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THE ECLIPSE OF THE U.S. TIRE INDUSTRY

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CES 97-13

September 1997

Census
REF
HC
103
.D57
1997
no. 13

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Abstract

This paper undertakes an in-depth analysis of the tire industry over the period 1970-1990. It attempts to uncover the causes and the consequences of the acquisition activity in the industry in the 1980s, which resulted in all but one large U.S. tire manufacturer being sold to foreign companies. We do not find that ownership was acquired by firms more efficient at managing the existing plants. Nor were the takeovers undertaken in response to the failure of internal control systems to induce downsizing. The most likely explanation is that the acquisitions were driven by an increase in cross-border production and trade by automobile manufacturers. This increased the need for cross-border production by the tire manufacturers that, in a slow growth industry, could only happen through acquisitions. U.S. manufacturers became the natural targets of this wave of acquisitions because they had delayed investment in the radial technology and, thus, had high costs of staying in the industry.

Keywords: tire industry, mergers, productivity, foreign competition, radial tire technology

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It is difficult to think of an industry which was affected more by the wave of mergers and acquisitions (M&A) in the 1980s than the U.S. Tire industry. Seventy five percent of the companies in the industry (accounting for 90% of the value) experienced a takeover bid or were forced to restructure during the period 1982-1989 (Mitchell and Mulherin, 1996). As a result of this activity, control changed hands in over half the companies in this industry. Even more remarkable, in the majority of cases, control was transferred to foreign owners. By the end of the decade, traditional American firms like Firestone, Uniroyal, Goodrich, Armstrong, and General Tire belonged to foreign companies. As a consequence, large U.S. owned tire manufacturers, who in 1971 represented 59% of the world production and included four out of the top five producers, in 1991 represented only 17% of world production with only one of the top five producers (see Table 1). These changes are even more dramatic when compared with the stability of the relative market shares of U.S. tire manufacturers for the previous fifty years.

The U.S. tire industry therefore presents an intriguing example of the changes wrought by the Mergers and Acquisitions wave that swept through the United States in the 1980s, and of its effect on the position of U.S. manufacturers in a global market. Anyone interested in the effects of mergers and acquisitions on the productivity and the long term competitiveness of the U.S. economy cannot ignore what has happened in this industry. The purpose of this paper, then, is to undertake an in-depth industry analysis of the events that lead to the demise of U.S. ownership in the tire industry, and of the effects of mergers on industry restructuring and productivity. To do so we call upon a variety of different sources, ranging from plant-level data to industry analyses (including contemporary reports in trade publications), interviews with executives, and accounting data. The goal is to attempt to explain why the merger wave occurred, why it was lead by foreign producers, and what its effects have been.

We are able to test (and reject) two main interpretations of these events. The first (neo-classical) hypothesis is that foreign manufacturers were more efficient in producing tires, and that this advantage (be it superior know-how or better management) could not be transferred to U.S. manufacturers without acquiring their plants. According to this view, the takeovers in the 1980s in the tire industry were simply a reflection of the fundamental tendency for assets

to move to the most efficient producers. Contrary to this view, we find that plants are not acquired by the most efficient producers (at least as far as plant level productivity is concerned) and we do not find any evidence of an increase in plant-level productivity after an acquisition.

A second explanation of the phenomena is advanced by Jensen (1993). He suggests that the evolution of the U.S. tire industry during the 1980s is a textbook example of the effects of what he calls "the third industrial revolution." According to Jensen, rapid technological change generates overcapacity in certain industries, requiring some firms to downsize or exit. But "managers fail to recognize that they themselves must downsize; instead they leave the exit to others while they continue to invest. When all managers behave this way, exit is significantly delayed at substantial cost of real resources to society. The tire industry is an example. Widespread consumer acceptance of radial tires meant that worldwide tire capacity had to shrink by two-thirds (because radials last three to five times longer than bias ply tires). Nonetheless, the response by the managers of individual companies was often equivalent to: 'This business is going through some rough times. We have to make major investments so that we will have a chair when the music stops.' " - Jensen (1993, p. 847). Since, internal control systems do not force managers to shrink, only the intervention of outside raiders can force these companies to downsize or exit. That the acquirers were foreign rather than domestic is not relevant for this interpretation, all that matter is that they were outsiders to the industry.

We do not find much support for this interpretation either. While, as suggested by Jensen (1993), there were some delays in closing bias ply capacity (also see Sull (1996)), the industry had made most of the necessary closures by the early 1980s - before the takeovers started! More specifically, we find no evidence that acquisitions hastened the closure of plants in general and more inefficient plants in particular. We also find that capital expenditures increase after an acquisition, which is inconsistent with the overinvestment hypothesis.

We then try to explore the reasons for the demise of the U.S. ownership in the tire industry by looking at the historical evolution of the tire industry in the United States and the rest of the world, with particular emphasis at the relationship between the car and the tire industry. The car industry plays an important role for two reasons. First, original equipment sales represent

about one quarter of all sales. Moreover, they have an important effect on the replacement sales given the tendency of consumers to buy the same type of tires. Second, major changes in type of tires used, like the introduction of radials, require some modifications in the design of cars. This raises an important coordination problem.

The most striking aspect of the U.S. tire industry is its delay in the introduction of radials. Michelin first commercially produced radials in France in 1948, and by 1970, 98% of tires sold in France were radials. The rest of Europe and Japan followed a similar path. Yet, in 1970 radials represented only 2% of the tires sold in the United States. The technology was well known to U.S. manufacturers, who were using it in their European subsidiaries. An attempt by Goodrich to launch radial production in the United States in 1965 failed because of the strong opposition of U.S. car manufacturers, who did not like the fact that radial tires required a whole new suspension system in the cars. Only in the beginning of the 1970s did the car producers announce that they wanted to switch to radials. Therefore, U.S. tire manufacturers delayed the transition to radials until the 1970s, a period characterized by the oil crisis and a severe recession in the car industry.

The switch to the radial technology required major capital investments because it was not economically feasible to convert the existing bias-ply capacity to producing radials - Firestone's attempt to do so ended in fiasco. As a result, tire producers faced the prospect of making major capital investment in a low margin sector at the same time as the growth prospects for the entire sector looked grim. The major diversified tire (Goodrich in particular) made the conscious decision to reduce their capital and development expenditure in the tire business, sell their foreign operations, and look for a buyer for domestic operations. Others, like Uniroyal, were less clear-cut about their prospects. However, barring Goodyear, all the tire manufacturers reduced their focus on tires. It is well possible that this was indeed the optimal strategy, since foreign producers had already sunk their investment in radials, while U.S. producers had to sink at a time when the long term growth prospect of the car industry (and thus indirectly of the tire industry) had worsened.

One possible solution at this stage was a consolidation of the U.S. tire industry. There were

two reasons, however, why that could not occur without the co-operation of outsiders. First, it was unclear whether such move would be accepted by the Federal Trade Commission. Second, and most important, automobile manufacturers heavily opposed any consolidation among their suppliers. They liked having a number of independent tire suppliers, to ensure competition. As a result, a merger between two tire suppliers would inevitably result in a redistribution of some of their share of the original equipment business to other tire manufacturers. The importance to tire manufacturers of having original equipment sales to the automobile manufacturers therefore precluded a large domestic tire manufacturer from merging with another large domestic manufacturer (unless, of course, one of the manufacturers had no original equipment sales as was the case with Goodrich which merged with Uniroyal).

In the meantime, the economics of the industry were changing in other ways. Most importantly, automobile sales and manufacture were becoming more international and there was growing need for tire manufacturers to follow their customers across countries. If Honda cars are equipped with Bridgestone tires, then Honda's exports in the United States automatically generate demand for Bridgestone tires in the U.S. replacement market. It is only natural for Bridgestone, thus, to take advantage of this demand by starting to sell in the United States. Given the high transportation costs, this will generate also the need for producing in the United States.

The globalization of the car industry also produced the need for a higher level of R&D, which could be borne only if spread over a higher volume of sales. For example, Goodyear's R&D and advertising expenses as a fraction of sales rose 27% between 1970-75 and 1980-90. As a result, only large multinational companies could survive.

If only multinationals could survive and there was not much room to build new capacity in any of the major industrialized countries, then only two possibilities were left: either the foreign producers acquired U.S. firms or U.S. firms acquired foreign producers. The latter alternative, however, was not feasible since most of the foreign companies could not be acquired. Michelin, for example, which is the major French tire producer, is fully controlled by a limited partnership, whose unlimited partner is Francois Michelin. He, rather than a majority of

Michelin shareholders, decides on the future of Michelin. Similarly, the major German producer, Continental, is controlled by a complicated web of shareholdings that prevented Pirelli from taking it over in 1990. The Japanese firms are even harder to acquire. By contrast, acquisitions, even acquisitions by foreign firms, were extremely easy in the United States during the 1980s. Although it is hard to establish how much weigh this asymmetry played, it is an important (and often ignored factor) that should be taken in consideration.

We, therefore, conclude that the roots of the dramatic change in the world and U.S. tire market between 1970 and 1990 lie largely in the failure U.S. tire manufacturers to adopt the radial technology when the rest of the world did so. Of course, hindsight is always 20/20. But even manufacturers such as Goodrich who realized the potential of the technology back in 1965 could not force its widespread acceptance. The structure of the domestic market, and specifically, the relationship between the automobile manufacturers and the tire producers, was probably instrumental in retarding the adoption of the technology. In other words, even though they acted rationally and in their own self interest, the structure of the domestic market led U.S. tire manufacturers – like actors in a Greek tragedy – inexorably toward their doom. By contrast, the domestic market structure in countries like France probably spurred innovation. Thus the paper highlights a possible link between domestic market structure, innovation, and the ability to compete internationally.

