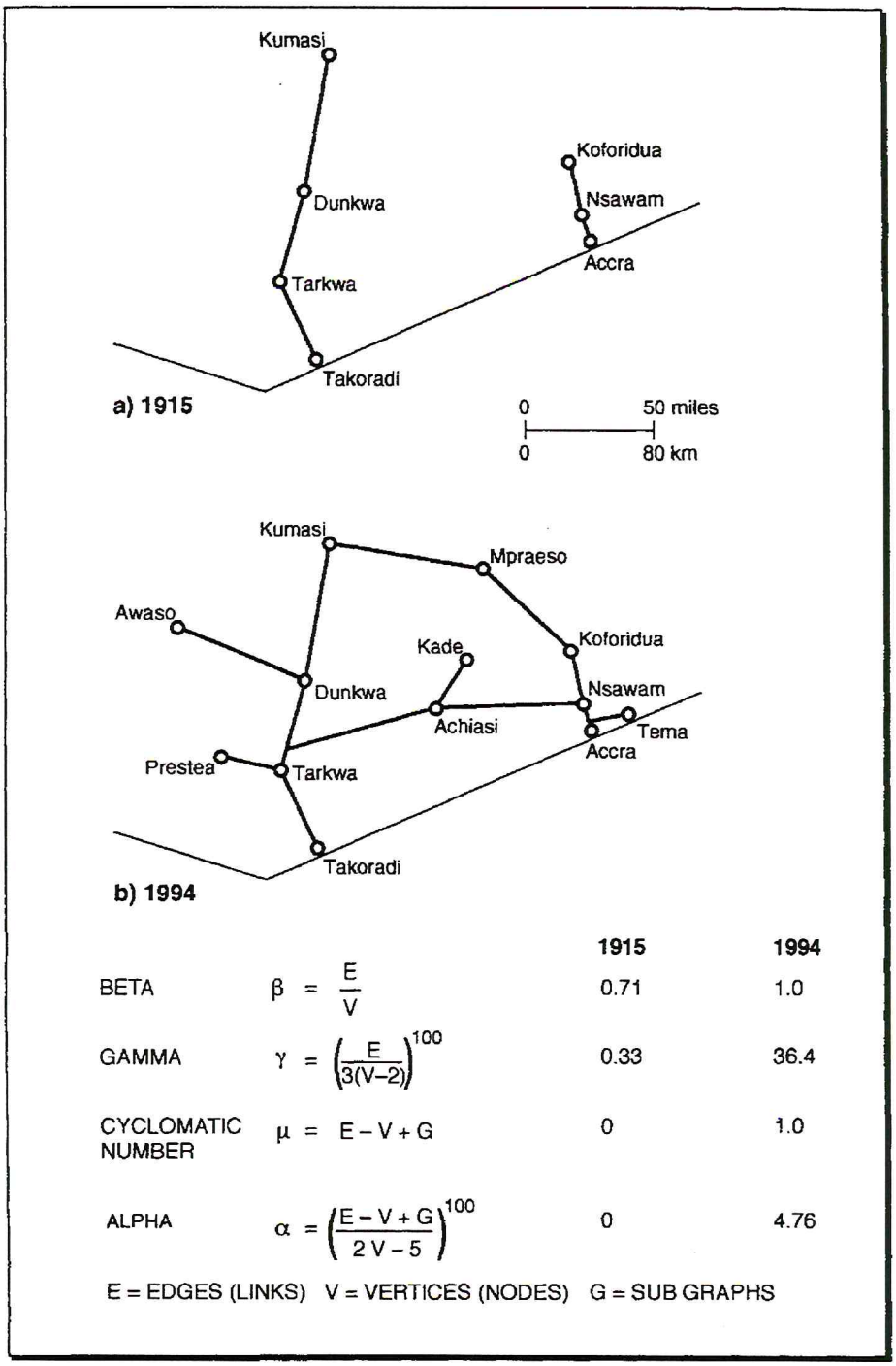
theory, but not always in practice, involve links between points at successively greater distances apart (Lachene, 1965; Taaffe *et al.*, 1963; Haggett and Chorley, 1969). To the extent that a transport link is provided with surplus capacity it serves not only to provide for immediate flow between the nodes but also for longer-term relative growth of these nodes—what has been called the accumulator effect to the network (Haggett and Chorley, 1969).

