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# Steel in Motor Vehicles— A 35-Year Perspective

By J. Weinberg, K. L. Harris, and G. White

UNITED STATES DEPARTMENT OF THE INTERIOR
Donald Paul Hodel, Secretary

BUREAU OF MINES
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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environment and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.


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## UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

| | | | |
|---|---|---|---|
| lb | pound | | |
| MMst | Million short tons | st | short ton |
| mpg | mile per gallon | yr | year |

# STEEL IN MOTOR VEHICLES—A 35-YEAR PERSPECTIVE

By J. Weinberg,[1] K. L. Harris,[2] and G. White [2]

## ABSTRACT

This Bureau of Mines report presents data on the changes in the use of steel in motor vehicles over the past 35 yr. Sources of supply of steel for the automotive sector have shifted from almost all domestic in the 1950's to about 50% domestic and 50% foreign in the 1980's. Downsizing, design changes, and substitution of lighter weight materials to achieve energy efficiency also contributed to the market loss of the domestic steel industry. Although plastics and aluminum have displaced some steel in motor vehicles over the years, heavy low-carbon steel is now being replaced most rapidly by lightweight high-strength steel. If the percent of domestic steel used in motor vehicles had not declined since 1950, domestic industry would have supplied 9.3 million more short tons of steel than it supplied in 1985. Downsizing and design changes accounted for 43% of the loss; steel imports, 32%; and substitution of plastics and aluminum, 25%. In 1985, the total value of market share lost by U.S. steel producers was $5.1 billion, of which $1.6 billion was lost to foreign steel producers and automobile manufacturers. Through aggressive marketing and increased efficiency, however, the domestic steel industry may be able to recapture some lost markets, as applications for high-strength steels expand, and as foreign-owned automotive plants in the United States provide fresh sales opportunities.

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## SUMMARY

Steel is the most important metal produced in the United States, in terms of both volume and value. The domestic steel industry has undergone drastic changes since 1979 in response to low product prices and industry profits; production has been reduced, obsolete plants have been closed, labor costs and the labor pool have been reduced, and operations have been streamlined. Still, bankruptcies have occurred and losses continue because of low demand.

Because many analysts, the Government, and other data-gathering concerns measure demand at the raw or semifinished stage, little is known of the long-term trends of demand for steel in final products. Moreover, for many final products, no data at all are available on steel content. The automotive market is one of the largest end uses for steel, and data necessary to determine steel demand are more readily available than for other uses.

A review of trends over the 1950–85 period provides some insight into the domestic steel industry's plight. As would be expected, substitution for steel has taken place, but per capita demand for steel in motor vehicles has remained relatively constant because demand for automobiles rose sufficiently to compensate for declining steel content per unit vehicle. Demand for steel in the automotive sector, however, has not kept pace with the growth in Gross National Product (GNP) or manufacturing.

Domestic steel producers are supplying less of the steel required to satisfy domestic consumer demand for motor vehicles. Sources of supply of steel for the automotive sector have shifted from almost all domestic in the 1950's to about 50% domestic and 50% foreign in the 1980's. Other market losses have occurred through downsizing of the automobile and by substitution of lighter weight materials, principally aluminum and plastics, because automotive manufacturers were forced to make their products more energy efficient. High-strength steels have also replaced low-carbon steel to reduce weight and now constitute the fastest rate of material substitution. If there had been no decline in the percent of domestic steel used in automobiles since 1950, automobiles in 1985 would have used 9.3 million more short tons of domestic steel. Imported steel accounts for about a third of the loss; steel substitutes for about a fourth; and downsizing and design changes for the remainder.

While it is expected that there will be a continuing growth in market share of imported motor vehicles, several factors may point to a brighter future for the domestic steel industry. First, the decline in the use of steel in motor vehicles is slowing and, may be reversed in the near future as applications for new lightweight high-strength steels expand. Second, the increase in the number of foreign-owned automotive plants in the United States, most of which do not use domestic steel to produce their vehicles, presents new sales opportunities for domestic steel producers. Through aggressive marketing and control of plant efficiency, the domestic steel industry may be able to supply some of these markets. Additionally, the growing awareness of the domestic automotive industry of the need to improve quality and maintain efficiency in its operations could enable it to maintain and perhaps regain lost markets, potentially benefiting the domestic steel industry.

## INTRODUCTION

Steel is produced and consumed in the United States in larger quantities than any other metal. It is an essential material in many consumer durables and nondurables and in the manufacture of most military hardware. Steel has played such a vital role in the development of modern economies that its manufacture in large quantities is viewed in most countries as a symbol of industrial, economic, and military power. Indeed, many developed nations, including the United States, have struggled for years to preserve and protect their steelmaking capability from a variety of threats.

Despite the importance of steel, few data exist that measure the quantity of steel contained in final products consumed in the United States; it is not known whether this quantity is increasing or decreasing over time, nor are the causes for change known. The reason for this lack of knowledge is that consumption of a metal, such as steel, is usually expressed in terms of apparent consumption, a measure obtained by summing domestic production[1] (from new materials and old scrap), net exports, and net inventory changes. Apparent consumption, however, does not account for the metal content of imported finished and semifinished manufactured goods. In the case of steel, such imports have contributed significantly to the quantity of metal used domestically. As imports of finished and semifinished goods grow, reliance on apparent consumption as a sole measure increasingly understates consumer demand for materials, and masks the true requirements of the economy for these materials.

The actual consumer demand for steel, the quantity consumed from both internal and external sources, provides a more accurate measure of the market than apparent consumption, thereby supplying the public and private sectors with more comprehensive information on which to plan investment, trade, tax, and other policies. Since information on steel content in foreign products is generally not available, total consumer demand for steel cannot be obtained. However, consumer demand trends can be approximated by measuring the consumption of steel in a major, high-volume end product. In the United States, the largest market for steel is the automotive sector. In addition, the domestic automotive industry consumes nearly half the imported steel. Analysis of the trends in domestic and foreign steel use in motor vehicles would provide insight into the changing importance of steel to the entire economy.

This Bureau report focuses on the steel used by the automotive sector from 1950 through 1985 and analyzes the trends in consumer demand for steel from both domestic and foreign sources and the factors contributing to changing demand. The ability of the motor vehicle industry to sell its products and, concurrently, the ability of the steel industry to sell steel to the motor vehicle industry, are highly dependent on the underlying condition of the economy; sales grow during economic expansions and shrink during recessions or periods of little or no growth. Although this report does not quantify the contribution of the business cycle to changes in steel demand, the difference between the maximum and minimum annual steel demand over the 35-yr study period is over 10 MMst. Coincidentally, the extremes occurred during a peak and a trough of separate business cycles (fig. 1). Eight expansions and seven recessions occurred between 1950 and 1985, and the sinuous path of the motor vehicle demand plot correlates with the business-cycle plot.

[1] In the case of steel, shipments are used instead of production.