The rest of the paper is as follows. In section 1, we discuss the structure of the tire industry, in section 2, we discuss the reasons for the delay in the introduction of radials into the United States. Section 3 tests the “neoclassical” and “overinvestment” hypotheses while section 4 examines the hypotheses that the U.S. manufacturers willingly quit a business they were too weak to compete in. Section 5 concludes with policy conjectures.

1 The Structure of the Tire Industry

1.1 History

The tire industry had its beginnings in tires made for bicycles.¹ At first, bicycles used solid rubber tires, but the invention of the pneumatic tire by John Dunlop in 1888 soon made this the dominant product. The industry took off on the back of an explosion in the demand for bicycles in the 1890s. By the time the craze for bicycles waned in the beginning of this century, automobiles started driving the demand for tires, and they account for a majority of tires manufactured even today.

The early focus in product innovation was on making the tire fit the wheel without slipping, while at the same time, making it easily removable. But the demand for product innovation did not cease once this was achieved. Automobiles became heavier and faster, which triggered major innovations in tire manufacture including the introduction of patterned treads. French (1991) argues that these innovations enabled smaller firms such as Goodyear and Firestone to compete with the large bicycle tire manufacturers.

Even though the basic form of the automobile tire was set by 1910, there have been tremendous advances since then in the product. The introduction of balloon tires in the 1920s and, as we will detail shortly, radials in the 1970s, were fundamental changes. Tires became flatter and wider, and tire life improved rapidly, especially in the 1920s and 1970s. Changes in manufacturing technology accompanied the changes in product technology. The industry had moved to mass production using tire-building machines by the 1920s. French (1991, p. xv) suggests that “technical changes increasingly disadvantaged smaller producers and consolidated the position of larger firms, leading to a decline in the number of firms after 1920”. Interestingly, innovation seems to have enabled small manufacturers to establish themselves when the industry was in its infancy, but as the industry matured, it seemed to become a barrier to entry. This relationship between innovation and number of firms has been formalized and applied to the tire industry

¹This section draws heavily from French (1991) and Tedlow (1991).

by Jovanovic and MacDonald (1994).²

This is reflected in the market shares of the various manufacturers. Four of the five biggest producers of tires in 1970 (Goodyear, Firestone, U.S. Rubber (later Uniroyal) and Goodrich) were also among the five biggest in 1910. This is not to say that there was no entry or exit early on. For instance, 60 firms entered the industry in 1919-1920 alone. But the turnover was largely confined to the small firms and new entrants. The large firms and their market share remained surprisingly stable. Moreover, entry eventually dropped off with virtually no entry between 1929 and 1970.

The major tire manufacturers in 1970 – the starting point for much of our analysis – had somewhat different origins. B.F. Goodrich and U.S. Rubber (Uniroyal) were primarily rubber goods manufacturers before they began producing tires. The tire business was a form of diversification for them. By contrast, Goodyear and Firestone started out in the tire business. The differences in their origin seemed to reflect in the extent to which they diversified outside the tire industry. Goodrich and Uniroyal had approximately 60% of their sales in the tire industry in 1970, while the figure was over 80% for both Firestone and Goodyear. The exception to this pattern is General Tire which started in 1915 supplying repair material but soon started tire production in 1916. It had only 40% of its sales in tires by 1970. As we will see, the extent to which the firm was diversified appeared to influence top management's commitment to stay in the business.

1.2 Structure of the Industry circa 1970

Table 1 shows the share of the world market for tires held by the major producers. Michelin was the only non-U.S. manufacturer in the top 5 in 1971. The top four producers controlled 60% of the world market. According to Knox (1970) and Dick (1980), the tire industry has been so heavily concentrated since the thirties: in the US market in 1935, the four largest producers accounted for 80% of the total sales; in 1958 the ratio was 74%, and at the end of the 1960s,

²Interestingly, they end their analysis in 1973 on the basis that the introduction of radial did not increase the optimal scale of production of tires.

72%.

Economies of scale in production do not seem to explain such a level of concentration. Plants in 1976 had capacity varying from 300 tires per day to 30,000 tires per day, with a mean capacity of 14,500 tires. *Modern Tire Dealer* reports there were 55 plants of significant size in 1976. That the minimum economic scale is not very large seems to be obliquely confirmed by John Ong, Chairman of the Board of BFGoodrich, "Today, under normal competitive conditions, it's not economically feasible to operate a tire plant with capacity lower than 9,000 to 12,000 tires a day. Mixing, calendering, and other equipment investments mandate a minimum size". This estimate would allow for about 100 plants in the United States.

1.3 Channels of Distribution

The tire industry essentially serves two markets; the Original Equipment Market (OEM) and the replacement market (RM). OEMs are the automobile manufacturers who, historically, have had tremendous bargaining power. In the words of William O' Neil, Sr., founder of General Tire, "Detroit wants tires that are round, black, and cheap - and it don't care whether they are round and black" (Tedlow (1991), p. 15). The automobile manufacturers have been content to play tire manufacturers against each other without actually building their own tire factories (though Ford briefly did so in 1938). But despite its low profitability, the OEM market has historically been important because it provides large orders (and hence the scale) as well as the prospect of future replacement sales (car owners typically replace tires with the same original equipment brand).

A possible explanation for the concentration of tire sales is that sales to the OEM market are critical. The primary requirements of an OEM supplier according to *Rubber World* (January 1966) are that the supplier must be a technological innovator. As a tire veteran put it "You just can't stand still with those boys [the automobile manufacturers]...Your tires have to carry heavier loads, last longer and go faster. The smaller firms cannot afford the kind of R&D operation this entails." Another requirement is that the tire manufacturer must be able to deliver the product. In other words, it must have "a distribution set-up capable of giving

Detroit what it wants, where it's wanted - and on time... It must have acceptance as national supplier... it must be able to warehouse Detroit's requirements well ahead of the call, stockpiling them, in order to avoid the risk of strikes." Finally, a sales network that is capable of servicing the OE tires is an added advantage in obtaining OE orders. Thus the economies of scale in research and distribution appear to be an important element of this industry.

Table 2 shows the share of the domestic OEM market held by U.S. manufacturers. Smaller manufacturers had a presence only in the replacement market, but even there, the majors controlled a significant fraction of the overall sales.³ The automobile manufacturers did not buy from one tire supplier. Instead, they spread their orders among the tire manufacturers, though they had their favorites. For instance, Goodyear and Chrysler, Uniroyal and General Motors, and Firestone and Ford were thought to enjoy special relationships. Since no foreign tire manufacturer produced locally, this explains why virtually the entire OEM market was held by the five major U.S. manufacturers in 1970.

The OEM sales of 37.5 million tires in 1970 accounted for 22% of the market. The rest is accounted for by replacement sales which were a further 130 million and accounted for 77%, while exports represented less than 1%. Buyers in the replacement market range from mail order and retail chains like Sears and Montgomery Ward who became significant buyers in the 1920s, to oil companies who entered tire retailing in the 1930s, own company stores, and independent merchants. In 1970, replacement sales were composed of sales to the service stations of large oil companies (15%), large department stores (15.5%), tire company stores (11%), and independent tire dealers (56%). Profits in the replacement market have historically been higher than in the OEM market. Benioff and Rosenbloom (1990) report that in 1966 the profit margins were between 3% and 5% in the OEM market and between 5% and 8% in the replacement market.

Not all tires are sold in the replacement market under the producer's own name. Part of the output sold to large oil companies, department and chain stores were distributed under private

³Most major manufacturers also produced for private labels. As a result, it is not easy to obtain an exact figure for the share of the replacement market controlled by each manufacturer. If we restrict our attention to the share of the market controlled by the major under their original names, Goodyear controlled 13% of the replacement market in 1974 and Firestone 10%.

names specific to the outlet. This market was especially important for smaller companies such as Armstrong and Mohawk since they did not need to advertise in order to sell. The tire producers distributed the rest under their own names (the national brands), or under less well-known names called "associate brands". As a result, even though the tires were produced by only a small number of companies, they were sold under more than 170 brand names. The market was effectively segmented; national brands, that were highly advertised nationally and were used as original equipment could command a higher price, while the other brands were sold in a very price-competitive market.

1.4 Technology

In the 1960s, there were fundamentally two different types of tire construction: bias-ply and radial ply. Technically, the two tires differ in the way the body cords are layered in the body of the tire - in bias ply tires, they are at an angle to the direction of rotation while in radials, they are perpendicular. In practice, the two tires differ substantially in performance. On good quality roads, bias tires assure a smoother ride, but they are inferior to radials on bumpy roads and they do not hold the road as well when it is wet. The radial tire offers more safety with better braking and cornering power. Radial tires also give better gas mileage. The major difference, though, is in life expectancy: a bias-ply tire lasts about 12,000 miles while the radial lasts 40,000 miles.

For reasons we shall discuss shortly, the tire manufacturers largely stuck to bias ply tires, though Goodrich made a failed attempt to introduce radials in 1965. From 1967 onwards, however, they quickly switched to an intermediate product, the belted bias ply tire. This tire had much of the ride characteristics of the bias ply tire but lasted about 24,000 miles. The belted bias tire had one advantage over radials - it was much cheaper to convert existing production lines to produce belted bias tires. In 1970, approximately 85% of tires manufactured were belted bias ply tires.

