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Truck Tyre Developments and their Effect on Natural Rubber Consumption[†]

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In 1995 some 240 million truck tyres (radial, bias and cross-ply) were produced, of which about 38%, or 90 million tyres, were those referred to as heavy commercial vehicle (HCV), with remainder being light commercial vehicle (LCV) tyres. The elastomer content of HCV tyres is about 70% -90% natural rubber and for LCV tyres is about 65% natural rubber. The paper analyses these statistics and elastomer contents in relation to the importance of truck tyres as major end-uses of natural rubber. The factors influencing the future use of natural rubber in truck tyres are examined, and some predictions of future demand are made. The possible influence of this major end-use on the natural rubber price is considered.

Truck (or commercial vehicle —CV) tyres are defined by the European Tyre and Rim Technical Organization (ETRTO) as those having a size 8.25–16 and above, where 8.25 represents the tread width of the tyre in inches and 16 is the rim diameter in inches. The term 'commercial' covers a vast range of vehicles from light trucks to heavy lorries, and the tyres fitted to these then are normally referred to as light commercial vehicle (LCV) or heavy commercial vehicle (HCV) tyres, with HCV tyres defined as those having a cross-sectional tread width of 10 inches or greater. These larger tyres are normally used for long-distance haulage work on large rigid trucks, tractor units and trailers or road-trains, or on passenger coaches and buses. In industrialised countries, CV tyres are virtually 100% radial construction with a life-span of about two or three times that of similar cross-ply tyres.

TYRE FUNCTIONS

Tyres are the vital component between a vehicle and the road surface. They support the weight of the vehicle and transmit steering, accelerating, decelerating and braking forces. Moving tyres are in a constant state of deformation — blending, expanding and flexing — in response to forces received from the road surface. To perform these functions satisfactorily, truck tyres must:

- Be strong enough to withstand the inflation pressure required by the imposed weight of the laden vehicle;
- Provide an effective combination of traction, steering control and skid resistance and give acceptable mileage in the service in which they are used; and

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- Withstand the stresses and strains caused by road shocks and heat build-up, particularly during long journeys, often at high speed.

Ever since the production of the first pneumatic tyres in the 1880s it has been the aim of tyre makers to fulfil these functions. However, improvements in one area have usually only been achieved at the expense of other areas. The search has been for an optimum balance of properties, a particularly onerous objective bearing in mind the changing needs of customers, raw material developments and the demands of economic necessity. Therefore, it is not surprising that tyres have developed by a series of 'trade-offs'.

USAGE OF TRUCK TYRES

Truck tyres have also developed within the specialisation of LCV and HCV for particular service requirements by fleet operators. This has resulted in HCV (radial-ply) tyres being designed for three specific wheel configurations or tyre-vehicle systems:

- *Steering axle — with a ribbed tread pattern* designed for uniform wear across the tread face, water dispersion and handling characteristics;
- Driving axle — with a lugged tread pattern for traction and better wear; and
- Trailer — with a ribbed tread pattern for cool running temperatures, improved tread wear and fuel economy.

The majority of trucks, especially in the industrialised countries, are managed by fleet operators who are particularly interested in the fuel economy of their operation. The primary contributory factor to fuel economy in fleet operations is the skill of the driver, but other important factors are:

- Vehicle design — type of vehicle, aerodynamic aids, side-gap seals, engine specification and drive train;
- Vehicle operations — speed, type of freight and gross vehicle weight;
- Environment — temperature, topography, weather and road surface; and
- Tyres — wheel alignment, axle configuration, inflation pressure, tyre construction and type.

For fleet operators, fuel is one of their primary variable costs and this expense is expected to increase in the future. Truck tyres have a significant impact on a vehicle's fuel consumption, as it has been estimated that they account for about one-third of the energy dissipation of a loaded tractor-trailer combination. The rubber compounds used in the manufacture of the tyre play a critical role in its rolling resistance characteristics, especially in the tread and shoulder areas.

Although the overriding factor controlling the development of LCV and, more especially, HCV tyres is economy; truck manufacturers also stress the importance of safety in their performance characteristics. Operators of both truck and bus fleets are very conscious of both tyre and fuel costs, much more so than the average motorist. Consequently, truck tyre wear, including irregular wear, is a major concern for fleet operators. Tyre tread wear—*i.e.* the abrasion of the tyre tread—is a cyclical process. Between each contact with the road surface the tread segment remains essentially at rest. During contact with the road, abrasion and stressing occur, with part of the energy dissipated in the form of heat Recovery of the tread then takes place so that energy can again be dissipated at the next contact with the road surface This process of tyre tread wear, which determines the useful life and durability of a tyre, depends on a multiplicity of factors, including cornering frequency and speed, acceleration/braking levels, vehicle drive configuration, tyre inflation pressures, load factors, wheel alignment, road systems and surfaces, and topography/climate