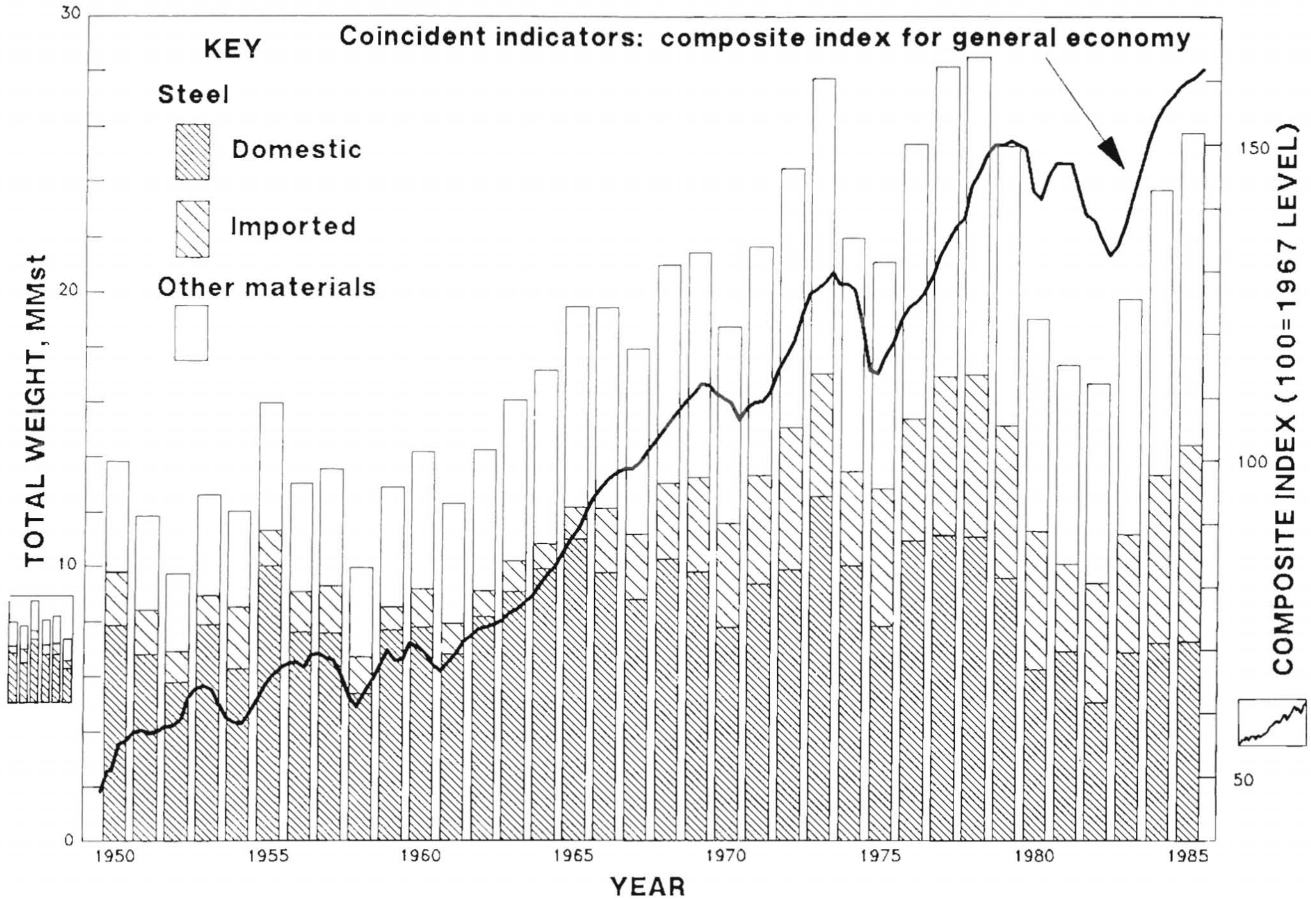


**Figure 1.—Materials used in motor vehicles sold in the United States. (Sources: Wards Communications, Wards Automotive Yearbook, various issues; Motor Vehicle Manufacturer's Association, Motor Vehicle Facts and Figures, various issues; U.S. Department of Commerce.)**

## BACKGROUND

Steel is readily available, durable, ductile, easily joined and finished, and relatively inexpensive. It is available in hundreds of alloys, and its physical properties can be altered to fit numerous applications. The automotive industry has been and continues to be the largest manufacturing consumer of steel, receiving over 20% of domestic steel mill shipments. Steel is used in a multitude of automotive applications, but the largest use is in sheets that form the body of the vehicle. For this use, in particular, the good finishing properties of steel and its ability to be formed easily with low wear to the forming dies are most important. Over 60% of the steel used in automotive applications is consumed in fabricating body parts. Steel sheets and strips, as well as forgings, castings, and structural shapes, have applications in other automotive components in the engine and drive train, the suspension system, and other components of the chassis. Many of these components must meet different design characteristics. For instance, steel components in the engine are subjected to high temperatures and pressures and require more durable steels than components of the body. Engineers are able to select from a multitude of steel alloys and heat and surface treatments to meet these diverse design requirements.

## METHODOLOGY

The domestic demand[4] for steel in motor vehicles (fig. 2) is made up of (1) shipments from domestic steel mills to the automotive industry,[5] (2) foreign semifinished steel imported for use in the manufacture of motor vehicles, (3) foreign steel contained in imported motor vehicles and motor vehicle parts, and (4) domestic steel exports that return in imported motor vehicles and automotive parts. In equation form, this appears as

$$D = S + I_s + I_v + I_{ds} \qquad (1)$$

where D = total domestic demand for steel in motor vehicles,

S = domestic steel mill shipments to the automotive industry,

$I_s$ = imported semifinished steel used in motor vehicles,

$I_v$ = foreign steel in imported motor vehicles and parts,

and $I_{ds}$ = domestic steel exports that return in the form of imported vehicles and parts.

[4] In this report, demand for steel refers only to domestic demand, not international or foreign demand.

[5] Including adjustments for shipments to steel service centers and distributors, shipments of spare parts, and scrap losses.

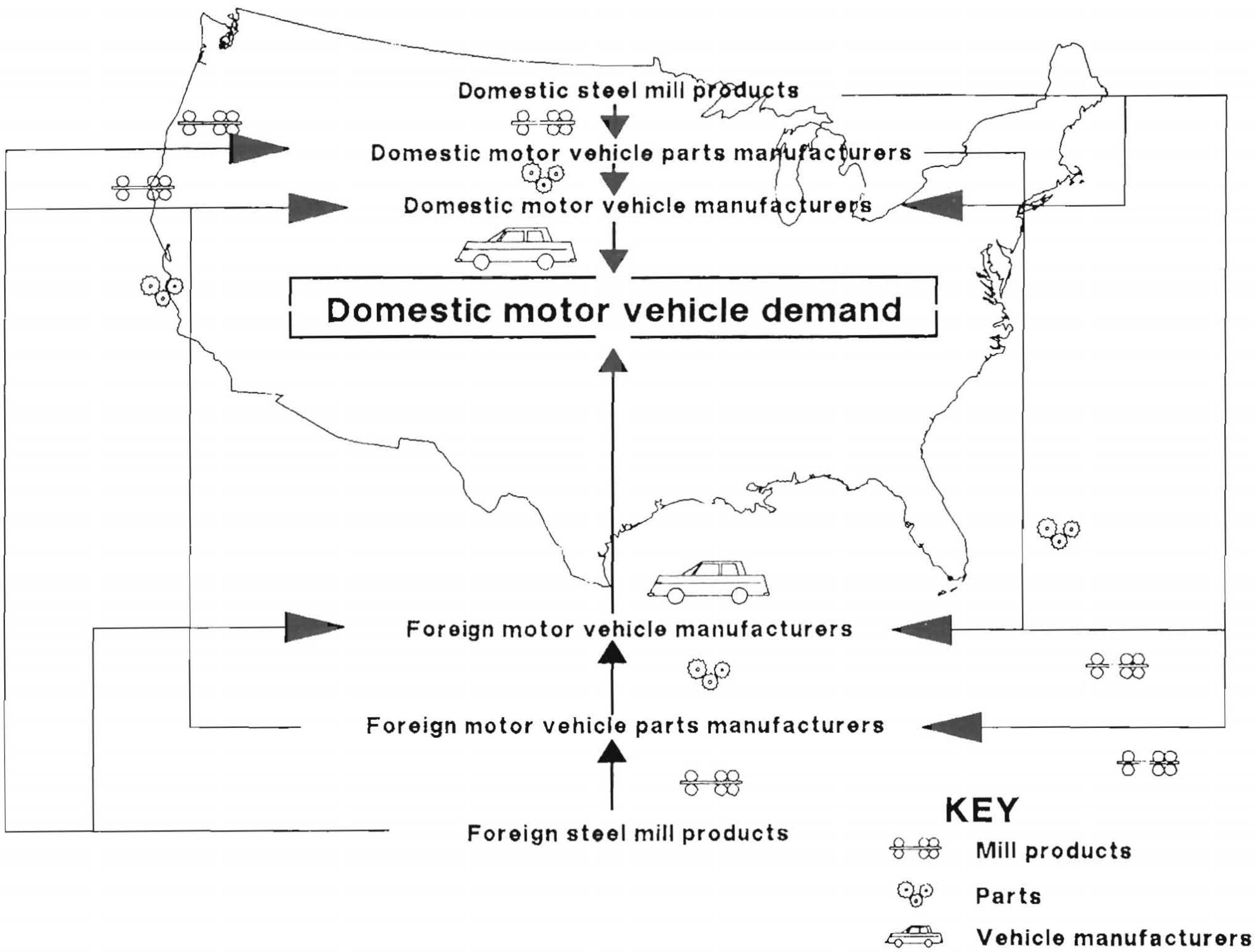


**Figure 2.—Material flows to domestic motor vehicle demand.**

Because data for $I$ and $I_v$ are not available, the following equation was used:

$$D = R \cdot W \cdot \frac{S_{mv}}{100} \qquad (2)$$

where R = total motor vehicle retail sales,
W = average curb weight of motor vehicles sold in the United States,
and $S_{mv}$ = average steel content, expressed in percent, of motor vehicles sold in the United States.

Because the quantity of U.S. steel contained in foreign automotive products is relatively small, all steel in foreign vehicles imported into the United States was assumed to be of foreign origin, or $I_{dx}$ = 0.

Two periods of time are analyzed, 1950–72 and 1973–85, before and after the oil crisis that precipitated major Government policy and automotive structural changes. Although the data used in the study encompass all motor vehicles—automobiles, trucks, and buses—the discussion focuses on automobiles, the largest single component. The assumptions, definitions, and statistical data appear in the appendix.

## 1950–72 TRENDS

The 1950's have been described by an automobile historian as the chrome age (*1*);[6] more appropriately, these years should have been called the steel age, in recognition of the average of more than 2,600 lb of steel contained in each of the nearly 70 million motor vehicles the United States produced during this decade. Although manufacturers introduced changes in the automobile's outward appearance every year, basic car design and material content changed little.