Because the resultant networks can be reduced to a series of points (nodes) and lines (links) they become amenable to geometric and mathematical analysis and this provides a basis for the comparison of different networks. Haggett and Chorley (1969) provide a valuable synthesis of previous work and ideas and a basis for much more recent work.

Several ideas of particular relevance to the present discussion may be noted. The shortest, straight line link may well be the ideal (Hay, 1973a) but it may be desirable to deviate from this for positive reasons (e.g. route length is increased to touch more points and generate more traffic and revenue or possibly for social reasons) or it may be necessary to deviate for negative reasons (e.g. to negotiate difficult terrain). The differing sensitivity of road and rail transport to gradient (see Chapters 3 and 5) provides obvious reasons for deviation. Deviation, for whatever reason, will be reflected in cost of construction and maintenance but this may be offset by a greater impact on traffic generating activity along the route.

Basic to the relationship between transport and development, however the latter is interpreted, are the associated concepts of connectivity and accessibility. *Connectivity* within networks can be compared on the basis of the number of links per node (the Beta index), the ratio between the actual and maximum possible number of links the (Gamma index), the number of loops in the network (the Cyclomatic number) and the ratio between the actual number and maximum possible number of loops (the Alpha index). In simple illustration the indices for the basic Ghanaian rail network at two points in time are shown in Figure 1.2. In similar calculations rail systems invariably produce a lower order of connectivity than roads, a vital consideration for development, and Developing Countries usually have far lower levels of connectivity for all modes than developed countries (Kansky, 1963). A detailed study of a large number of countries (Garrison and Marble, 1962) showed a close correlation between high indices of connectivity and high technical and socio-economic status.

Accessibility may be interpreted in two ways. At the one level it is related to connectivity and may be defined as the number of links that have to be traversed, or sub-journeys made, from any particular node to reach all other nodes, in effect the 'reachability' of that node (Lowe and Moryadas, 1975). At another level, accessibility may mean the number and distribution of places at which one can join the network. For example, it is possible to walk, or even perhaps drive, on and off an unengineered path in open country at virtually any point whereas there are but few points at which one can join a motorway. Likewise, roads of all types apart from motorways have a fineness of access that is not possessed by railways.



		1915	1994
BETA	$\beta = \frac{E}{V}$	0.71	1.0
GAMMA	$\gamma = \left(\frac{E}{3(V-2)}\right)^{100}$	0.33	36.4
CYCLOMATIC NUMBER	$\mu = E - V + G$	0	1.0
ALPHA	$\alpha = \left(\frac{E - V + G}{2V - 5}\right)^{100}$	0	4.76

E = EDGES (LINKS) V = VERTICES (NODES) G = SUB GRAPHS

Figure 1.2 Ghanaian railway network—indices of connectivity

The implications with respect to spatial impact are all too obvious and this is basic to the idea of differential settlement growth and development described by McMaster (1970). We shall return to these ideas in discussing the different modes.

Other characteristics of networks will also have implications in relation to spatial interaction and development. The route length in relation to surface area, the *network density,* has been shown to be closely related to population density and networks frequently assume a *geographic orientation* which favours movement along certain axes and in some directions rather than others. Networks also tend to develop *hierarchic structures* and these clearly relate to similar differential growth in settlements and the services they provide and the hinterlands they serve—this is basic to central place theory. Networks can also be said to have differing levels of *efficiency* which in addition to those characteristics already noted would include a variety of technical features related to surface, gradient, curvature, alignment and capacity.

It is usually the case that networks have within them a variety of weak points. These may be the result of inadequacies in connectivity, accessibility or the efficiency with which the system operates and where, for whatever reason, the capacity of the network is inadequate in relation to the demands placed upon it there may be evidence of *stress*. This may be reflected in congestion, delay, accidents, loss of time in transit, deterioration of the system and increased cost. While few if any transport networks are devoid of stress points it is probably the case that in many Developing Countries they are the norm rather than the exception and examples will be identified in later sections of this book. An essential aspect of transport planning is the identification of potential stress points well in advance so that action can be taken.

With these general considerations in mind attention will now be directed to the specific modes of transport with particular emphasis on their technical characteristics, organisation and relationship to the broader issues of spatial organisation and development outlined above.