The main causes of uneven or irregular wear — poor alignment and incorrect tyre pressures — can be controlled by fleet operators with proper maintenance procedures. The two major factors influencing the fleet operator's decision to purchase tyres are performance and economy Multi-retreadable and regroovable radial truck tyres provide truck and bus fleet operators with the options of using new or retreaded tyres to reduce their costs per operating mile There are basically six main categories of fleet operators and their general preference for truck tyres is detailed below:

- International and long distance hauliers — mainly new HCV tyres,
- Medium size fleet hauliers (middle distance) — new and retreaded HCV tyres;
- Small fleet operators (middle distance) — new and retreaded HCV tyres and new LCV tyres for vehicles for local deliveries,
- Local delivery fleet — new and retreaded LCV tyres (as well as car tyres for car-derived vans);
- *Tipper and on/off road operations* — mainly retreaded HCV tyres for tipper uses, and new and retreaded HCV tyres for on/off road applications,
- Large fleet bus/coach operators — mainly new HCV tyres for long distance and retreaded HCV tyres for local operations

The commercial vehicle industry has been affected in recent years not only by their own 'cost-consciousness' but also by the environmental issue of fuel economy of both light and heavy trucks as a means of conserving energy This is particularly important for large fleet operators since it has been estimated that an improvement of 10% in tyre rolling resistance in truck tyres can improve fuel consumption by 2%–4% Tyre construction is a major factor in determining rolling resistance, and the change from cross-ply to radial construction has reduced this by up to 30%. Recent developments in the truck tyre industry have not only been concerned with the longevity of the life of the tyres, but also with improvements in compounding to give lower rolling resistance.

TRUCK TYRE STATISTICS

The development and growth of world production of truck tyres by major producing countries from 1975–95 is shown in *Figure 1* The production of CV tyres is affected by the number of commercial vehicles produced annually (original equipment demand, *Figure 2*) and the demand for replacement tyres for the CVs in use (truck parc, *Figure 3*) The production of commercial vehicles has grown steadily with occasional downturns, whereas the commercial vehicle parc has advanced uniformly upwards over the period