[6] Italic numbers in parentheses refer to items in the list of references preceding the bibliography at the end of this report.

### IMPORTS

In the late 1950's, U.S. imports of motor vehicles increased sharply as a result of trade policies, foreign government financial assistance for automotive industries, tax incentives in the European Economic Community (EEC) and Japan, as well as increased demand for economical, high-quality small cars. Imports accounted for less than 1% of U.S. retail motor vehicle sales in 1955; they were 9% of sales by 1959, however, and 13% by 1970. The Federal Republic of Germany led the surge, accounting for at least 30% of U.S. imported vehicles between 1955 and 1970.

The Volkswagen, as well as many varieties of foreign cars that followed, frequently offered the American consumer a smaller, lighter, more fuel-efficient, and less expensive vehicle. The 1960 Volkswagen weighed 1,700 lb and cost $1,600, compared with the 1960 American compact, which weighed 800 lb more and cost an average of $500 more (*2*).

By the end of the 1960's, the compact car accounted for about one quarter of all cars sold in the United States. Domestic manufacturers met the challenge of lightweight small imported cars by introducing small cars of their own, but they were not as light as imports. Subsequently, heavy options, such as more powerful engines and auxiliary equipment such as air conditioning, automatic transmission, power steering, and power brakes were added. As a result, the average automobile curb weight between 1950 and 1972 fluctuated within a narrow range (fig. 3).

Foreign trade policies affected imports not only of automobiles but also of steel. The United States changed from being a net exporter to a net importer of steel in 1960. The greatest amount of steel imports came from the EEC countries in the 1960's, but by the mid-1960's imports from Japan totaled nearly as much (fig. 4). Increases in imports, although largely unnoticed at first, in later years resulted in large losses of market share for domestic manufacturers of both automobiles and steel. The domestic steel content of the average motor vehicle[7] fell 28% from 1950 to 1970, while foreign steel content rose 40%.

[7] The average motor vehicle includes domestic and imported cars, trucks, and buses.

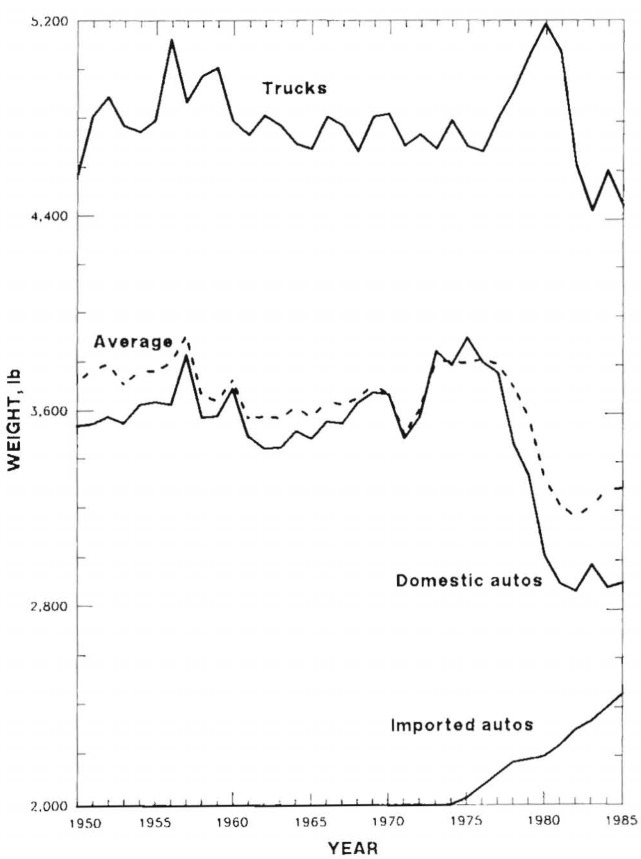


**Figure 3.—Average motor vehicle curb weights (weights of imported autos between 1950 and 1974 are estimated at 2,000 lb). (See table A-2.)**

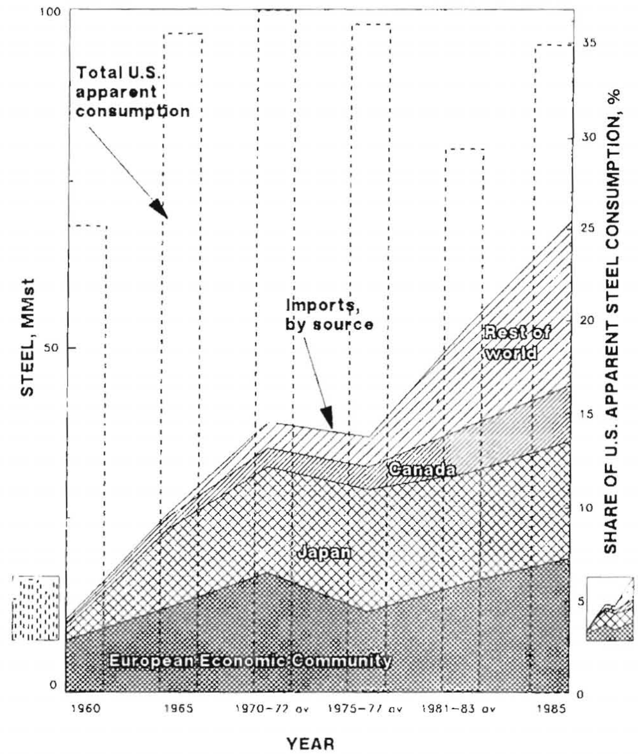


**Figure 4.—Steel imports, by source, as percent of U.S. apparent steel consumption. (Sources: World Steel Trade Developments, 1960–83: A Statistical Analysis, OECD, 1985, Paris, p. 24; American Iron and Steel Institute, Annual Statistical Report, 1985.)**

## SUBSTITUTE MATERIALS

Not only was foreign steel replacing domestic steel, but substitutes began to make inroads in the quantity of steel consumed as well. Between 1965 and 1970, the quantity of plastic in the average vehicle more than tripled, growing from 29 to 99 lb (see figure 5 and table A–2). Plastics long had been considered a low-cost, low-performance substitute, used mostly for disposable goods markets. Intensive research in previous decades, however, began to pay off in new materials that were more lasting than their predecessors and that could be introduced economically into the automotive manufacturing process. The use of plastics for many automobile applications became attractive because of high strength-to-weight ratio, formability, corrosion-free performance, and ease of finishing. In 1967, a new polyester resin was introduced that made it possible to paint parts directly after molding, reducing tooling costs by 25% and finishing and labor costs by over 40%. The net results were reduced manufacturing costs and superior material performance.

From 1950 to 1970, as the motor vehicle lost 376 lb of steel, it gained 80 lb of plastic, 10 lb of aluminum, 17 lb of iron, and 214 lb of other materials. Foreign steel content of the average vehicle rose from 14% to 20% of total weight.