1.5 Investment and Financial State.

The majors invested substantial amounts in the 1960s as they expanded production and switched production to belted bias ply (while conversion was cheaper than converting to radials, it was not costless). Goodyear opened four new plants over this decade while Firestone opened three. Both Goodyear and Firestone were largely in tire production, so Compustat firm level data can be used as an approximate measure of their investment in tires (domestic and foreign). Both firms invested 6% of sales, on average, in the first half of the 1960s, and 8% on average in the second half.

Despite the substantial investment (the majors did not invest such large amounts relative to sales again), the majors entered the 1970s in reasonably good financial condition. Interest coverage (= EBITDA/Interest Expense) ranged from a low of 3 for Goodrich to a high of 7 for Firestone. Netting out cash from both debt and assets, the debt to assets ratio ranged from a high of 0.38 for Goodrich to a low of 0.23 for Firestone. Interestingly, Goodyear which was the only major to survive, entered the 1970s right in the middle of the pack in terms of leverage.

1.6 Industrial Relations

The last important aspect of the tire industry to be considered is industrial relations. Workers in the tire industry were organized by the United Rubber Workers during the thirties and early forties. Historically, wages in tire plants have moved in tandem with increases in the Big Three auto contracts. This principle has underlined URW bargaining since the forties. Competition from imports, however, placed greater pressure on tire companies to reduce costs over the 1970s and 1980s. In response, management attempted less expensive settlements. Also, they shifted production by opening new plants in the southern part of the USA, where unions were less strong. As a result, of the nine plants constructed since 1970, only one has been organized, while all 21 plants built during the sixties were organized.

2 The Radial Technology and its Delayed Entry in the U.S. Market

In 1970, U.S. manufacturers were the largest in the world with extensive international operations. Looming ahead, however, was the spectre of wrenching change for the tire manufacturers. Even though they had just converted to the intermediate technology of belted bias ply tires, the single most important issue faced by the tire industry in the beginning of the 1970s was the impending arrival of radial tires. Contrary to popular belief, neither were radials a new technology nor did the oil crisis in late 1973 precipitate the introduction of radials. This raises the question of why the U.S. manufacturers sunk so much in the intermediate belted bias technology without moving directly to radials, and why they took so long to introduce the radials. We argue that both the U.S. automobile and tire industries were in a low technology equilibrium that was disrupted only by the entry of foreign manufacturers.

2.1 Brief History of the Radial Tire

The first radial tire was invented in 1913 by Gray and Sloper of the Palmer Tyre Company (UK). In 1948, Michelin first introduced the tire into commercial production (the Incredible X) and patented a radial with steel belt. In 1951, Pirelli patented its own radial tire, with rayon belts (named Cinturato) and in the late fifties, Continental, Dunlop and the European subsidiaries of Goodyear, Firestone and Uniroyal started the production of radial tires. While in 1970, over 98% of tires manufactured in the United States were bias ply or the belted bias tire, 97% of tires in France and 80% of tires in Italy were radials. Thus, the radial technology was neither commercially new, nor was it unknown to the U.S. manufacturers. But it simply was not used in the United States.

2.2 The Production Technology

In 1970, radial production required 20 to 35% more labor than bias tires. Furthermore, it required substantial investment and changes in the method of production. "One of the certainties about radial-ply manufacture is that, new production equipment will be a necessity... new tire building machines, fabric and wire bias-cutters, new or modified curing, special stacking and handling systems, and (perhaps) new feeding equipment. This is due to the radial's unique construction" (Rubber World, November 1965). Moreover, radials necessitated closer tolerances, stricter quality control, frequent inspections, and the percentage of scrap and defective radial tire was twice as high as with conventional tires. Another reason for their increased cost was that the raw materials needed to produce a radial tire cost 35% more than for a bias one.

2.3 The Attitude of the Automobile Manufacturers.

U.S. automobile manufacturers had grown complacent over the 1960s. Tedlow (1991, p. 24) points out that the 1967 Cadillac Eldorado was "priced at \$6,277 and weighing in at 3,000 pounds, "plowed through tight corners in ungainly fashion and got only ten miles to the gallon." The Mercedes Benz 250 of that year weighed half a ton less, cost \$ 2,000 less, was more than a foot and a half shorter, and ran twice as long on a gallon of gas." American cars were built to be land cruisers, floating on large highways, and fuelled by cheap gas. The smooth mushy ride that manufacturers thought consumers required could only be provided by the bias ply tires. The emphasis in automobile design was not so much on the handling or product quality but on looks. "There was only one kind of car headquarters wanted to hear about: A Car Just Like Last Year's." (Easterbrook, 1992, p. 317.) The problem, however, was that customer preferences had changed considerably, and they now wanted better handling, quality, and - after the oil crisis - mileage. This was reflected in the rising tide of automobile imports as Detroit failed to meet the needs of its customers.⁴

⁴It is also possible that the driving experience with car imports led customers to acquire a taste for radials.

2.4 The Diffusion of the Radial Tire in the U.S.

Seeing the changing preferences of consumers, Ford in 1970 and General Motors in 1972 announced plans to introduce models with steel belted radials. "Suddenly [the tire manufacturer's] expectations were confounded by dramatic external changes, and the switch to radials had to be undertaken swiftly..." (French (1991), p.101). What were the changed expectations? In 1972, *Rubber Age* projected the growth of the radial market in the United States based on the diffusion of the tire in the German and U.K. market. It estimated that the radial ply would grow from 3% of the OE market in 1972 to 65% in 1976. It was somewhat more conservative in its estimate of penetration in the replacement market, given the popularity of belted bias ply tires. *Rubber Age* felt radials would have 30% of the replacement market by 1976. Sull (1996) also argues that two tire manufacturers in 1973 made similar projections for 1976.

These estimates are important because they preceded the oil crisis (recall that the trebling of oil prices was unimaginable until it actually occurred in late 1973). What is amazing is the actual penetration of radials in the OE market in 1976 (see Table 3) was 64%, while in the replacement market, it was 29%. This suggests that at least some industry sources could see the writing on the wall, and the forces precipitating the change to radials were in place even prior to the oil crisis. This view is confirmed by our conversations with industry sources.

What is puzzling about the switch to radials is not that it occurred so fast. In fact, the switch from bias ply to belted bias ply towards the end of the 1960s occurred even faster. The puzzle is why radials were not introduced while belted bias ply tires were – almost as soon as they could be produced commercially. As we will argue, this delay in adopting an innovation which the rest of the world had already implemented put U.S. industry at a disadvantage. We will also attempt to explain why the introduction took place when it did. Understanding all this is critical to understanding the takeovers in the 1980s.

2.5 The Causes for the Delayed Introduction of the Radial Tire

We point to three special characteristics of radials to explain why U.S. manufacturers settled into a low technology equilibrium. First, car suspensions have to be built differently to accommodate radials. This involves substantial redesign and investment. Thus, unlike with the change from bias to belted bias, the change to radials required the support of the automobile manufacturers. As we have argued above, the car manufacturers were reluctant to abandon the cushy ride offered by the bias ply tires even though consumer preferences may have been changing. Thus the reluctance to innovate upstream hampered innovation downstream. To complicate matters, radials were a radically different technology, unlike the belted bias ply tires. While U.S. manufacturers had some experience in manufacturing radials in their European subsidiaries, they were certainly not the leaders (see *Rubber World*, April 1976). Adapting radials to U.S. cars and U.S. production methods still required considerable innovation. Thus U.S. automobile manufacturers did not have an assured supply of high quality radials if, in fact, they decided to switch.

Second, unlike with bias belted tires, radials could not be manufactured on the same machinery as bias ply tires. Enormous new investment in new machinery was required to change to radial manufacture. But the third factor comes in here. In the OE market, much of the rents from the improved technology would be extracted by the automobile manufacturers. And the technology had the potential to shrink the replacement market even more than belted bias ply tires. Thus rents from the new technology would accrue largely to the automobile manufacturers, and indirectly to consumers, while the investments costs would be wholly borne by the tire manufacturer.⁵ To summarize, there were two barriers to switching to the radial technology; a co-ordination problem and a rent sharing problem. The co-ordination problem was that car manufacturers were afraid to change their designs absent a serious commitment to radials by tire manufacturers. Tire manufacturers, on the other hand, were unwilling to make the massive

⁵Implicit in this argument is that the OE market and the replacement market are only loosely connected so that the automobile manufacturer does not extract all the rents from replacement sales also. If consumers always replaced tires on their car with the same brand, then presumably the automobile manufacturer could extract not only the profits on the OE tire but also the profits on the replacement.

investments in moving to radials without the assurance of rents from a large market.⁶ Yet, in all likelihood, it appeared that their most profitable market (the replacement market) would shrink as a result of the longer life of the new product. This appears to be a textbook example of the the hold-up problem as modeled by Grossman and Hart (1986).

What was different in the other countries? Consider France, which was the first to switch. When Michelin introduced the radial tire, it controlled Citroen, having acquired it in the 1930s when Citroen was unable to repay the debts owed to the tire company. Thus the coordination and rent sharing problem in upstream and downstream innovation was solved by the simple expedient of vertical integration. Moreover, the tire market in France was dominated by Michelin (it had 63% of domestic market share in 1975 with the second producer having only 12% (see West (1984, p 44))). So not only could it keep some of the rents from innovation while dealing with other car manufacturers, it could also capture rents in the replacement market from the improved product. As in Grossman and Hart (1986), the hold-up problem is resolved by integration.