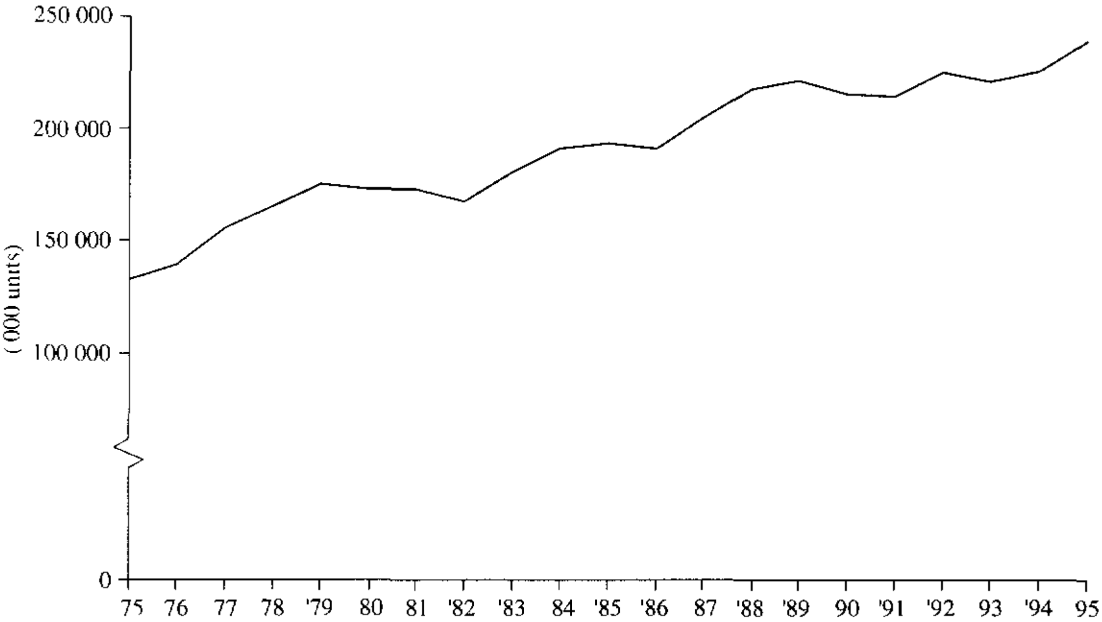

Figure 1 World CV tyre production 1975 1995

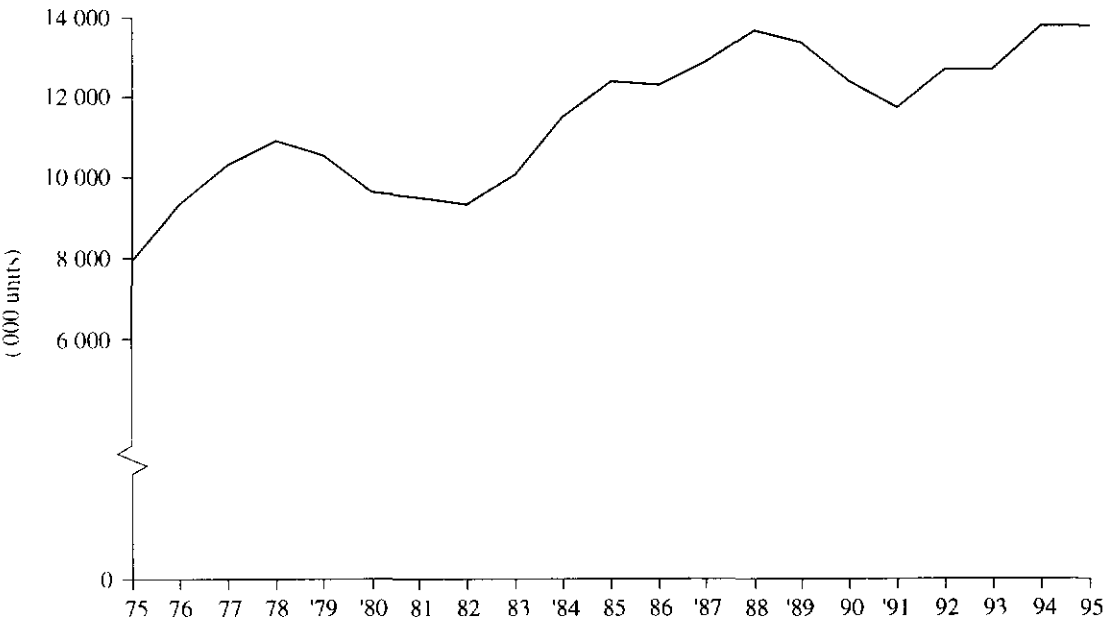

Figure 2 World CV production 1975 - 1995

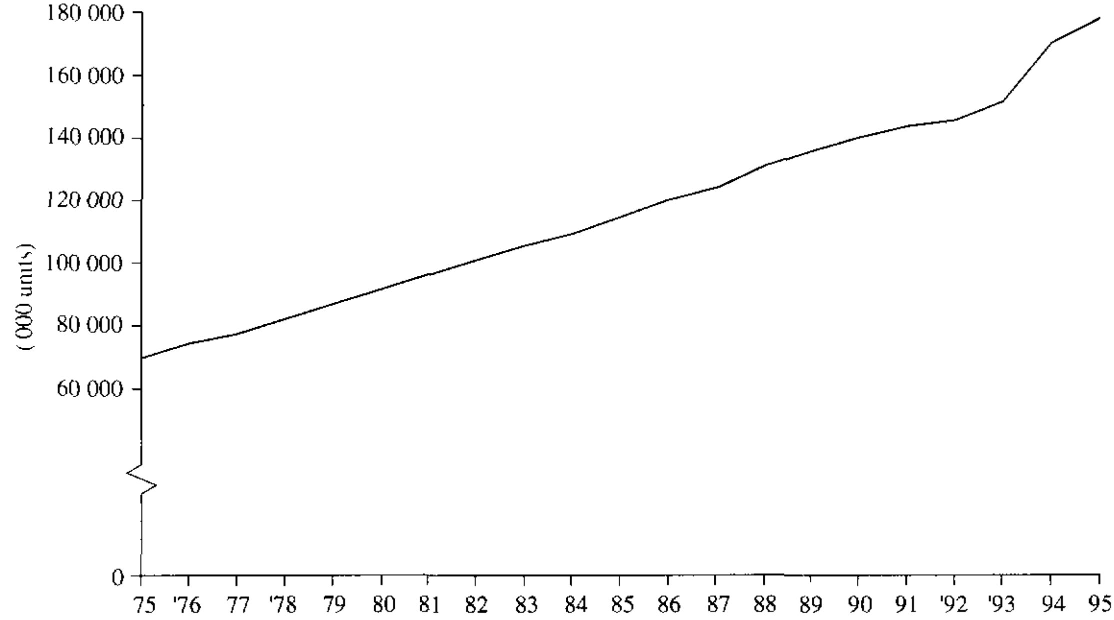

Figure 3 World CVs in use 1975 1995

The level of production of LCV and HCV tyres differs from region to region, and is particularly important as this affects not only the levels of elastomer usage, but also the split between natural and synthetic rubber.

ELASTOMER CONTENT

In heavy-duty applications, considerable heat is generated in the shoulder area of the tyre between the casing and the tread and can lead to blow-out or to separation of the tread from the carcass. In this area of the tyre there is a high usage of natural rubber as its high resilience reduces heat build-up Natural rubber/ polybutadiene rubber blends can also provide excellent wear characteristics coupled with good resistance to tread-groove cracking and rib tearing. For LCV tyres these considerations are less critical, and they use lower levels of natural rubber than HCV tyres In general, the larger the truck tyre the higher the usage of natural rubber, with the large CV tyres using almost 90% natural rubber.