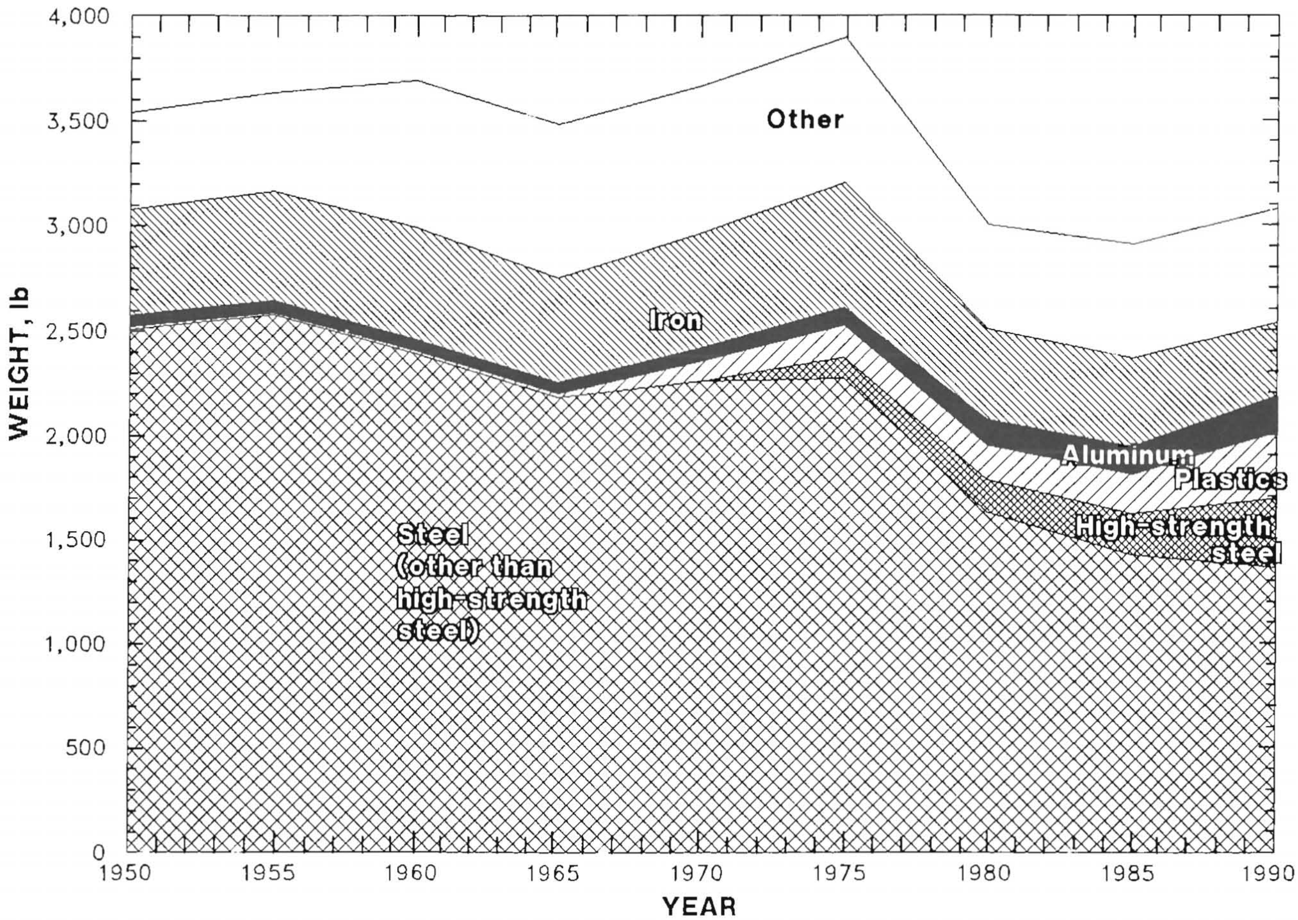


**Figure 5.—Materials used in average domestic car. (Source: Institute of Iron and Steel Scrap; data shown for 1988–90 are based on a projection by Ford Motor Co.)**

## 1973–85 TRENDS

The average motor vehicle weighed about 3,800 lb between 1973 and 1978. This gain of about 200 lb over the previous decade occurred before energy conservation measures took hold and, in part, reflected increased emphasis on safety through heavier cars. Average motor vehicle weight peaked in 1976, but fell steadily through 1982 when it registered 3,160 lb. Even though the average weight of imported cars rose, it generally remained lower than that of domestic vehicles (fig. 3). Average vehicle weight has risen since 1982, largely because fuel prices have declined and sales of lightweight trucks, which are heavier than cars, have increased as a proportion of total motor vehicle sales.

### IMPORTS

From 1973 to 1985, the import share of U.S. retail motor vehicle sales continued to grow, rising from 14% to 23% of the volume and further reducing the quantity of domestic steel required by the automotive industry. Energy conservation—more easily attained with the smaller foreign car—and the strong dollar in the early 1980's, played important roles in the dramatic rise in the volume of imported cars. By 1985, 3.6 million imported vehicles were sold in this country, with Japan accounting for 83% of the import total.[6] Despite voluntary export restraints agreed to in 1981, the number of vehicles imported from Japan continued to surge upward, resulting in a significantly reduced domestic steel content in the average motor vehicle.

Imported steel, which accounted for about 14% of the U.S. market in the early 1970's, had grown to about 20% a decade later. Again, just as in automobiles, Japan has been the single largest source of U.S. steel imports for well over a decade, accounting for more than 40% of total steel imports during the 1970's. In earlier years, imports were primarily simpler steel products such as bars and rods. As the Japanese steel industry developed, the composition of imports shifted to higher value sheet and strip as well as pipe and tube products used in automobile manufacturing *(3)*.

By 1982, the United States was the only major steel market relatively open to foreign imports *(4)*. Both the open market and the relatively high value of the dollar fostered import growth. Hoping to stem the tide, the U.S. Government negotiated voluntary limits on exports of steel to the United States through 1989 with 16 countries,

[6] Statistics on U.S. motor vehicle retail sales include imports from Canada as domestic vehicles.

including Brazil, the EEC, Japan, the Republic of Korea, and Spain. Despite the limits, U.S. steel imports in 1985 exceeded those in 1983 by 43%. Undoubtedly, much of this steel found its way into the U.S. manufactured automobile.

### DOWNSIZING

Automobile manufacturers not only used lighter materials in their attempts to meet the Government-mandated fuel efficiency standards,[9] but also downsized vehicles. Because many consumers continued to prefer the family-size car, downsizing required reducing the exterior dimensions of a vehicle, where heavy steel is used, without a commensurate reduction in the passenger or load-carrying capacity. In 1977 and 1978, General Motors reduced the length and width of its full-size and intermediate models, saving as much as 1,000 lb—mostly steel—per car. Comparable weight reductions were achieved by Ford, Chrysler, and American Motors.

### SUBSTITUTE MATERIALS

By the late 1970's and early 1980's, automobile manufacturers could use a variety of materials as substitutes for steel to achieve reductions in vehicle weight. For example, a bumper previously made from carbon steel could also be made from lightweight, high-strength, low-alloy (HSLA) steel, from plastic, or from aluminum. Substituting HSLA steel for conventional steel can achieve a 30% weight savings; substituting plastics can achieve a 40% weight savings, depending on the kind of plastic used; and using aluminum instead of steel can achieve a 50% weight savings (*5*). Manufacturers look for a number of other characteristics in a new material besides lighter weight, including ease of forming and joining, durability, and type of surface. Cost also influences the choice of materials, but it is the cost of an installed product rather than the cost of the raw material that determines the manufacturer's decision (*6*).

During the late 1970's, high-strength steels became substitutes for conventional steel in the automotive market. Although developed in the 1960's, high-strength steels for the automotive market were not produced in large scale until the mid-1970's. Their use in the automobile more than doubled from 1975 through 1985, surpassing the growth rate of both plastics and aluminum. The effect of this substitution has been to reduce the total steel content of the automobile. High-strength steels, both HSLA and high-strength plain carbon steels, can be up to three times stronger than conventional steels. They are used in body or suspension members, and bumper reinforcement bars. One problem in use of these steels, however, is their lack of formability, a characteristic that declines in steels as strength increases. On the other hand, conversion to high-strength steels requires minimum retooling (unlike conversion to plastics), which is a significant advantage.

The plastic content of the average motor vehicle more than doubled from 1970 through 1985 (table A–2, fig. 5), largely as a replacement for parts formerly composed of steel. Use of plastics in the automobile escalated throughout the 1970's, and by the early 1980's, two U.S. cars—the Pontiac Fiero and Chevrolet Corvette—had plastic skins over steel frames. Higher feed materials cost for plastics, low production rates for plastic parts, incompatibility with currently used paint systems, and the size of the required investment for retooling prevent the substitution of plastics for steel from growing at a faster pace.[10]

Although aluminum accounted for only 1% to 2% of automobile weight in the early 1970's, its share increased to more than 4% by the early 1980's (table A–2, fig. 5). In many applications, aluminum yields weight reduction benefits beyond those of HSLA steel and lends itself to conventional processing methods better than plastics. Aluminum is more costly than steel, however, and requires more energy to produce. Furthermore, it has less strength and stiffness than steel, so a greater quantity of aluminum must be used to be as effective as steel. Except for wheels, in which cast aluminum has replaced some fabricated steel products, most of the increased use of aluminum has been as a substitute for cast iron rather than steel.

As a result of these factors—the increases in imports of steel and automobiles, increased use of substitute materials, and downsizing—the domestic steel content of the average motor vehicle fell 46% between 1973 and 1985, while foreign steel content rose 49%. Total steel content dropped from 61% of the average vehicle in 1973 to 56% by 1985.

## OUTLOOK

In 1985, net imports of motor vehicles and iron and steel accounted for 40% of the $125 billion U.S. merchandise trade deficit. The deficit in motor vehicles was $40 billion—more than any other industry—and the deficit in iron and steel was $10 billion. It is unlikely that the use of domestic steel in the automotive market will increase in the next few years, despite the recent decline in the dollar. The Department of Commerce anticipates that sales of imported cars will increase 34% from 1986 to 1990 while domestic sales will decline about 9%. Automotive imports will grow from 28% of the automotive market in 1986 to 34% in 1987, and nearly 37% by 1990 (*7*).

Japan will continue to account for the largest share of U.S. imports, although the 1987 volume of Japanese imports is not expected to grow (*7–8*).[11] The United States will import larger quantities of automobiles (and thus steel) from countries relatively new to the U.S. market such as the Republic of Korea, Yugoslavia, Australia, Brazil, Romania, and Taiwan.

New foreign-owned motor vehicle assembly plants are locating in the United States. About 75 Japanese parts companies have plants in the United States and 20 more are expected soon, some as joint ventures with U.S. firms (*9*). Most of the major components and original equipment parts, however, are being imported (*7*) thus leaving steel import trends unaffected.