Even though tire manufacturers in Italy, Germany, and the U.K. did not own automobile manufacturers, they adopted quickly. This was because once Michelin had shown the success of the radial, it could offer it in neighboring countries where it had a foothold.⁷ This forced tire manufacturers in the other countries to offer radials.

What changed in the United States in the early 1970s to propel adoption? Ford and GM expressed an intent to start manufacturing cars with radials. An important factor in this decision was Michelin's decision in 1970 to re-enter the U.S. market (which it had abandoned in 1930) and produce radials from a plant in Nova Scotia. Not coincidentally, it obtained a contract to produce radials for the 1970 Ford Continental at the same time (see Tedlow (1991)).

⁶West (1984) focuses on this last issue; "the way in which the US transnationals delayed launching the radial tire in their home market is a classic example of the use of market power by large firms to slow down the pace of innovation in an industry". We, however, believe that automobile manufacturers also played an important part in the delay.

⁷West (1984) reports that Michelin had 30 % of the Italian market in 1973, 23 % of the U.K. market in 1972, and 21% of the German market in 1975. It should also be noted that Pirelli independently made substantial innovations in radial manufacture. Furthermore, unlike Michelin, it appropriated the rents not by manufacturing elsewhere but by licensing the technology out.

In mid-1973 Michelin also announced plans to build two tire plants in the United States (*Wall Street Journal* 08/28/73).

Another factor was the growing volume of automobile imports from Europe and Japan which convinced manufacturers of changing consumer preferences, even before the oil crisis. Once the automobile manufacturers signed on to the new tire technology, and there was a credible high quality producer (Michelin) to supply it, the low technology equilibrium was broken. Now the competitive nature of the industry forced all the manufacturers to either adopt the technology or exit. The oil crisis in 1973 did not initiate the move to radials. It simply reinforced, and perhaps accelerated it.

2.6 The Structure of the Tire Industry and Innovation.

A number of issues have been highlighted about the industry which will help us in our later discussion of the causes of the takeovers. First, rents in this business exist only in markets where firms interact with individuals; the intermediate goods market is very competitive. Second, the tire industry is mature enough that it is hard for manufacturers to get a sustainable advantage through innovation. Finally, there is a co-ordination problem especially when both the upstream tire manufacturers and downstream automobile manufacturers have to innovate.

These features of the market explain why the returns to innovation accrue, if at all, to the largest tire manufacturers who have a substantial presence in the replacement market, while the costs of innovation are borne by all. Goodrich failed in its early attempt to introduce radials in the United States in 1965 because it could not convince the automobile manufacturers to switch. Goodyear, on the other hand, was not the first out with the belted bias ply tire. But once it saw customer acceptance of the belted bias, it accelerated development and retained its share of both the OEM market and the replacement market. Of course, once Goodyear switched to producing belted bias, the automobile manufacturers demanded it of the other manufacturers.

Similarly, when radials were introduced, Goodyear was not in the vanguard of innovators. It misjudged the acceptability of the tire, and lost a few points in OE market share between 1972

and 1974. But once it was convinced the radial was there to stay, it switched its substantial resources to developing and producing radials. Its large (and somewhat inertia bound) position in the replacement market gave it an advantage in recovering market share in the OE market. The nod of approval from Goodyear then made radials the de facto industry standard. The other manufacturers had to scramble to adapt.

With this understanding of the industry and the dramatic impact of the introduction of radials, let us return to the question of why the major U.S. producers were acquired by foreign firms. Before doing that, however, let review the major events in the merger and acquisition wave.

2.7 The Corporate Control Events

The tire industry has a long M& A history. In 1968, shortly after the failed attempt to introduce radials, Goodrich was the target of one of the first hostile takeovers in U.S. history. Goodrich, however, succeeded in fending off that attempt and after that there is no record of any major corporate control transaction until 1985.

As Table 4 indicates, in 1985 Uniroyal had to undertake a defensive leverage buyout in response to a hostile bid by Carl Icahn. At the same time, Sumitomo (a Japanese company) emerged as a white knight to rescue Dunlop (a British company) from a hostile bid. In the next five years, every major U.S. tire producer had to face an hostile bid and all but one, Goodyear, ended up being acquired by foreign manufacturers.

For a graphical analysis of the relationship between acquisitions and plant closure, we also report in Table 4 the plants that were opened and closed during the period. Clearly, most of plant closures took place between 1978 and 1981, well before the beginning of the intense takeover activity.

3 An Empirical Analysis of the Possible Causes of the Acquisitions by Foreign Firms.

We now test the two main hypotheses laid out in the introduction.

3.1 Higher Productivity of Foreign Producers?

The first hypothesis is that the acquisition of existing plants by foreign producers was the best way to transfer plants into the hands of more efficient producers. To address this question, we analyze plant-level productivity following an acquisition. In particular, we test two direct implications of the hypothesis that foreign manufacturers acquired U.S. plants because they were more efficient. First, we should observe higher productivity in plants owned by foreign manufacturers. Second, we should observe an increase in the productivity following an acquisition, especially an acquisition by foreigners.

3.1.1 The Data

The plant level data we use come from the Longitudinal Research Database (LRD) maintained at the Center for Economic Studies (CES) at the Bureau of Census. The LRD file is a time series of economic variables collected from manufacturing establishments in the Census of Manufactures (CM) and Annual Survey of Manufactures (ASM) programs.

The census universe covers approximately 350,000 establishments. The CM reports data on all these establishments every 5 years (in years ending in "2" and "7"), while the ASM covers a subset of the universe in each of the 4 years between censuses. The ASM, though, contains a complete time series for establishments with 250 or more employees.

The LRD file contains identifying information at the establishment level; basic information on the factors of production (inputs, such as levels of capital, labor, energy and materials) and the products produced (outputs); and other basic economic information used to define the operations of a manufacturing plant. In addition to these items, since 1972, establishments

in the ASM sample panel have been asked to supply detailed information on assets, rental payments, supplemental labor costs, consumption of specific types of fuels, and other selected items. Unlike the census, the ASM does not request data on individual materials consumed and products shipped, although product class information is collected. These data, thus, are available only in census years.

We are interested in U.S. tire plants. We extracted from the LRD all the data on manufacturing establishments with SIC code 3011 (tire and inner tubes). We identified 3061 plant-year observations from 493 plants and 402 firms. The first year for which we have comprehensive data is 1967. The next year of data is 1972 after which we have data for all the years till 1993.

To maximize the homogeneity of the group we analyze, we restrict our analysis to passenger tire plants (Primary Product Code = 1), ignoring truck tires and other special tires. This reduces our sample to 71 plants and 741 plant-years. Twenty one observations and four plants lack some or all the data required by our specification. This leaves us with 67 plants corresponding to 720 plant-years.

Table 5 contains the summary statistics for this dataset. Note that the Census data are confidential and this prevents us reporting data when it would reveal the identity of a single company in the sample. All the reported analysis based on LRD data will, by necessity, be aggregated.

To check how exhaustive the ASM is, to obtain data on plant ownership from an independent source, and to produce a series of dummy variables (foreign, acquisition and nonunionization), we collected a dataset on passenger tire plants from the trade magazine *Modern Tire Dealer*. Starting in 1976, the January issue of the journal lists all U.S. tire plants, their production capacity, their location, the company they belong to, and (starting in 1984) whether the plant is unionized or not. We identified a sample of 66 plants. Overall our impression is that the LRD dataset is representative of passenger tire plants operating in the United States⁸.

⁸For disclosure related reasons we cannot give further detail about the nature of and exact differences between the two samples.

3.1.2 The Methodology

We want to compare productivity across different plants and over time. It is standard in this literature (see Lichtenberg, 1992) to use the notion of total factor productivity, defined as output per unit of total input:

$$\pi = \frac{VA}{F(K, L)}, \quad (1)$$

where VA is output net of purchased intermediate goods and $F(L, K)$ is a production function, with L denoting labor input and K capital input.

If we assume that the production function is a Cobb-Douglas so that $F(L, K) = L^\alpha K^\beta$ and we take logarithms, we obtain

$$\log VA = \alpha \log L + \beta \log K + \log \pi. \quad (2)$$

If we assume the technical parameters α and β are invariant across plants, we can test our hypotheses using the following specification

$$\log VA_{it} = f(X_i) + \alpha \log L_{it} + \beta \log K_{it} + \delta Year_t + \epsilon_{it}, \quad (3)$$

where $f(X_i)$ are plant-specific characteristics (like ownership, unionization, etc), $Year_t$ is a calendar year dummy, and ϵ_{it} is an error, which we assume orthogonal to the input quantities.

3.1.3 The Results

Table 6.a reports the results obtained by estimating equation (3). Columns I to III estimate equation (3) with Ordinary Least Squares on the entire sample of plants. The plant-specific characteristics we test are an acquisition indicator (equal to one in the years subsequent to an acquisition), a foreign ownership indicator (equal to one if the plant belongs to a subsidiary of a foreign manufacturer), an indicator if the plant is not unionized, and the age of the plant

measured as years since the plant was built.⁹

Column I tests whether foreign-owned plants are more or less productive in general. The estimates indicate that the total factor productivity of foreign-owned plants is 20% less than that of U.S.-owned plants. This effect is highly statistically significant. There is no evidence that non-unionized plants are more productive. Column II adds the acquisition indicator to the basic specification. Plants that have been acquired are 9% less productive after an acquisition, but this effect is not statistically significant even at the 10% level. The results are substantially unchanged if we insert a measure of a plant's age (column III).