Currently (1995) there are some 240 million CV tyres (*Appendix 1*) being produced annually[1], of which some 62% or 150 million are LCV tyres

During the 1980s it was assumed that the average HCV tyre used about 20 kg – 22 kg of elastomers The ratios of natural and synthetic rubber used in the production of cross-ply and radial-ply HCV tyres were 66·34 and 76:24, respectively (Bottasso, 1980) In the late 1980s, Carr *et al.*, using an elastomer content of 9–24 kg/tyre, estimated that truck tyres (including retreads) used about 24% of total rubber consumption.

The levels of natural and synthetic rubber vary considerably in the many different types of tyre This is particularly important in assessing consumption in this market as the last 10–15 years have seen a very large growth in the production of tubeless radial LCV and HCV tyres, as well as low-profile radial HCV tyres *Table 1* gives the estimated elastomer contents of truck tyres in western countries[2].

The average elastomer content has also been reported by Gelling and Newell[3] for the tread and sidewall components of CV tyres from 1974–1990 (*Table 2*)

Baker[4] has indicated that the subtread component of CV tyres is 80%–100% natural rubber, with bead stocks normally 100% natural rubber but with no natural rubber in innerliners

Using the above information it may be assumed that the average HCV tyre contains 21 kg–28 kg of elastomers, of which about 70%-90% is natural rubber. Similarly, LCV tyres may be assumed to contain about 10 kg of elastomer, of which about 65% is natural rubber. Thus the estimated rubber consumption by CV tyres alone is shown in *Table 3*, which indicates that 47% of the world production of six million tonnes of natural rubber is used in CV tyres HCV tyres, using some 1 8 million tonnes, are the largest single use of natural rubber[5]. This may have implications for the movements in the natural rubber price (*Table 3*).

TRUCK TYRE DEVELOPMENTS

Industrialised Countries

The widespread use of radial-ply tyres began in Europe in the early 1960s and spread to North America and Japan 10–15 years later The main advantage of radial CV tyres is in tyre life, which can be from 40% – 100% greater than that of a cross-ply tyre. In long-haul operations mainly on motorways, steering tyres can achieve 100–120 000 miles, drive tyres about 250–280 000 miles and trailer tryes about 130–150 000 miles before retreading, which can further extend tyre life In addition, where motorways predominate, the lower rolling resistance of radials gives an improvement in fuel economy of 6%–10%

The main driving forces behind the radialisation of truck tyres were changes in the design and loading of trucks, namely

- Increased power—higher brake horse-power trucks and tractor units for sustained high speeds increases heat build-up leading to increased wear and fatigue;
- Loading—increased permitted weight per axle;
- Power steering—tighter and faster cornering; and
- Configuration—vehicle and trailer configurations giving inequalities in axle loading, again leading to increased wear.

The development of radial HCV tyres with lower rolling resistance has become a top

TABLE 1. ESTIMATED ELASTOMER CONTENT OF CV TYRES

	Rubber content (kg)	Natural rubber (%)
LCV tyres		
Conventional	4.5 – 8.5	31 – 68
Radial, tubed	5.0 – 8.5	40 – 89
Radial, tubeless	7.0 – 10.0	45 – 90
HCV tyres		
Conventional	21.0 – 23.5	52 – 73
Radial, tubed	21.5 – 27.0	69 – 87
Radial, tubeless	24.0 – 28.0	77 – 85
Radial, low profile	24.0 – 27.0	84 – 87

TABLE 2. ELASTOMER CONTENTS OF CV TYRE COMPONENTS

Year	Tread		Sidewall	
	NR	SR[a]	NR	SR[a]
1974	45	55	48	52
1981	60	40	44	56
1983	77	23	58	42
1985	86	14	62	38
1990	86	14	75	25

[a]Styrene butadiene rubber (SBR) and polybutadiene, except in sidewalls in 1985 and 1990, when it was totally SBR.

priority for tyre manufacturers. With the continuing development of regrooving and multiple retreading, the life of HCV tyres is now approaching 400 000–600 000 miles. Like new tyres, retreads are becoming specialised relative to their axle position. In Europe the sales ratio of retread truck tyres to new tyres is about 1:1 in the replacement market, whereas in the USA this ratio rises to 1.4:1.

The development of low-profile CV tyres to reduce platform height and overall vehicle height while maintaining load capacity began in the mid-1980s and has continued in the 1990s. The larger rim diameters provide more space for the larger braking systems required with the elimination of asbestos brake liners. Other developments during the last 10 years have been the growth of tubeless tyres in both

TABLE 3. NATURAL RUBBER CONSUMPTION IN CV TYRES (MILLIONS OF TONNES: 1995)

	NR	SR	Total
LCV tyres	1.0	0.5	1.5
HCV tyres	1.8	0.5	2.3
Total	2.8	1.0	3.8

the LCV and HCV sectors, and the introduction of the wider 'super single' tyre to replace twin rear tyres. The super single tyre offers the advantage of reduced weight, reduced overall cost and better fuel economy. They are particularly advantageous for tanker truck operations because they allow the tank to be lower to the ground, giving a lower centre of gravity. However, with their smaller footprint on the road surface and high inflation pressure they cause greater road damage and in the case of deflation the truck cannot continue its journey.