As previously discussed, the declining use of steel per automobile primarily resulted from attempts to reduce au-

[9] Title V of the Energy Policy and Conservation Act of 1975 mandated that automobile manufacturers meet a fleet-average fuel-efficiency standard of 27.5 mpg of gasoline for automobiles produced during and after model year 1985. The fuel-economy standards for passenger cars were the following: Model year 1978, 18 mpg; 1979, 19 mpg; 1980, 20 mpg; 1981, 22 mpg; 1982, 24 mpg; 1983, 25 mpg; 1984, 27 mpg; and 1985, 27.5 mpg. In late 1985, the Department of Transportation reduced the standard to 26 mpg for model year 1986, and additional changes are being considered.

[10] General Motors abandoned plans for a plastic sports car in late 1986 because the venture proved too costly.

[11] See "1973 85 Trends" section.

tomobile weight. Motor vehicle weight in 1985 was 24% less than in 1976, while steel weight declined 21% (compare figures 3 and 5). The percentage of steel in the automobile in 1992 is likely to grow without a commensurate weight increase as a result of increased use of advanced high-strength steels, which can be made into lighter products than carbon steels can. From 1985 to 1992, the percentage of steel used in the motor vehicle is expected to increase to the levels of the mid-1970's (see table A–2) (*10*).

In addition to greater use of high-strength steel, the use of plastics as a replacement for carbon steel in the automobile is likely to continue growing. Plastics have already displaced 7% to 9% of the carbon steel in motor vehicles and are expected to replace an additional 8% to 20% by the year 2000 (*11*). General Motors expects that by 1990 it will produce 1 million cars a year with plastic outer panels, in comparison with 150,000 in 1986. Chrysler has begun a 5-yr development project to determine the economic feasibility of manufacturing a vehicle made almost entirely of steel-substitute materials. The vehicles will have plastic outer bodies and composite structural parts, including frames (*12*).

For the future, the automotive industry is looking at fiber-reinforced plastics for making components that must bear heavy loads, as well as a flexible thermoplastic that can be molded into body panels to limit damage in minor collisions (*13*). Du Pont recently unveiled a new plastic called arylon, an exceptionally hard material the company predicts will replace traditional steel in both automotive and nonautomotive applications and will cost 20% less than current products.

A plastic sheet molding compound has recently been developed that can be molded into automotive components at assembly line speeds and which reduces cost and manufacturing differences between plastic and steel. Its manufacturer, the Budd Co., anticipates that use of the new material will provide a further boost to the use of plastics in motor vehicles during the next decade and eventually give U.S. automakers an edge over foreign rivals (*14*).

In sum, total demand for steel in motor vehicles is expected to grow by 1990, even though use of steel substitutes such as plastics continues to grow. Demand for domestic steel for the automotive sector is likely to decline, however, as steel imports continue to rise. The increase in use of domestic HSLA steel is not expected to compensate for the greater demand for imported steel in finished vehicles.

## CONCLUSIONS

The changes that have occurred in the use of steel in motor vehicles over the past 35 yr are more apparent if the actual 1985 demand levels are compared with the levels that would have been attained in 1985 had there been no changes in the amounts and proportions of materials used. If the only change since 1950 had been growth in the number of vehicles required, use of domestic steel in motor vehicles would have totaled over 16.5 MMst in 1985, more than twice the actual 1985 level of 7.2 MMst (fig. 6). About 43% of the 9.3-MMst loss was attributable to downsizing

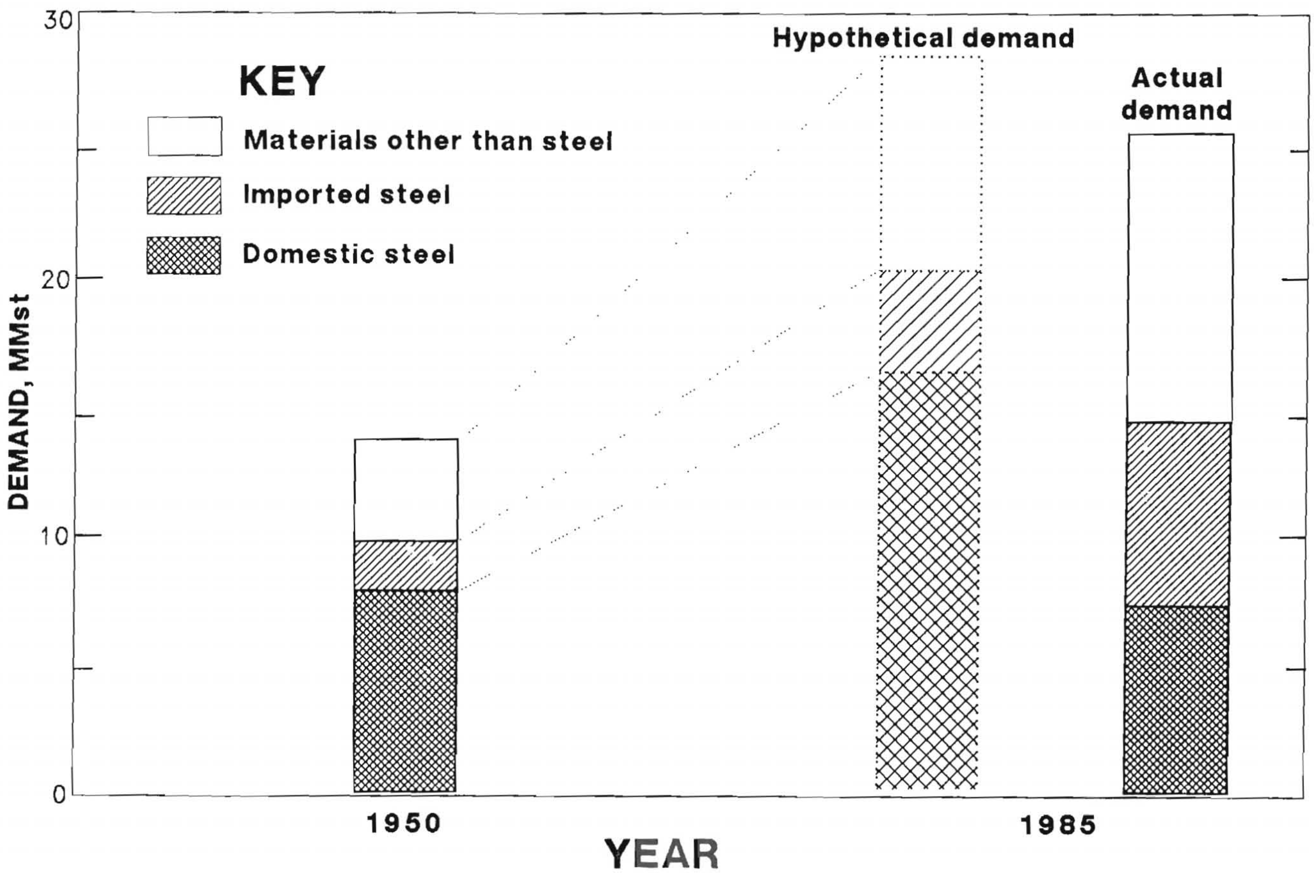


**Figure 6.—Comparison of automotive materials demand, 1950 and 1985. (Hypothetical 1985 demand based on 1950 vehicle material content.)**

and design changes. About 32% of the loss was attributable to steel imports, more than 90% of which entered the country in finished vehicles; and 25% was attributable to substitution of plastics and aluminum for steel. In 1985, the total value of market share lost by U.S. steel producers was $5.1 billion,[12] of which $1.6 billion was lost to foreign steel producers and automobile manufacturers.[13]

Domestically produced steel used in motor vehicles fell 8% or 0.6 MMst between 1950 and 1985, while retail sales of motor vehicles increased 112%, total material demand increased 86%, and total steel demand increased 47% (figs. 1 and 7). In 1965, foreign steel used per vehicle was only about one-tenth the quantity of domestic steel; by 1985, the two were nearly equal (fig. 1). In 1965, the quantity of all raw steel imports was 9.3 MMst; it had doubled by 1978, and almost tripled to 26.2 MMst by 1984. At the same time automotive imports rose from 5% of retail sales in 1965 to 16% by 1975, and peaked in 1982 at 25%.[14]

While the total amount of steel consumed in motor vehicles in the United States on an annual basis grew slightly more than 1% per year between 1950 and 1985 (fig. 1), consumption per vehicle declined 1% annually over the same period. Demand rose from 9.8 MMst in 1950 to 14.4 MMst in 1985 (table A–1), while demand per vehicle declined nearly 800 lb in the last 35 yr. Per capita demand for steel in motor vehicles has remained fairly constant, since growing motor vehicle sales volume more than made up for the decline per unit steel content resulting from substitute materials and automobile downsizing. Demand for steel in the motor vehicle sector, however, has not kept pace with the growth in GNP or in manufacturing. Demand trends diverge for the periods before and after the energy crisis of the early 1970's, with demand for steel growing at 2.4% per year between 1950 and 1973 and declining 1.4% per year from 1973 through 1985. Despite the negative growth rate for 1973 through 1985, average annual demand was still 30% higher than for 1950 through 1973 (table 1).