It is possible that the estimated adverse effects of foreign ownership are the result of some misspecification. We might miss some plant-specific characteristics which reduce productivity and happen to be correlated with the foreign ownership indicator. For example, since most of the plants owned by foreigners became so because they were acquired during the period by foreign companies, it is possible that the observed effect captures adverse selection rather than inefficiency: foreigners buy less productive plants. For this reason we re-estimate equation (3) (estimates not reported) restricting the sample to new plants. Productivity of foreign-owned plants is again significantly less than U.S.-owned plants.

Is it that foreign acquirers pick poor plants, or are they poor managers? We try to control better for plant-specific characteristic by re-estimating equation (3) with plant fixed effects. Since our measure of capital is a noisy proxy for the real level of capital, it is not surprising that the coefficient on capital drops by 50% and becomes insignificant. However, the indicators are the variables of interest. Controlling for the plant specific characteristics, an acquisition reduces a plant's total factor productivity by a statistically significant 25%. This phenomenon is not just temporary. In an unreported regression we allowed for the impact of an acquisition to be different in the two years following an acquisition and in the long run. The effect is entirely concentrated in the long run. The effects are robust to the inclusion of a measure of the age of the plant. Older plants are less productive, 0.2% per year of age.

⁹Since we do not have data on construction year before 1960, for any plant built before 1960 we set the year of construction to 1959.

When we include plant specific effects, the acquisition indicator is almost collinear with the foreign indicator (there are only few acquisitions that are not made by foreign firms). Nevertheless, we try including both variables in the regression. The effect of acquisition is still negative and bigger in absolute sign, while the incremental effect of foreign ownership (separate from that of acquisition) is positive and statistically significant. The combined effect of a foreign acquisition, though, remains negative: it reflects a 17% drop in total factor productivity. Interestingly, the coefficient of age becomes positive and highly statistically significant. This suggests that while newer plants are more productive, a plant itself becomes more productive with age. Hence the difference in coefficient between the OLS and the Fixed Effects estimates.

Although we could not reject the hypothesis that the production function for plants was the same, independent of the quantity of radials produced, in Table 6.b we test the robustness of our result to restricting the estimates to plants producing at least 80% radials. The main thrust of the results is unchanged. If anything the results are more striking: foreign-owned plants are 50% (rather than 20%) less productive than U.S. owned-plants.

Since our measure of the capital stock is likely to be very noisy, in Table 6.c we report the basic regressions when the amount of energy consumed is used as a proxy for capital, as done by Burnside et. al (1995). The coefficient for capital and labor now appears more sensible, but all the other results remain substantially unchanged. In an unreported regression we also estimated the same specifications using the quantity of energy consumed as an instrumental variable. The results are substantially unchanged.

In sum, little support emerges for this narrow version of the neoclassical hypothesis, which focuses on plant level productivity. Plants do not seem to be acquired by more efficient producers. Even more surprisingly, plants do not experience an increase in productivity following a change of ownership. This implies that if we want to explain the M&A activity of the late 1980s, we have to look elsewhere.

3.2 Failure of Internal Control Systems?

The second hypothesis we want to test is that acquisitions forced the closure of inefficient plants that were kept open long after they became unprofitable because of a failure of internal control systems. The argument is that internal systems do not force managers to downsize when needed (Jensen, 1993), and market forces take a long time to act because internal resources take a long time to be fully dissipated.

This hypothesis has already been challenged by Sull (1996), who documents that 69% of the plant closures took place before 1981, the year of the first hostile takeover threat in the tire industry. He also shows that the adoption of antitakeover devices is not significantly related with the plant closure.

Here we extend Sull's analysis in three ways. First, we consider the effect of acquisitions themselves on the probability of plant closure. Second, we control for the total factor productivity of the plant. Third, we fully use the data on the time dimension by estimating the probability of closing a plant between time t and time $t + 1$, conditional on it not having been closed till time t . This captures the essence of Jensen's hypothesis that a failure of the internal control system delayed the closing of inefficient plants.

3.2.1 The Results

The results obtained estimating a proportional hazard ratio model of the probability of closing a plant are in Table 7. The first column reports the estimates obtained when the only determinants of plant closure are the logarithm of total factor productivity, as defined in equation (2), and calendar year dummies. Not surprisingly, more efficient plants are less likely to be closed, and this effect is statistically significant at the 5% level. More interesting for our purposes is column II. It shows that acquisition of a company has no impact on the probability of closing a plant (after the efficiency of the plant is accounted for). If anything, the impact is negative (albeit not statistically significant). A more direct test of whether acquisitions improved the ability of managers to close inefficient plants is to examine the differential effect of productivity

on plant closure when a firm is acquired. As column III shows, less productive plants were no more likely to be closed by acquirers. Similar results obtain when a plant is owned (or acquired) by a foreign firm. So there is no evidence that different corporate governance systems or external threats had any impact on the decision to close a plant.¹⁰ Nor is there evidence that acquisitions changed the speed of plant closing.

A different way to get at the same question is to analyze the behavior of capital expenditures following an acquisition. If acquisitions were aimed at disciplining managers who were overinvesting in their plants, we should observe a reduction in investment following an acquisition. In fact, as Table 8 shows, the opposite is true. The level of capital expenditure (over sales) of a plant goes up by four percentage points after an acquisition and this effect is statistically significant at the 5% level. Interestingly, this effect is entirely due to foreign acquisitions.

The results are less clear-cut for employment. If we control for plant specific factors, acquisitions do not seem to have any effect on employment. However, decomposing acquisitions further, acquisitions increase employment, albeit not statistically significantly, while if the acquirer is foreign, employment falls.

3.2.2 Comments

In sum, we find no evidence supporting the idea that acquisitions were aimed at disciplining managers who were delaying the closure of inefficient plants or were overinvesting in existing plants.¹¹ Assuming foreign acquirers made sensible investment decisions, we find quite the opposite: there was some underinvestment before the plants were acquired.¹²

This is not to say that internal control systems worked perfectly, only that much of the needed restructuring had taken place before the acquisitions. We will argue that the advent of radials, and the inability of the conglomerate tire manufacturers (General, Goodrich, and

¹⁰The raw data confirm this. No plant was closed by a foreign manufacturer, and, as pointed out earlier, most of the closures took place prior to acquisition.

¹¹In what follows, whenever we mention a single company's name, there is no intention to suggest that such a company is in the LRD sample.

¹²For instance, Bridgestone announced capital expenditures of \$ 1.5 billion after it took over Firestone, and industry sources suggest that some of this was to compensate for past underinvestment by Firestone.

Uniroyal) to improve their position even with such dramatic change simply confirmed to them the need to get out of the tire industry. Thus they were unlikely to overinvest in tires. Goodyear was fortunate in 1972 to get a CEO who was an outsider, understood the potential of radials, and quickly implemented the needed restructuring. Firestone best exemplifies a firm's failure to rationalize its operations (see Sull (1996)), but even it got an outside CEO in 1979 who quickly closed down plants. Thus it was not the inability of internal systems to respond quickly to the radials that led to takeovers by the foreign firms.

Rather, we will argue that the conglomerate tire manufacturers did not have a secure enough position in profitable markets to justify the demand for continuous innovation. They were ready to sell out, though during the 1970s and early 1980s, there was no obvious domestic buyer. But over this time, car exports and cross-border car production by domestic car manufacturers increased. Large manufacturers like Michelin, Pirelli, Bridgestone, and Continental who had secure domestic markets were eager to move into the United States and realize the economies of scale in product development and marketing. Even if they wanted to, Goodrich and Uniroyal, who had neglected R&D and investment in the tire business and had withdrawn from international tire production in the 1970s, were poorly positioned to capture these economies. General Tire was too small, and furthermore, had little international experience to speak of. Firestone had a severe liquidity problem in the late 1970s as a result of its problems in switching to radials.

This forced it to withdraw from international operations, and it also became a willing candidate for acquisition. Only Goodyear maintained its international operations even as it switched to radials. Also, it had the scale both domestically and internationally to justify the expenditures on R&D and advertising to keep it competitive with the large foreign manufacturers. As a result, only Goodyear survived the "internationalization" of the industry.

4 What led to the eclipse of the U.S. (owned) tire industry?

We now elaborate on our explanation. Table 9 has the fraction of total sales accounted for by tires for each of the 5 major manufacturers between 1970 and 1985. While Firestone and Goodyear tire sales were steady at approximately 80% of total sales, Goodrich tire sales dropped from 58% in 1970 to 44% in 1985 and Uniroyal sales dropped from 56% to 49%. This suggests that both Goodrich and Uniroyal were attempting to reduce their stake in the tire business. The exception among the diversified conglomerates is General Tire which maintained a steady share at 39%, though as we shall see, it decided to reduce its commitment to the tire business from the early 1980s onwards.

Some of the tire manufacturers report data segment by segment. These data are available from Compustat from 1978 onwards. While Goodyear and Firestone each invested an average of 5% of annual tire sales in their tire business in the period 1978-1986, General Tire invested only 3.7% while Goodrich invested 3%. When we look at the ratio of investment in tires to total investment, the ratio fell from an average of 46% for General Tire in 1978-80 to 25% in 1984-86. Goodrich was already investing very little in the tire business but this fell slightly further from 24% to 23% over this period.

Thus it appears that the diversified tire firms were investing more of their cashflows outside the tire business. They appeared eager to get out, a fact confirmed by published and industry sources.