Future changes in truck design and construction expected to influence future HCV tyre design are likely to include:

- Spread axles for laws relating to the load distribution on bridges;
- Twin-steer axles for increased load capacity, payload and improved truck/trailer configuration;
- Tandem spread axles with lift axles;
- Multiple tyre sizes for maximum cubic air capacity to support higher loads and to accommodate tri-axles;
- New vehicle designs with improved aerodynamics; and
- New tractor unit designs.

Other factors which may need to be considered by tyre manufacturers are:

- Pavement damage;
- Fuel economy developments;
- The development of larger road-trains and vehicle configurations; and
- Vehicle design coupled to changing legislation.

Developing Countries

These developments occurring in industrialised countries may not necessarily apply to continental Asia, Latin America and Africa, where the switch from cross-ply to radial-ply CV tyres has been very slow and much slower than predicted during the 1980s. Here, the local road, driving and loading conditions still favour the use of cross-ply tyres, which are suited to the poor road conditions since the more rigid sidewall is not as susceptible to damage under severe operating conditions caused by poor tyre maintenance, regular over-loading and constant kerbing. There appears to be little published information in the performance of radial truck tryes under these conditions, as most trials are conducted by tyre manufacturers for their own information. However, the results of a very small trial using steel radial precured first-life retreads has been published[6]. In India, six out of ten retreads failed despite fitment to express buses to avoid overloading and poor road conditions Four failures occurred below tyre-tread half-life, while two failed close to complete tread life at 59–60 000 km travelled. In Indonesia, eight out of ten retreads failed, although service conditions were again chosen to avoid overloading and use on poor roads. Four failures were below tyre half-life, but four failed only after travelling in excess of 100 000 km. In Malaysia, eight retreads travelled over 100 000 km without failures, although the condition of the casings would have precluded further retreading. The causes of radial retread failures are shown in *Table 4*.

Thus, it is evident that steel radial tyres are capable of providing high mileages, but the chances of premature failure are high and it is doubtful that retreading would be feasible, seriously affecting the economics of truck fleet operation

It is anticipated that up to the year 2000, tubed conventional truck tyres will predominate in these areas as they are ideally suited to local conditions of overloading and poor road construction because of their lower susceptibility to carcass damage, especially of the sidewall. In these countries, future developments in the construction and design of conventional tyres are expected to include·

- Heavier ply gauges to protect against higher shear stresses;
- Extra chafers or thicker rubber skim to increase abrasion resistance and protect against rim digging due to overloading;
- Larger dimensions for increased air volume to improve load-carrying capability,
- Thicker sidewalls for better protection against cut/impact damage,
- The use of twin bead construction in place of a single bead, and
- More robust shoulder ribs.

However, the majority of investments being announced by the major tyre companies in developing countries relates to radial tyre production. These tyres may initially be intended for the export market to reduce production costs.

FUTURE PROJECTIONS OF CONSUMPTION IN CV TYRES

A recent report by the Economist Intelligence Unit (EIU)[7] has indicated that the production of CV tyres will increase to about 270 million units in the year 2000 and rise to nearly 315 million units in the year 2005. Given the tyre developments referred to in the section under Truck Tyre Developments, it is anticipated that not only will there be an absolute increase in the usage of natural rubber in CV tyres due to increased production, but also that the proportionate usage relative to synthetic rubber will rise. Thus it is envisaged in 2005 that HCV tyre production will be in the order of 125 million units (with ·LCV — 190 million units), with an average elastomer content of nearly 90% natural rubber (LCV – 70%). Therefore the usage of natural and synthetic rubber in CV tyres only is estimated in *Table 5*.

In the case of natural rubber the main source of the absolute increase in consumption is to be derived from the additional one million tonnes usage by HCV tyres.

TABLE 4 STEEL RADIAL PRECURED RETREAD FAILURES

Distance travelled (km)	Cause of failure
	India
23 486	Shoulder damage: penetration
26 675	Sidewall crack: impact penetration
27 787	Sidewall cut: stone impact
30 323	Sidewall cut: impact
58 136	Sidewall failure: impact
63 171	Crown penetration
	Indonesia
6 850	Sidewall break-up: concussion
15 160	Sidewall damage: impact
15 520	Casing break-up: under-inflation?
39 726	Sidewall damage: impact
>105 000	Sidewall damage: impact
>105 000	Sidewall damage: concussion
>105 000	Sidewall cracking: fatigue?
>105 000	Sidewall damage

TABLE 5. NATURAL RUBBER CONSUMPTION IN CV TYRES (MILLIONS OF TONNES: 2005)

	NR	SR	Total
LCV tyres	1.2	0.7	1.9
HCV tyres	2.8	0.3	3.1
Total	4.0	1.0	5.0

Recent estimates by the IRSG Secretariat indicate that the total world elastomer demand in 2005 is likely to reach 23 million tonnes, of which natural rubber's share will be about 40% or 9 million tonnes[8]. Thus the share of CV tyres in natural rubber consumption is expected to remain roughly constant at around 45%, with HCV tyres continuing to provide the major outlet accounting for some 30% of total world natural rubber consumption.