Although domestic steel producers had been losing motor vehicle steel market share since the 1950's, they experienced a trend of growing sales and shipments to this sector through the late 1970's, after which severe erosion occurred in the market. Steel shipments to the automotive sector reached a low in 1982, only 9 yr after the peak (fig. 1). The growing trend in shipments through the 1970's provided only an illusion of well-being for domestic steelmakers, masking the magnitude of the changes in this market and the urgency of the challenges of the 1980's. Although the declining demand for domestic steel is predominantly a problem of declining market share for domestically produced motor vehicles, aggressive marketing of steel products that meet motor vehicle design and manufacturing requirements is now being undertaken by domestic steelmakers. Another possibility for increasing domestic steel sales for domestic motor vehicle manufacture lies in the supply of steel to the domestic plants of foreign motor vehicle manufacturers. Without continued improvements and greater success in marketing by the domestic steelmakers, the declining use of domestic steel in motor vehicles is unlikely to be reversed.

[12] 1985 steel price was $552 per short ton.

[13] Loss of market would have been about 30% higher had scrap been included in the calculation.

[14] Excluding imports from Canada.

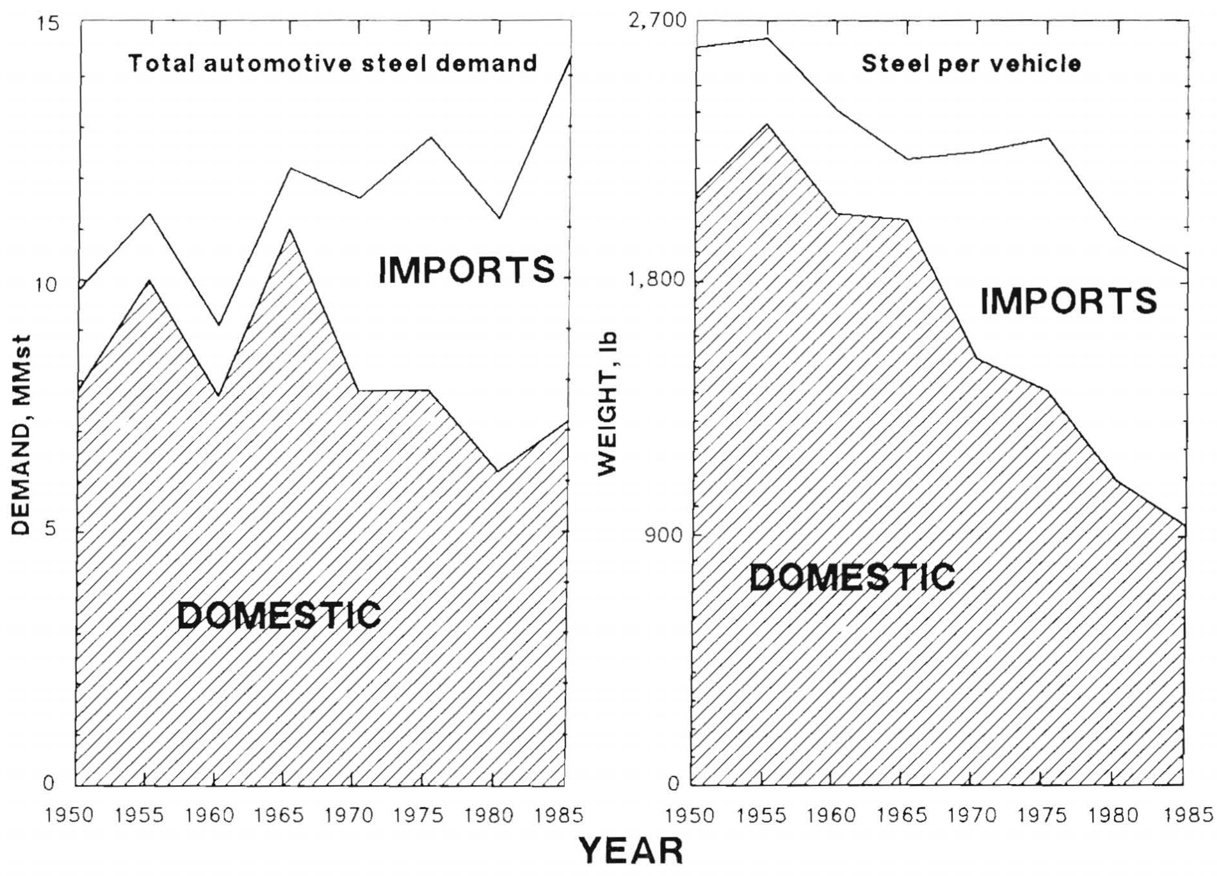


Figure 7.—Automotive steel demand and steel used per vehicle. (See tables, A–1—A–3.)

**Table 1.—Motor vehicle demand trends**

| | Annual demand, MMst | | | | | | Compound annual rate of growth, % | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1950–73 | | 1973–85 | | 1950–85 | | | | |
| | Mean | Std dev | Mean | Std dev | Mean | Std dev | 1950–73 | 1973–85 | 1950–85 |
| Steel: | | | | | | | | | |
| Domestic | 8.5 | 1.7 | 8.6 | 2.2 | 8.4 | 1.8 | 2.1 | −4.5 | −0.2 |
| Imports | 2.1 | 1.2 | 5.0 | 1.1 | 3.1 | 1.8 | 3.7 | 4.0 | 3.8 |
| Total steel | 10.5 | 2.5 | 13.6 | 2.5 | 11.5 | 2.8 | 2.4 | −1.4 | 1.1 |
| Other materials | 5.7 | 2.1 | 9.5 | 1.5 | 6.9 | 2.6 | 4.4 | .5 | 3.0 |

Std dev Standard deviation.

## REFERENCES

1. Roberts, P. Collector's History of the Automobile. Bonanza Books, 1978, p. 201.

2. National Research Council. The Competitive Status of the U.S. Auto Industry: A Study of the Influences of Technology in Determining International Industrial Competitive Advantage. Natl. Acad. Press, 1982, pp. 72–73.

3. U.S. International Trade Commission. Foreign Industrial Targeting and Its Effects on U.S. Industries, Phase I: Japan. USITC Publ. 1437, Oct. 1983, p. 196.

4. U.S. President. Annual Report of the President of the United States on the Trade Agreements Program, 1984–85, Twenty-Eighth Issue. Feb. 1986, p. 39.

5. U.S. General Accounting Office. Policy Conflict—Energy Environmental, and Materials: Automotive Fuel-Economy Standards Implication for Materials. Rep. to Congr., Feb. 5, 1980, pp. 23–24.

6. Eggert, R. G. Changing Patterns of Materials Use in the U.S. Automobile Industry. Mater. and Soc., V. 10, No. 3, 1986, pp. 405–431.

7. U.S. Department of Commerce. 1987 U.S. Industrial Outlook. p. 36–2.

8. Hampton, W. Detroit's Share Keeps Getting Smaller. Business Week, Jan. 12, 1987, p. 71.

9. Sundstrom, G. 800,000 Drop Seen in Domestic Sales. Automotive News, Jan. 5, 1987, pp. 1, 39.

10. Clark, J. P., and M. C. Flemings. Advanced Materials and the Economy. Sci. Am., v. 255, No. 4, Oct. 1986, p. 53.

11. Balazik, R., and B. Klein. The Challenge of New Materials. Sec. in BuMines Minerals and Materials. A Bimonthly Survey. Dec. 1986/Jan. 1987, p. 8.

12. O'Neil, T. The Drift of Things. Min. Eng. (Littleton, CO), Aug. 1986, p. 792.

13. Gjostein, N.A. Automotive Materials Usage Trends. Mater. and Soc., v. 10, No. 3, 1986, pp. 369–404.

14. Automotive News. Part-a-Minute Plastic Challenges Steel. Oct. 20, 1986, p. D–16.

## BIBLIOGRAPHY

American Iron and Steel Institute. Annual Statistical Report. Washington, DC, various issues.

——. United States Indirect Steel Trade—1985. Washington, DC, Oct. 1986, 25 pp.

Automotive News, various issues.

Bell, D., P. Fish, and F. Gillett. The European Car in 1990. Metal Bull. Monthly, Mar. 1984, pp. 61–65.

Berry, B. Automotive Materials: Steel Holds Steady, Plastics Keeps Gaining. Phoenix Q., v. 19, No. 1, Spring 1987, p. 4.

Branham Automobile Reference Book. Branham Publ. Co., Santa Monica, CA, various issues.

Compton, W., and N. Gjostein. Materials for Ground Transportation. Sci. Am., v. 255, No. 4, Oct. 1986, pp. 93–100.

Cook, J. The Molting of America. Forbes, Nov. 22, 1982, pp. 161–167

Dean, K. C., and J. W. Sterner. Dismantling a Typical Junk Automobile To Produce Scrap. BuMines RI 7350, 1969, 17 pp.