Consider Goodrich. It was the first to introduce radials in the United States (in 1965), and this turned out to be a miserable marketing failure as neither the automobile industry nor the other tire manufacturers responded. Tedlow (1991, p. 67) analyzes Goodrich's situation thus: "The failure to leapfrog the competition in radials was the beginning of the end of Goodrich's tire business. If they could not dramatically alter their position in the industry by pioneering a breakthrough of this magnitude, Goodrich management apparently realized they never would...[P]laying second fiddle to Firestone and Goodyear was untenable on a long

term basis...and it was [Firestone and Goodyear]...who would determine product policy in this industry...In the mid-1970s, Goodrich realized that it had to get out of the tire business. ... The strategy... was simplicity itself. The tire business was always to generate more cash than it used. ...[The first step] was abandoning the Original equipment market altogether [in the early 1970s]. ”

By abandoning the OE market (Table 2 shows that by 1985, Goodrich was out), Goodrich could focus on replacement sales which were highly profitable. Of course, the OE market was a way for a firm to invest in future replacement sales, so this move was again a form of cutting investment.

Uniroyal, by contrast, had historically been focussed on OE sales, and specifically, sales to General Motors. It hoped to make a breakthrough in radials in the early 1970s with its Zeta 40M tire. But in order to make it profitable, and perhaps even to sell more in the OE market, Uniroyal had to establish a credible presence in the replacement market by expanding its retail stores (recall that automobile manufacturers like a supplier to have these stores because they can service tires sold as Original Equipment). But Uniroyal's internal cash flow was low because of the low profitability of the segments it served and it had an enormous debt burden, especially in the late 1970s (average interest coverage in the period 1976-1980 was 2.4, the lowest in the industry). Moreover, it had an unfunded pension liability which, in 1979, amounted to 79% of its net worth. So Uniroyal faced a cash crunch just when it needed to expand its network of stores, and they dwindled from 535 in 1972 to none in 1981 (see Tedlow, p 59). Thus Uniroyal did not have the option of harvesting its Original Equipment sales, and limped along investing minimal amounts in maintaining its plants.

Finally, General Tire was the only true conglomerate. It was run by the O'Neil family. Tedlow reports that “back in 1980, Jerry O'Neil was...determined about tires. He has no intention of getting out, he thinks Uniroyal probably will, and in the end, Goodrich. In the shrunken field, he sees General surviving and prospering.” But by 1984 when our data show the fall in General Tire's investment in the tire business “O'Neill was more willing to consider exiting the industry. The possibility of spinning the tire business off into a merger with another

firm was on his mind" (Tedlow (1991), p. 84).

What this suggests is that initially, the diversified majors perceived the advent of radials as a market opportunity where they could challenge the dominance of Goodyear and Firestone. Even though Firestone made a major misstep (see below) that General Tire and Michelin cashed in on, the industry was mature and innovation did not result in dramatic sustainable advantage. The market segment that was readiest to switch to the innovation (the automobile manufacturers) was unprofitable. There was substantial inertia in the profitable replacement segment, and by the time an innovator made some headway, the leaders would have their own products. At the same time, the smaller manufacturers had to constantly match the successful innovations, else lose market share. Therefore, even though we have argued the economies of scale in production were not significant for the major manufacturers, significant fixed investments had to be made in R&D, advertising, and the distribution network in order to keep up.

Table 10 shows the average investment in R&D and advertising over the 1970s and 1980s. The figures for the diversified tire firms should be interpreted with caution since the figures are not by segment, but for the overall firm. Nevertheless, the pattern of investment by both Goodyear and Firestone suggests that the requirement for R&D and advertising increased dramatically over the two decades, from 3.1% in 1971-75 for Firestone to 4.2% in 1986-87, and from 4.1% in 1971-75 for Goodyear to 5.2% in 1986-87. By contrast, the level of investment by the diversified majors was smaller, and perhaps would look smaller still if we had tire segment data. Furthermore, it declined steadily for Uniroyal and Goodrich. Again, General is the exception, but recall that in the early 1980s, it was doing all that was necessary to stay in the industry. In fact, General's investment in R&D seems to mirror its changing commitment to the industry. It peaked at 3.1% of sales in 1983 and then fell steadily every year to 1.7% of sales in 1988 when the tire division was sold.

To summarize then, the diversified majors did not have the scale to compete on R&D and advertising, or in sustaining the distribution network. Their decision to sell out, though made at different times, was understandable. We still have to ask why Firestone was taken over, why

Goodyear survived, and why the acquirers were foreign.

4.1 Goodyear and Firestone

In hindsight, Firestone's problems can be traced to its large investment in the late 1960s in the intermediate technology of belted bias ply tires. In order to avoid scrapping its existing investment, Firestone manufactured radials through a process that required relatively minor modification of the machinery. The resulting product, the Firestone 500 Steel-Belted radial was initially successful but had tread separation problems. Even though top management knew about this, it was only in 1978 (six years after production began) that production was stopped, and the tire recalled at enormous cost. The popular press was very critical. Tedlow (1991, p. 60) cites Time magazine as reporting "The company just kept churning out the 500 tires; they just kept failing; customers kept returning them. And company lawyers just kept defending lawsuits brought by accident victims - and their heirs." The damage to the company's reputation was enormous. Firestone's OE sales fell from 24% of the OE market to 21.5% between 1975 and 1980 (see Table 2), while its replacement sales under its own brand name fell from 11.8% of the market in 1977 to 9% in 1981.

Table 10 shows Firestone's annual investment in R&D in 1971-75 was only 1.5 % of sales while, by comparison, Goodyear's was 2.4 % of sales (and Goodyear's sales were considerably more). Therefore, even though Firestone matched Goodyear in capital expenditure and advertising, it lagged behind in expenditure on R&D which may partly explain its quality problems.

Soon after the recall, John Nevin, who had been CEO of Zenith, became the CEO. The firm had now become, he declared "a company of limited resources. The day has passed when Firestone can say: We are a tire company and we will participate actively in every element of the tire business, throughout America and throughout the world." (Tedlow (1991), p.42). The strategy now was to eliminate the least profitable aspects of the tire business and diversify. As we will argue, the economics of the business had changed to make this strategy infeasible.

Goodyear, by contrast, made all the right decisions early on. Even though it was not the first out with radials, it neither attempted to skimp on the investment necessary to convert to

radial production, nor did it compromise on the quality of radials produced. A key factor in this was Charles Pellioid, CEO from 1972 to 1982, who came with substantial experience of radials from Goodyear's European subsidiary. According to industry sources, he saw the writing on the wall and forced Goodyear to make the tough choices such as closing down old plants and investing heavily in new ones. As can be seen, Goodyear's spending on R&D and advertising also went up at this time. But Pellioid also wanted to diversify out of tires. This did not happen until he was succeeded by Robert Mercer as CEO, after which Goodyear bought the Celeron Corporation (an energy company) in 1983 and started investing in the All-American Pipeline. Despite the sudden attempt at diversification (which proved disastrous), Goodyear did not reduce its investments in the tire business. In fact, both R&D and advertising increased, even as the firm was diversifying outside the tire business.¹³

4.2 The Eclipse of the U.S. (owned) tire industry.

Even while the U.S. manufacturers were struggling to adapt to radials and shut down excess capacity, another dramatic change was taking place around the world. The automobile industry was becoming more global and its methods of design and production were changing. There was increasing talk of producing the same car for different markets at different locations. The Japanese were the first to do this with cars like the Honda Accord being produced both in Japan and the United States. Similarly, as U.S. and European tastes converged, the U.S. automobile manufacturers started planning for production in both the United States and Europe. It made sense to have close co-operation between the tire supplier and the car manufacturer both at the design and manufacturing stage. Just in time manufacturing made it almost imperative that tires be produced close to the locale for automobile assembly. The greater the number of markets in which a tire manufacturer produced, the shorter the supply cycle, and the more valuable the supplier would be to the car manufacturer. A related reason for a global presence is that car exports increased tremendously. A tire manufacturer who had a presence both at

¹³It is unlikely that pipelines need much R&D and advertising. So even though we only have data on firm level R&D and advertising to sales, the firm level ratio is likely to underestimate the ratio devoted to tires.

the point of production and the country to which the car was exported would be able to take advantage of replacement sales. Furthermore, the car manufacturer would be able to get some of the benefits of the advertising done by the tire manufacturer in the export market. In sum, the increasing cross-border production and trade of cars increased the need for multinational tire producers.

But barring Goodyear, the U.S. tire manufacturers had spent the 1970s concentrating their resources on domestic radial production, and withdrawing from foreign markets. West (1984) reports that Firestone exited, among others, the United Kingdom, Switzerland, Australia, Sweden, and Chile. Uniroyal sold its entire European tire operations to Continental in 1979 and also quit Australia. Goodrich exited Australia, Holland, West Germany, and Brazil, and General Tire quit Spain and Venezuela (it did not have much of an international presence anyway). Interestingly, many of the plants were sold to the big foreign producers such as Continental, Bridgestone, and Pirelli. In fact, Continental became a multinational producer largely as a result of its purchase of Uniroyal's European operations.