HCV TYRE SALES AND THE NATURAL RUBBER PRICE

Although the natural rubber price undoubtedly moves in cycles related to the world economy, there are 'spike' movements, whereby in a few months it moves dramatically downwards or upwards. Such spikes occur at the beginning and end of cycles of world economic prosperity. As noted above, HCV tyres represent the largest single use of natural rubber, currently accounting for 30% of total natural rubber consumption. It therefore appears possible that major fluctuations in HCV tyre demand — and hence production — might have a detectable influence on the natural rubber price. One possible cause of such fluctuations has been identified in the use by transport fleet operators of wheels from trailers made redundant by reduced demand during the lead-in to an economic recession to replace worn tyres on those units still in use

Although retreaded tyres are often used on trailers, there will in these circumstances be increased economic pressure to reduce the purchases of new tyres in this way. When the next economic upturn occurs, there may be a higher demand for truck tyres for the 'hibernating' trailers to bring them back into use This could rapidly increase the demand for both new and retreaded HCV tyres Work is currently under way using data provided by the major rubber manufacturers' associations to examine whether changes in truck tyre demand may be a major 'fundamental' in the demand — and hence the price — of natural rubber[9].

CONCLUSIONS

Natural rubber is an essential component in the manufacture of LCV and HCV truck tyres, especially those of radial-ply construction. Over the past 20 years the use of natural rubber in truck tyres has increased slowly in percentage terms, but significantly in absolute volume This has been primarily due to the increasing penetration of radial technology for truck tyres and the development of tubeless and low-profile LCV and HCV tyres. In radial HCV tyres, which can be retreaded two or three times, natural rubber content may be as high as 90%.

The emphasis of truck tyre development over the last 10 years has been primarily on economy, which has been based on low rolling resistance, wear resistance and retreadability These may continue to be the priorities for the future although lower tyre weights, reduced irregular wear, lower noise levels and lower heat build-up may also become more important.

With regard to the usage of elastomers in truck tyres over the next few years, the following aspects should be important

- Natural rubber will continue to be used in large quantities in most components in a truck tyre;
- Sidewalls will still use natural-synthetic rubber blends, although future developments may encourage the usage of synthetic rubber, and
- New CV tyre retread components will continue to use high levels of natural rubber, whether the tyre is used in a steering, driving or trailer position, but synthetic rubber will continue its dominance of the retread market.

It is future developments in the construction of trucks in the western world and the development of improved road systems in Asia, Latin America and Africa that will increase the radialisation of CV tyres. As world economies continue to develop this will provide the future growth in derived demand for natural rubber from the manufacture of truck tyres, which will remain the largest market for natural rubber at about 45% of the total, with HCV tyres alone continuing to account for around 30% of world natural rubber consumption.

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APPENDIX 1. COMMERCIAL VEHICLE TYRE PRODUCTION ('000 UNITS)