Dean, K. C., J. W. Sterner, M. B. Shirts, and L. J Froisland. Bureau of Mines Research on Recycling Scrapped Automobiles. BuMines B 684, 1986, 46 pp.

Gjostein, N. (Ford Motor Co., Dearborn, MI). Private communication, Oct. 20, 1986; available upon request from J. Weinberg, BuMines, Washington, DC.

Gunnarson, S., R. Ericsson, and A. Steen. Automotive Materials. Sec. in Encyclopedia of Mater. Sci. and Eng. Pergamon, 1986, pp. 246–261.

Hu, P. Motor Vehicle MPG and the Market Shares Report: The First Six Months of Model Year 1985. U.S. Dep. Energy, ORNL TM-9631, 1985, 74 pp.

International Iron and Steel Institute, Committee on Economic Studies. Steel and the Automotive Sector. Brussels, 1983, chs. 5 and 6.

Motor Vehicle Manufacturers' Association. Motor Vehicle Facts and Figures. Detroit, MI, various issues.

——. World Motor Vehicle Data. Detroit, MI, 1984–85, 366 pp.

Niemczewski, C. The Changing Materials Content of Automobiles. Sec. in The Impacts of Materials Substitution on the Recyclability of Automobiles, ed. by R. Blelloch. ASME, 1984, pp. 11–37

Organization of Economic Cooperation and Development. World Steel Trade Developments, 1960–83: A Statistical Analysis. Paris, 1985, 161 pp.

Sterner, J. W., D. K. Steele, and M. B. Shirts. Hand Dismantling of Japanese Automobiles To Determine Material Contents and Metal Recoveries. BuMines RI 8855, 1984, 25 pp.

U.S. Bureau of the Census. Census of Manufacturers, various issues.

Wards Communications. Wards Automotive Yearbook. Detroit, MI, various issues.

## APPENDIX.—ASSUMPTIONS AND DEFINITIONS

1. Net shipments of steel mill products to the automotive sector include scrap generated during production, steel used in spare parts, and accumulated inventories by motor vehicle producers. This report makes the following adjustments to steel shipments so that only steel actually contained in motor vehicles is considered.

a. A factor for scrap is subtracted. The scrap factor is 0.333 for 1950–70; $0.333 \cdot 0.996586^N$ for 1971–85 where N = number of years following 1970. The annual decline in scrap is the result of increasingly efficient operations from 1971 through 1985.

b. A factor for spare parts is subtracted. The spare parts factor is 0.295.

c. All inventories by motor vehicle producers are eventually sold and are, therefore, treated as equal to zero.

d. The amount of steel going into motor vehicle exports is subtracted.

2. Some steel mill shipments destined for use in motor vehicles go to service centers and distributors. This report assumes the percentage of shipments going to service centers, but eventually destined for automotive use, is equal to the same percentage of total steel shipments going directly to the automotive sector.

3. This report assumes that trucks use the same proportion of materials as cars.

4. This report assumes that all steel in imported vehicles is of foreign origin.

5. Passenger cars generally include station wagons, but exclude passenger vans. Passenger vans are included with trucks and buses.

6. Shipping weight is the weight of the vehicle excluding fluids such as gas and oil, curb weight is the weight of the vehicle including fluids, and gross vehicle weight (GVW) is the weight of the vehicle including fluids plus the payload.

7. Data on curb weight of trucks were not available. GVW was adjusted downward based on manufacturers' estimates. The degree of error is unknown, but relatively small, since it affects the amount of steel in the average vehicle only marginally.

8. Weighted average curb weight of motor vehicle imports was estimated at 2,000 lb between 1950 and 1975 based upon available information.

9. Retail sales of domestic vehicles include imports from Canada.

## Table A-1.—Domestic demand for steel in motor vehicles

| Demand component | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Steel shipments, steel service centers . . . MMst | 13.4 | 14.4 | 13.3 | 14.9 | 12.0 | 15.8 | 16.8 | 14.5 | 10.9 | 13.0 | 12.5 | 12.4 | 12 3 | 13.1 | 15.6 | 16.4 | 16.4 | 14.9 |
| Steel shipments, automotive, MMst: | | | | | | | | | | | | | | | | | | |
| Steelmill | 14.5 | 13.0 | 10.9 | 14.7 | 11.8 | 18.7 | 14.1 | 14.2 | 10.1 | 14.2 | 14.6 | 12.6 | 15.2 | 16.9 | 18.4 | 20.1 | 18.0 | 16.5 |
| Service center [1] | 2.7 | 2.4 | 2.1 | 2.7 | 2.2 | 3.5 | 2.8 | 2.6 | 1.8 | 2.7 | 2.6 | 2.4 | 2.6 | 2.9 | 3.4 | 3.6 | 3.3 | 2.9 |
| Total steel shipments, automotive | 17.1 | 15.4 | 13.0 | 17.4 | 14.0 | 22.2 | 17.0 | 16.8 | 12.0 | 16.9 | 17.2 | 14.9 | 17.8 | 19.8 | 21.8 | 23.7 | 21.3 | 19.4 |
| Less spare parts factor [2] | 5.1 | 4.5 | 3.8 | 5.1 | 4.1 | 6.6 | 5.0 | 5.0 | 3.5 | 5.0 | 5.1 | 4.4 | 5.3 | 5.8 | 6.4 | 7.0 | 6.3 | 5.7 |
| Less scrap factor [3] | 4 0 | 3.6 | 3.0 | 4.1 | 3.3 | 5.2 | 4.0 | 3.9 | 2.8 | 4.0 | 4.0 | 3.5 | 4.2 | 4.7 | 5.1 | 5.6 | 5.0 | 4.6 |
| Less motor vehicle export factor [4] | .3 | .5 | .3 | .3 | .4 | .4 | .4 | .4 | .3 | .3 | .3 | .3 | .2 | .3 | .4 | .2 | .2 | .4 |
| Domestic steel mill shipments to the automotive industry | 7.8 | 6.8 | 5.8 | 7.9 | 6.2 | 10.0 | 7.6 | 7.5 | 5.3 | 7.6 | 7.7 | 6.8 | 8.1 | 9.0 | 9.9 | 11.0 | 9.8 | 8.8 |
| Retail sales of motor vehicles,[5] million vehicles: | | | | | | | | | | | | | | | | | | |
| Domestic retail sales [6] | 7.4 | 6.3 | 5.1 | 6.7 | 6.3 | 8.4 | 6.7 | 6.7 | 5.0 | 6.4 | 7.1 | 6.5 | 7.8 | 8.6 | 9.0 | 10.3 | 10.0 | 9.1 |
| Import retail sales | ([7]) | ([7]) | ([7]) | ([7]) | ([7]) | .1 | .1 | .2 | .4 | .7 | .5 | .4 | .4 | .4 | .5 | .6 | .7 | .8 |
| Total | 7.4 | 6.3 | 5.1 | 6.8 | 6.4 | 8.5 | 6.9 | 6.9 | 5.4 | 7.1 | 7 6 | 6.9 | 8.2 | 9.0 | 9.5 | 10.9 | 10.7 | 9.9 |
| Average vehicle weight, production-weighted . . lb | 3,717 | 3,768 | 3,791 | 3,711 | 3,764 | 3,761 | 3,797 | 3,908 | 3,659 | 3,641 | 3,723 | 3,571 | 3,474 | 3,569 | 3,614 | 3,571 | 3,639 | 3,623 |
| Steel in vehicle . . % | 70.8 | 70.8 | 70.8 | 70 8 | 70.8 | 70.8 | 69.6 | 68.4 | 67.1 | 65.9 | 64.7 | 64.3 | 63.8 | 63.4 | 62.9 | 62.5 | 62.3 | 62.1 |
| Total domestic demand for steel in motor vehicles MMst | 9.8 | 8.4 | 6.9 | 8.9 | 8.5 | 11.3 | 9.1 | 9.3 | 6.7 | 8.5 | 9.2 | 7.9 | 9.1 | 10.2 | 10.8 | 12.1 | 12.1 | 11.1 |
| Demand met by imports . . . MMst | 2.0 | 1.6 | 1.1 | 1.0 | 2.2 | 1.3 | 1.5 | 1.7 | 1.3 | 0.9 | 1.4 | 1.1 | 0.9 | 1.1 | 0.9 | 1.2 | 2.3 | 2.4 |
| Imports share of total steel demand % | 20.0 | 19.3 | 15.9 | 11.7 | 26.4 | 11.4 | 16.5 | 18.5 | 20.0 | 10.0 | 15.4 | 14.3 | 10.3 | 11.0 | 8.5 | 9.7 | 19.4 | 21.3 |
| Total motor vehicle weight . . . MMst | 13.8 | 11.8 | 9.7 | 12.6 | 12.0 | 15.9 | 13.0 | 13.5 | 9.9 | 12.9 | 14.2 | 12 3 | 14.2 | 16.0 | 17.2 | 19.4 | 19.4 | 17.9 |
| Weight of other vehicle materials . . MMst | 4.0 | 3.5 | 2.8 | 3.7 | 3.5 | 4.7 | 4.0 | 4.3 | 3.3 | 4.4 | 5.0 | 4.4 | 5.1 | 5.9 | 6.4 | 7.3 | 7.3 | 6.8 |
| Other materials share of total weight . . . % | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 30.4 | 31.6 | 32.9 | 34.1 | 35.3 | 35.7 | 36.2 | 36.6 | 37.1 | 37.5 | 37.7 | 37.9 |
| Steel per motor vehicle, lb: | | | | | | | | | | | | | | | | | | |
| Domestic steel | 2,105 | 2,153 | 2,256 | 2,319 | 1,961 | 2,359 | 2,206 | 2,176 | 1,965 | 2,159 | 2,037 | 1,966 | 1,988 | 2,013 | 2,081 | 2,015 | 1,829 | 1,773 |
| Foreign steel | 527 | 515 | 428 | 308 | 704 | 304 | 436 | 495 | 492 | 241 | 372 | 328 | 229 | 249 | 194 | 217 | 439 | 478 |
| Total | 2,632 | 2,668 | 2,684 | 2,627 | 2,665 | 2,663 | 2,642 | 2,672 | 2,457 | 2,400 | 2,409 | 2,295 | 2,217 | 2,262 | 2,275 | 2,232 | 2,268 | 2,251 |
| Other materials per motor vehicle, lb: | | | | | | | | | | | | | | | | | | |
| Plastics | 19 | NA | NA | NA | NA | 19 | NA | NA | NA | NA | 19 | NA | NA | NA | NA | 29 | NA | NA |
| Aluminum | 52 | NA | NA | NA | NA | 53 | NA | NA | NA | NA | 52 | NA | NA | NA | NA | 50 | NA | NA |
| Iron | 532 | NA | NA | NA | NA | 538 | NA | NA | NA | NA | 540 | NA | NA | NA | NA | 511 | NA | NA |
| Other | 483 | NA | NA | NA | NA | 489 | NA | NA | NA | NA | 703 | NA | NA | NA | NA | 749 | NA | NA |
| Total | 1,085 | 1,100 | 1,107 | 1,084 | 1,099 | 1,098 | 1,155 | 1,236 | 1,202 | 1,241 | 1,314 | 1,276 | 1,257 | 1,307 | 1,339 | 1,339 | 1,371 | 1,372 |
| Real GNP index | 100.0 | 110.3 | 114.6 | 119.2 | 117.7 | 124.2 | 126.7 | 128.9 | 127.9 | 135.3 | 138.3 | 142.0 | 149.5 | 155.6 | 163.9 | 173.4 | 183.5 | 188.7 |
| FRB index of manufacturing | 100.0 | 107.9 | 112.4 | 122.4 | 114.5 | 129.1 | 134.5 | 136.1 | 126.4 | 142.4 | 145.5 | 145.8 | 158.8 | 168.2 | 179.7 | 199.1 | 217 3 | 221.5 |
| Population index | 100 0 | 101.7 | 103.5 | 105.2 | 107.1 | 109.0 | 110.9 | 112.9 | 114 8 | 116.8 | 118.7 | 120.6 | 122.5 | 124.3 | 126.0 | 127.6 | 129.1 | 130.5 |
| Motor vehicle steel demand index | 100.0 | 85.7 | 70.4 | 91.1 | 86.8 | 115.6 | 92.7 | 94.8 | 68.3 | 86.8 | 93.8 | 80.7 | 93.0 | 104.1 | 110.6 | 124.4 | 123.8 | 113.9 |