Thus the conglomerate tire manufacturers, in pursuance of their objective of reducing their exposure to the tire business, sold their foreign plants. As the car manufacturers geared up to produce transnationally, the conglomerates had the choice of either returning anew to foreign markets, or exiting the tire business entirely by selling their U.S. holdings. By contrast, the foreign multinational tire producers such as Bridgestone, Continental, Michelin, and Pirelli only needed a U.S. base to round out their portfolio. Given that new capacity was not needed by the late 1980s even in radials, and that the multinationals' position in their domestic markets was much stronger than the U.S. conglomerates' position in the U.S., a transfer of ownership of the tire business from the U.S. conglomerates to the multinationals made eminent sense.

One could ask why Goodyear or Firestone did not buy out the tire operations of the conglomerate manufacturers earlier. Apart from a lack of funds on the part of these two firms, the foreign manufacturers probably valued the conglomerates more: In order for the foreign manufacturers like Bridgestone, Pirelli, or Continental to be credible partners for the automobile firms, they needed a U.S. production base. By contrast, neither Goodyear nor Firestone

needed additional U.S. capacity. Rather, in all likelihood, they would probably lose some of the OEM sales of the acquired firm as automobile manufacturers rebalanced their portfolio of suppliers to avoid too much dependence on one vendor. Thus the nature of the industry made it hard for mergers between U.S. firms to take place. Not coincidentally, the only merger that was consummated, albeit temporarily, was between Goodrich and Uniroyal. This was clearly helped by the fact that Goodrich had no OEM sales.

Firestone was not interested in exiting the tire business. But it was extremely difficult to be a major niche player – after exiting from various lines and countries – in what had become a full service, global, business. Tedlow (1991, p44.) cites the vice-president of international sales thus: "When we withdrew from radial truck tires in the United States, our overseas customers whose business with us is 25% for trucks, saw it as a lack of commitment to tires...". Firestone simply did not have the resources to compete. If one had to point to one factor leading directly to its demise, it would have to be its lack of attention to R&D and quality control which, in turn, led to the Firestone 500 disaster.

5 Conclusions

Our analysis of the forces that lead to the demise of the U.S. tire industry points to two major factors. First, the U.S. tire companies were the last to switch to radials. They faced this choice when the prospect of the entire tire industry were most grim. While their competitors had already paid the sunk costs, U.S. firms had not and, as a result, were more resistant to invest. If any major player had to leave, the U.S. firms were the most likely candidate. As a result, in this period they did not invest sufficiently in their plants, which may partly explain the large capital expenditure made by foreign acquirers after the takeover, as well the lower productivity of these plants.

Second, the internationalization of the market for cars triggered the need for tire producers to follow their customers. Since the flow of cars was toward the United States, it was natural that foreign tire firms wanted to penetrate the U.S. market and not the other way around. In

the absence of major growth in the market the way to acquire a presence in the United States was to integrate with existing producers.

Of course, a number of factors may explain why U.S. manufacturers were taken over by foreign manufacturers rather than the other way around. Of these, the most interesting possibility is that takeover legislation is much more friendly to targets in other countries, making it easier for ownership to change in one direction than the other. Understanding the influence that these barriers have in shaping international competition is an important topic for future research.

From a policy perspective, it is not clear that any changes are warranted. While there may have been insufficient incentives to innovate in the competitive U.S. domestic market, the internationalization and consolidation of the market ensured each of the large manufacturers has the scale as well as enough pockets of market power to reward innovation. Also, an international manufacturer can ignore the U.S. market only at the risk of losing credibility elsewhere. Therefore, despite the eclipse of the U.S. owned tire industry, the U.S. consumer has no cause for complaint.

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Table 1:

World Market Share of the Largest Tire Producers

This table presents each manufacturer's tire sales as a percentage of world sales. C4 is the sum of market shares of the four largest producers. The Herfindahl index is the sum of the squared market shares of each producer. Sources: West (1984) and Financial Times, 1988 and 1995.

Company	Home Country	1971	1979	1986	1993
Goodyear	US	24	23	19	17
Michelin	France	11	16	18	19
Firestone	US	17	14	7	
Dunlop	UK	4	4		
Pirelli	Italy	6	6	6	5
Bridgestone	Japan	3	7	9	18
Uniroyal	US	8	5	6	
Goodrich	US	6	4		
General Tire	US	4	4		
Continental	Germany	2	3	8	7
Sumitomo	Japan			6	6
Yokohama	Japan			4	5
Toyo	Japan			2	3
Concentration indexes	C4	60	60	54	61
	Herfindahl	12	11	10	11

Table 2:

Tire Manufacturer Shares of Original Equipment Market in the United States

This table presents each tire manufacturer's share of sales to the Original Equipment Market. All the figures are percentage of total sales of tires to automobile manufacturers in the United States. Source: Modern Tire Dealer (1991).

Company	1968	1975	1980	1985	1990
Goodyear	31.0	35.0	28.0	32.0	36.5
Firestone	24.0	24.0	21.5	21.5	17.0
Uniroyal	25.0	20.0	24.4	22.0	17.0
Goodrich	15.0	8.0	10.3	0.0	
General Tire	5.0	11.5	10.8	13.0	12.0
Michelin		1.5	5.0	11.0	15.7
Continental				0.4	
Pirelli				0.1	
Dunlop					1.5
Bridgestone					0.3

Table 3:

Relative Importance of Original Equipment and Replacement Tire Markets

Passenger tire shipments in the Original Equipment market and the Replacement market are in thousands of units and are taken from the RMA Tire Industry Facts 1994. The number of cars produced (also in thousands of units) is from Ward's Automotive. Shipments.

Year	Original Equipment	% Radials	Replacement	% Radials	Car Production
1965	51,413	0.0	94,893	0.0	9,329
1966	47,362	0.0	101,812	0.0	8,599
1967	40,827	0.0	108,499	0.0	7,405
1968	49,873	0.0	121,088	0.0	9,843
1969	46,172	0.4	129,112	1.5	8,219
1970	37,535	0.3	129,608	2.1	6,545
1971	48,609	0.1	135,009	3.6	8,578
1972	51,292	4.6	141,295	6.2	8,821
1973	55,960	17.6	142,002	12.1	9,661
1974	43,307	43.1	123,460	22.4	7,290
1975	39,281	63.9	122,469	27.0	6,706
1976	49,905	64.3	122,690	29.1	8,492
1977	55,689	66.3	129,270	32.7	9,211
1978	54,963	67.2	135,151	37.5	9,173
1979	48,188	76.6	121,922	42.4	8,423
1980	34,932	80.0	106,912	50.0	6,373
1981	35,979	83.3	125,263	60.9	6,251
1982	33,981	83.6	130,539	65.9	5,074
1983	43,845	83.5	133,964	70.1	6,782
1984	50,993	83.8	144,580	75.7	7,774
1985	54,839	83.5	141,455	81.6	8,185
1986	54,392	84.2	144,267	86.7	7,829
1987	52,913	85.0	151,892	90.2	7,098
1988	54,131	85.5	155,294	93.7	7,136
1989	51,170	87.3	151,156	95.3	6,825
1990	47,199	87.6	152,251	96.7	6,076
1991	41,859	88.4	155,400	97.9	5,439
1992	46,307	89.1	165,794	98.9	5,667
1993	52,335	88.7	165,146	99.2	5,982
1994	58,448	90.0	169,983	99.4	6,601

Table 4:

Chronology of Events in the US Tire Industry

Sources: Modern Tire Dealer and Wall Street Journal Index.

Year	Corporate Control Events	New Plants			Closed Plants		
1966		Firestone	Bloomington	Ill.			
		Goodyear	Danville	Va.			
1967		General	Charlotte	N.C.			
1968		Goodyear	Union City	Tenn.			
		Mohawk	Salem	Va.			
		Mohawk	Salem	Va.			
1969	Hostile takeover attempt against Goodrich by Northwest Ind.	Dunlop	Huntsville	Ala.			
		Firestone	Oklahoma City	Okla.			
		Goodyear	Fayetteville	NC.			
		Uniroyal	Ardmore	Okla.			
1970							
1971							
1972		Firestone	Lavergne	Tenn.			
1973	Armstrong buys Nashville (Tn.) plant from Gates	Firestone	Wilson	NC.			
1974		General	Mt. Vernon	Ill.			
1975		Michelin	Greenville	SC.			
1976					Goodrich	Akron	Oh.
1977					Goodyear	Akron	Oh.
1978		Goodyear	Lawton	Okla.	Mansfield	Mansfield	Oh.
					Mohawk	Akron	Oh.
					Uniroyal	Los Angeles	Ca.
1979		Michelin	Dothan	Ala.	Iri	Louisville	Ky.
					Mohawk	West Helena	Arka.
1980					Firestone	Barbeton	Oh.
					Firestone	Dayton	Oh.
					Firestone	Los Angeles	Cal.