Year	Canada	USA	Argentina	Brazil	Chile	Colombia	Mexico	Venezuela	Other Latin America	Austria	Benelux	Finland	France	Germany	German D R	Greece	Italy	Portugal
1975	2,529	28,611	1,190	2,752	***57***	***378***	***1,913***	***801***	***500***	***500***	762	36	4,935	3,468	***2,071***	***230***	2,886	314
1976	3,299	29,474	1,324	3,037	***151***	***408***	2,240	***821***	***600***	***550***	696	27	5,131	3,724	***2,123***	***240***	2,798	293
1977	3,327	38,199	1,416	3,422	***204***	***377***	2,188	***880***	***650***	600	827	30	5,404	4,044	***2,195***	***250***	2,762	409
1978	***3,200***	40,226	1,298	3,505	***191***	***547***	2,884	***927***	***750***	640	851	115	5,736	3,883	***2,220***	***275***	2,734	510
1979	3,357	38,659	1,532	3,506	***223***	***451***	3,138	***1,033***	***800***	755	977	110	***6,366***	***4,242***	***2,274***	***300***	2,894	510
1980	3,325	28,402	1,440	3,942	***232***	***513***	3,520	***1,045***	***850***	825	1,070	115	6,182	4,220	***2,332***	***340***	2,794	560
1981	2,895	31,973	1,041	4,161	***217***	***460***	3,510	***990***	***750***	730	1,096	130	5,360	3,977	***2,319***	430	2,570	650
1982	2,873	29,019	537	6,300	***120***	***472***	***4,610***	***930***	***850***	620	981	140	4,049	3,558	***2,327***	450	2,370	570
1983	3,432	30,667	***1,064***	6,494	***150***	***486***	***6,540***	***900***	***950***	630	1,064	160	4,427	3,757	***2,435***	280	2,330	620
1984	4,198	36,441	810	5,624	***228***	***526***	***4,330***	***896***	***1,000***	825	1,077	165	5,460	3,805	***2,570***	315	2,847	460
1985	4,135	34,339	1,190	5,182	***216***	***540***	***4,870***	***1,350***	***1,100***	595	1,169	246	4,249	3,970	***2,760***	***340***	2,795	502
1986	3,980	30,939	1,400	7,170	***216***	***567***	5,350	***1,505***	***1,250***	560	1,254	***220***	5,499	4,023	***2,823***	365	2,805	584
1987	3,904	35,455	1,690	9,924	***306***	***580***	5,600	***1,634***	***1,370***	560	1,339	***215***	5,590	4,192	***2,891***	***350***	2,974	671
1988	2,468	37,010	1,970	7,681	***333***	***594***	6,000	***1,562***	***1,440***	***550***	1,608	***190***	5,801	5,017	***2,919***	***530***	2,946	644
1989	2,927	37,844	***1,689***	8,069	***390***	***567***	3,995	***1,253***	***1,460***	***540***	1,747	***220***	6,083	5,366	***2,930***	***350***	3,027	640
1990	2,694	35,804	1,736	7,868	***408***	***553***	4,989	***1,203***	***1,290***	***570***	1,766	200	5,858	5,475	***1,620***	***300***	2,933	471
1991	2,646	32,811	1,400	8,260	***456***	***460***	5,408	***1,433***	***1,440***	***650***	1,809	***370***	5,799	5,980		***290***	2,752	***600***
1992	2,842	37,525	1,730	8,806	***500***	***480***	5,139	***1,416***	***1,590***	***530***	1,920	***255***	5,928	6,331		***150***	2,679	***620***
1993	3,363	39,927	1,790	6,170	***550***	***440***	4,736	***1,644***	***1,760***	***480***	***1,900***	***375***	5,143	5,187		***130***	2,367	***650***
1994	3,755	42,264	1,711	6,670	***571***	***460***	5,396	***1,628***	***1,790***	***500***	***2,030***	***360***	5,713	4,855		***140***	2,500	863
1995	4,448	45,027	1,782	7,070	***583***	***440***	4,952	***1,620***	***1,810***	***580***	***2,140***	***350***	5,925	6,065		***140***	3,030	***900***

APPENDIX 1. COMMERCIAL VEHICLE TYRE PRODUCTION ('000 UNITS) (CONTD)

Year	Spain	Sweden	UK	Bulgaria	Czech Rep.	Hungary	Norway	Poland	Romania	Russian Fed	Slovak Rep.	Slovenia	Switz-erland	Turkey	F R. of Yogo-slavia	Other Europe	South Africa	Other Africa
1975	2,111	213	3,790	417	1,494	670	10	2,749	1,926	20,469			5	713	582		1,429	1,000
1976	1,950	123	3,825	420	1,519	688	10	2,543	2,140	21,676			5	740	643		1,274	1,050
1977	2,180	183	3,665	449	1,636	706	15	2,371	2,217	22,822			5	742	925		1,311	1,100
1978	2,496	155	3,499	425	1,669	663	15	2,085	2,390	23,466			10	913	1,010		1,415	1,100
1979	2,749	185	3,285	429	1,694	650	20	2,400	2,413	23,849			10	870	1,043		1,398	1,150
1980	2,843	156	3,447	521	1,739	655	25	2,502	2,602	23,882			10	999	1,091		1,519	1,200
1981	2,800	82	2,895	533	1,784	615	25	1,741	2,693	24,045			10	815	1,197		1,838	1,250
1982	2,031	83	2,418	536	1,577	549	25	1,550	2,804	24,057			10	985	1,069		1,782	1,300
1983	1,965	59	2,249	543	1,562	732	25	1,917	2,780	24,520			10	1,298	1,073		1,503	1,300
1984	2,420	84	2,422	567	1,617	792	40	1,039	3,059	24,647			15	1,488	1,124		1,659	1,350
1985	2,930	105	2,294	564	1,651	825	49	2,221	2,013	26,104			20	1,670	1,283		1,479	1,400
1986	2,511	110	2,329	567	1,671	857	50	2,143	2,235	26,375			20	1,767	1,148		1,590	1,400
1987	2,769	115	2,539	631	1,711	888	50	1,993	1,857	26,906			20	1,688	1,005		1,712	1,450
1988	3,127	118	2,668	576	1,789	903	40	2,078	1,919	27,326			18	1,635	937		1,949	1,450
1989	3,344	116	2,972	599	1,849	967	35	1,960	1,840	27,517			17	1,417	1,072		1,997	1,500
1990	2,975	19	2,782	598	1,819	855	20	1,129	1,267	26,317			19	1,114	1,026		2,270	1,500
1991	2,872	31	2,839	382	1,662	612	-	1,800	890	25,181			10	2,038	503		1,875	1,550
1992	3,029	169	2,479	353	2,154	516	-	1,810	862	16,919		1,447	7	1,683	194	4,900	2,141	1,450
1993	2,989	169	3,084	266	2,150	441	-	1,700	733	13,470	660	1,529	-	1,792	78	4,000	1,501	1,500
1994	3,249	69	3,222	187	1,270	508	-	2,100	691	7,244	1,150	1,621	-	1,528	143	2,500	1,551	1,550
1995	3,558	120	3,349	218	1,820	660	-	2,700	774	6,333	1,644	977	-	1,658	114	3,000	1,729	1,600