Year	Corporate Control Events	New Plants			Closed Plants		
1980					Firestone Salinas	Cal.	
					Goodyear Los Angeles	Cal.	
					Uniroyal Chicopee Falls	Ma.	
					Uniroyal Detroit	Mich.	
1981		Michelin	Lexington	SC.	Armstrong West Haven	Conn.	
					Firestone Akron	Oh.	
1982	Firestone and Bridgestone agreement for Lavergne (Tenn.) plant (\$52 M)						
1983	Cooper buys Tupelo (Miss.) plant from Mansfield				Firestone Memphis	Tenn.	
1984					Goodyear Conshocken	Pa.	
					Goodyear Jackson	Mich.	
1985	Hostile takeover (BTR) attempt against Dunlop, that is bailed out by Sumitomo Hostile takeover attempt (C.Icahn) against Uniroyal						
1986	Uniroyal and Goodrich merge in Uni-Goodrich Hostile takeover attempt (Goldsmith) against Goodyear				Goodrich Miami	Okla.	
					Goodrich Oaks	Pa.	
					Firestone Albany	Ga.	
1987	Continental buys General (\$650 mil) Goodrich adopts anti-takeover plan				General Waco	Tex.	
					Goodyear Cumberland	Md.	
1988	Pirelli's bid for Firestone Bridgestone buys Firestone (\$2.6 bil) Pirelli buys Armstrong (\$197 mil)						
1989	Yokohama buys Mohawk (\$150 mil)						
1990	Cooper buys Firestone's Albany (Ga.) plant Michelin buys Uni-Goodrich						
1991							
1992		Cooper	Albany	Ga.			
1993							

Table 5:

Summary Statistics

Value added is the logarithm of a plant's value added measured in thousands of U.S. dollars. Capital is the logarithm of the net amount of property, plant, and equipment. Labor is the logarithm of production-worker-equivalent man-hours, as defined in Lichtenberg (1992). The foreign ownership indicator is one if the plant is owned by a foreign company in that particular year. The acquisition indicator is one in all plant-years following a change in control taking place in the period 1970-1993. The non union indicator is one for those plants that were not unionized. All the data are from the LRD, except for foreign ownership and unionization indicators, which are constructed from data in *Modern Tire Dealer*.

A: Continuous Variables

	Means	Stand. Dev.	N. Obs.
Value added	11.08	0.99	720
Capital	4.92	0.95	720
Labor	7.90	0.68	720
Capex	0.05	0.17	720
Employment	7.20	0.68	720

B: Discrete Variables

	Frequency	Percent	N. Obs.
Closure	13	1.82	712
Foreign	107	14.86	720
Acquisition	110	15.28	720
Non union	96	13.33	720

Table 6:

Effects of Ownership on Productivity

The dependent variable is the logarithm of a plant's value added in a given year. Capital is the logarithm of the net amount of property, plant, and equipment. In table c the logarithm of constant price energy consumption has been used as a proxy for capital. Labor is the logarithm of production-worker-equivalent man-hours, as defined in Lichtenberg (1992). The foreign ownership indicator is one if the plant is owned by a foreign company in that particular year. The acquisition indicator is one in all plant-years following a change in control taking place in the period 1970-1993. The non union indicator is one for those plants that were not unionized. Age is the number of years since the plant was originally built. For plants built before 1960 we set the year of construction to 1959. All the data are from the LRD, except for foreign ownership, unionization indicators, which are constructed from data in *Modern Tire Dealer* and age of the plant which is from *Tire Business*. All the specification contain calendar year indicators (coefficient estimates not reported). Heteroskedasticity robust standard errors are reported in brackets.

A: Whole Sample						
	OLS			Fixed Effects		
capital	0.091 (0.033)	0.091 (0.032)	0.088 (0.033)	0.061 (0.039)	0.056 (0.038)	0.056 (0.041)
labor	1.022 (0.038)	1.015 (0.038)	1.018 (0.038)	1.102 (0.051)	1.111 (0.051)	1.111 (0.055)
foreign dummy	-0.196 (0.056)	-0.163 (0.071)	-0.145 (0.076)		0.184 (0.094)	0.184 (0.101)
acquisition dummy		-0.086 (0.080)	-0.085 (0.082)	-0.249 (0.061)	-0.354 (0.093)	-0.354 (0.100)
nounion dummy	0.041 (0.047)	0.039 (0.048)	0.013 (0.051)			
age			-0.002 (0.001)			0.061 0.004
Adjusted R-squared	0.846	0.846	0.852	0.908	0.908	0.920
N. Obs.	720	720	720	720	720	720

B: Radial Sample

	OLS			Fixed Effects		
capital	0.115 (0.069)	0.139 (0.073)	0.159 (0.072)	-0.033 (0.085)	-0.051 (0.079)	-0.051 (0.041)
labor	0.952 (0.077)	0.961 (0.076)	0.941 (0.074)	0.838 (0.097)	0.853 (0.097)	0.853 (0.097)
foreign dummy	-0.487 (0.056)	-0.546 (0.079)	-0.543 (0.079)		0.226 (0.147)	0.226 (0.147)
acquisition dummy		0.124 (0.088)	0.095 (0.090)	-0.136 (0.078)	-0.307 (0.149)	-0.307 (0.149)
nounion dummy	0.051 (0.049)	0.069 (0.049)	0.115 (0.055)			
age			0.006 (0.002)			0.054 0.007
Adjusted R-squared	0.776	0.779	0.782	0.888	0.891	0.891
N. Obs.	265	265	265	265	265	265

C: Whole Sample. Proxy for Capital

	OLS			Fixed Effects		
capital (energy)	0.280 (0.054)	0.284 (0.052)	0.281 (0.052)	0.207 (0.079)	0.209 (0.078)	0.209 (0.078)
labor	0.870 (0.046)	0.860 (0.046)	0.862 (0.046)	0.997 (0.096)	1.003 (0.095)	1.003 (0.095)
foreign dummy	-0.135 (0.052)	-0.094 (0.064)	-0.084 (0.066)		0.199 (0.102)	0.199 (0.102)
acquisition dummy		-0.102 (0.078)	-0.101 (0.077)	-0.227 (0.063)	-0.340 (0.099)	-0.340 (0.099)
nounion dummy	0.052 (0.045)	0.049 (0.045)	0.033 (0.047)			
age			-0.001 (0.001)			0.056 0.004
Adjusted R-squared	0.867	0.868	0.868	0.912	0.912	0.912
N. Obs.	729	729	729	729	729	729

Table 7:

Determinants of Plant Closures

We estimate a proportional hazard ratio model, where the dependent variable is the probability of closure between year t and year $t+1$ conditional on surviving up to time t . The explanatory variables are the total factor productivity as estimated with specification (3) in the text, a foreign ownership indicator, and an acquisition indicator. The foreign ownership indicator is one if the plant is owned by a foreign company in that particular year. The acquisition indicator is one in all plant-years following a change in control taking place in the period 1970-1993. The non union indicator is one for those plants that were not unionized. All the data are from the LRD, except for foreign ownership and unionization indicators, which are constructed from data in *Modern Tire Dealer*. All the specifications contain calendar year indicators (coefficient estimates not reported). The standard errors are reported in brackets.

	I	II	III	IV
total factor productivity	-1.73 (0.61)	-1.82 (0.63)	-1.85 (0.63)	-1.86 (0.63)
acquisition dummy		-0.78 (1.26)	-0.80 (1.36)	-0.94 (1.56)
acquisition X total factor productivity			0.61 (1.92)	0.35 (1.69)
foreign dummy				0.43 (2.19)
Pseudo R2	0.11	0.11	0.12	0.12
Nobs	549	549	549	549

Table 8:

Effects of Acquisitions on Capital Expenditure and Employment

The dependent variables are either the level of capital expenditure over sales or the logarithm of the number of plant employees in the year. The foreign ownership indicator is one if the plant is owned by a foreign company in that particular year. The acquisition indicator is one in all plant-years following a change in control taking place in the period 1970-1993. The non union indicator is one for those plants that were not unionized. All the data are from the LRD, except for foreign ownership and unionization indicators, which are constructed from data in *Modern Tire Dealer*. All the specifications contain calendar year indicators (coefficient estimates not reported). The heteroskedasticity robust standard errors are reported in brackets.

	Capex				Employment			
	OLS		Fixed Effects		OLS		Fixed Effects	
	I	II	I	II	I	II	I	II
acquisition dummy	0.02 (0.01)	0.01 (0.01)	0.04 (0.02)	0.00 (0.02)	-0.43 (0.11)	0.15 (0.09)	-0.02 (0.08)	-0.19 (0.10)
foreign dummy		0.01 (0.01)		0.04 (0.01)		-0.50 (0.10)		0.09 (0.05)
nounion dummy					0.15 0.07	0.13 0.07		
Adjusted R-squared	0.01	0.01	0.61	0.61	0.02	0.02	0.81	0.79
N. Obs.	731	731	731	731	731	731	731	731

Table 9:

Extent of Diversification Away from the Tire Business by Major U.S. Producers.

Percentage of total sales in tires (from company annual reports and from West (1984)).

	1970	1975	1980	1985
Goodyear	83	83	83	80
Firestone	83	83	79	89
Uniroyal	56	57	49	49
Goodrich	58	53	42	43
General Tire	39	36	44	41

Table 10:

Investment in R&D and Advertising by Major U.S. Tire Producers

Average R&D and Advertising expenses as a percentage of total sales in different periods. Source: Computat.

	Goodyear			Firestone			Uniroyal		
	R&D	Advertising	Sum	R&D	Advertising	Sum	R&D	Advertising	Sum
1970-75	2.40	1.80	4.10	1.50	1.70	3.20	2.70	2.00	4.70
1975-80	2.00	1.80	3.80	1.40	1.60	3.10	2.00	1.80	3.80
1980-85	2.70	1.90	4.60	2.00	2.00	4.00	1.90	1.50	3.40
1985-90	2.90	2.30	5.20	2.30	1.90	4.20			

	Goodrich			General Tire		
	R&D	Advertising	Sum	R&D	Advertising	Sum
1970-75	2.20	1.50	3.70	1.90	1.00	2.80
1975-80	1.70	0.90	2.70	1.40	1.00	2.40
1980-85	1.90	1.10	3.00	2.70	1.20	3.90
1985-90	2.20	0.90	3.10	2.20	1.60	3.80