APPENDIX I COMMERCIAL VEHICLE TYRE PRODUCTION ('000 UNITS)

Year	Australia	China	India	Indonesia	Iran	Israel	Japan	Rep of Korea	Malaysia	New Zealand	Pakistan	Philippines	Sri Lanka	Taiwan	Thailand	Other Asia	World Grand Total
1975	***577***	***5,950***	2,880	***1,006***	***600***	***293***	25,782	1,363	***500***	***200***	***120***	***794***		***639***	900	***400***	133,500
1976	***649***	***5,860***	2,724	***1,678***	***500***	***336***	28,199	1,559	***633***	***230***	***100***	637		***701***	867	***450***	140,700
1977	***679***	***6,221***	3,069	2,339	***550***	***344***	31,113	1,854	***725***	***230***	***110***	797		***730***	1,066	***500***	157,800
1978	***595***	***6,837***	3,410	2,540	***600***	***308***	33,446	2,604	***689***	***240***	***110***	889		***1,035***	1,141	***500***	166,700
1979	***645***	***7,713***	3,473	2,898	***400***	***263***	38,866	3,179	***692***	***240***	***115***	958		773	1,276	***550***	175,300
1980	534	***7,627***	3,707	2,051	***600***	***248***	46,133	2,790	***688***	***250***	***120***	883		847	1,167	***550***	173,100
1981	597	***6,061***	3,825	2,242	***500***	***221***	44,572	4,906	***798***	***240***	***110***	879		874	1,547	***550***	173,500
1982	493	***6,567***	4,340	2,859	***600***	***217***	42,272	3,764	***652***	***240***	***100***	1,006		966	1,363	***550***	167,500
1983	***475***	***8,055***	4,449	2,401	***650***	***209***	46,368	4,642	***663***	***190***	***100***	1,100		1,300	1,610	***600***	180,700
1984	***470***	***9,220***	4,613	2,501	***700***	***202***	48,287	5,699	696	***220***	***125***	***950***		2,093	1,790	***600***	192,100
1985	***480***	***10,559***	4,680	2,880	***621***	***190***	48,259	6,296	568	204	***138***	***850***	23	2,361	1,221	***600***	194,100
1986	880	***10,550***	4,933	***3,251***	***537***	***149***	44,009	8,420	525	168	***130***	***588***	80	1,340	1,244	***600***	192,700
1987	1,070	***12,090***	4,170	***3,343***	***688***	***185***	45,518	9,160	672	***215***	***181***	***724***	85	1,560	1,580	***650***	206,500
1988	1,150	14,315	5,569	4,360	***668***	***115***	49,879	10,531	811	***130***	***272***	***1,218***	78	1,840	2,057	***650***	219,400
1989	***1,200***	15,152	5,809	5,199	***721***	***151***	50,003	10,319	895	***140***	***317***	***1,216***	77	***1,931***	2,250	***700***	222,400
1990	***1,250***	13,862	5,989	5,874	***962***	***156***	49,656	11,791	1,044	***120***	***333***	***1,308***	103	***2,131***	1,737	***700***	216,500
1991	***1,200***	17,292	6,015	6,128	***847***	***157***	48,997	13,819	1,438	***120***	***274***	***1,100***	101	***1,849***	1,924	***750***	216,800
1992	***1,250***	22,229	6,533	6,191	***1,003***	***178***	46,562	14,856	1,370	***130***	***249***	***1,400***	81	1,609	2,212	***800***	225,200
1993	***1,250***	29,317	6,662	6,853	***996***	***171***	41,357	14,680	1,460	***140***	***274***	***1,550***	44	1,340	2,544	***850***	222,200
1994	***1,300***	32,099	7,554	8,142	***1,308***	***193***	40,812	15,520	1,539	***150***	***288***	***1,700***	80	1,140	2,900	***850***	225,400
1995	***1,350***	32,134	8,629	9,227	***1,200***	***184***	44,531	16,514	1,596	***160***	***351***	***1,600***	95	850	3,600	***900***	240,000

Source World Rubber Statistics Handbook Vol 5

Figures in bold italics are estimates