**Table A-1.—Domestic demand for steel in motor vehicles—Continued**

| Demand component | | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Steel shipments, steel service centers | MMst | 16.1 | 17.6 | 17.7 | 16.2 | 18.6 | 22.7 | 23.2 | 15.6 | 14.6 | 15.3 | 17.3 | 18.2 | 16.2 | 17.6 | 13.1 | 16.7 | 18.4 | 18.4 |
| Steel shipments, automotive, MMst: | | | | | | | | | | | | | | | | | | | |
| Steelmill | | 19.3 | 18.3 | 14.5 | 17.5 | 18.2 | 23.2 | 18.9 | 15.2 | 21.4 | 21.5 | 21.3 | 18.6 | 12.1 | 13.2 | 9.3 | 12.3 | 12.9 | 13.0 |
| Service center [1] | | 3.4 | 3.4 | 2.8 | 3.3 | 3.7 | 4.7 | 4.0 | 3.0 | 3.5 | 3.6 | 3.8 | 3.4 | 2.3 | 2.7 | 2.0 | 3.0 | 3.2 | 3.3 |
| Total steel shipments, automotive | | 22.6 | 21.7 | 17.3 | 20.7 | 21.9 | 27.9 | 22.9 | 18.2 | 24.8 | 25.1 | 25.0 | 22.0 | 14.5 | 15.8 | 11.3 | 15.4 | 16.1 | 16.2 |
| Less spare parts factor [2] | | 6.7 | 6.4 | 5.1 | 6.1 | 6.5 | 8.2 | 6.8 | 5.4 | 7.3 | 7.4 | 7.4 | 6.5 | 4.3 | 4.7 | 3.3 | 4.5 | 4.7 | 4.8 |
| Less scrap factor [3] | | 5.3 | 5.1 | 4.1 | 4.9 | 5.1 | 6.5 | 5.3 | 4.2 | 5.7 | 5.8 | 5.7 | 5.0 | 3.3 | 3.6 | 2.5 | 3.5 | 3.6 | 3.6 |
| Less motor vehicle export factor [4] | | .4 | .4 | .4 | .4 | .5 | .7 | .9 | .8 | .9 | .8 | .9 | 1.0 | .7 | .7 | .4 | .6 | .5 | .6 |
| Domestic steel mill shipments to the automotive industry | | 10.2 | 9.8 | 7.8 | 9.3 | 9.9 | 12.5 | 10.0 | 7.8 | 10.9 | 11.1 | 11.0 | 9.5 | 6.2 | 6.9 | 5.0 | 6.8 | 7.2 | 7.2 |
| Retail sales of motor vehicles,[5] million vehicles: | | | | | | | | | | | | | | | | | | | |
| Domestic retail sales [6] | | 10.4 | 10.4 | 8.9 | 10.7 | 11.8 | 12.6 | 10.0 | 9.3 | 11.6 | 12.5 | 13.1 | 11.4 | 8.6 | 8.0 | 7.9 | 9.5 | 11.4 | 12.1 |
| Import retail sales | | 1.1 | 1.2 | 1.3 | 1.6 | 1.8 | 2.0 | 1.6 | 1.8 | 1.7 | 2.4 | 2.3 | 2.8 | 2.9 | 2.8 | 2.6 | 2.9 | 3.1 | 3.6 |
| Total | | 11.5 | 11.6 | 10.2 | 12.3 | 13.6 | 14.6 | 11.5 | 11.1 | 13.3 | 14.9 | 15.4 | 14.2 | 11.5 | 10.8 | 10.5 | 12.3 | 14.5 | 15.7 |
| Average vehicle weight, production-weighted | lb | 3,649 | 3,704 | 3,663 | 3,501 | 3,606 | 3,804 | 3,798 | 3,794 | 3,810 | 3,787 | 3,693 | 3,570 | 3,313 | 3,208 | 3,160 | 3,206 | 3,270 | 3,274 |
| Steel in vehicle | % | 62.0 | 61.8 | 61.6 | 61.5 | 61.4 | 61.3 | 61.2 | 60.8 | 60.6 | 60.0 | 59.6 | 59.8 | 59.3 | 58.0 | 56.3 | 56.4 | 56.3 | 56.0 |
| Total domestic demand for steel in motor vehicles | MMst | 13.0 | 13.2 | 11.5 | 13.3 | 15.0 | 17.0 | 13.4 | 12.8 | 15.3 | 16.9 | 17.0 | 15.1 | 11.3 | 10.0 | 9.4 | 11.1 | 13.3 | 14.4 |
| Demand met by imports | MMst | 2.8 | 3.5 | 3.8 | 4.0 | 5.2 | 4.5 | 3.4 | 5.0 | 4.4 | 5.8 | 5.9 | 5.6 | 5.0 | 3.2 | 4.4 | 4.3 | 6.1 | 7.2 |
| Imports share of total steel demand | % | 21.2 | 26.1 | 32.6 | 29.8 | 34.4 | 26.3 | 25.6 | 39.1 | 29.0 | 34.2 | 35.0 | 36.8 | 44.8 | 31.4 | 46.6 | 38.6 | 46.0 | 49.8 |
| Total motor vehicle weight | MMst | 21.0 | 21.4 | 18.7 | 21.6 | 24.5 | 27.7 | 21.9 | 21.1 | 25.3 | 28.1 | 28.5 | 25.3 | 19.0 | 17.3 | 16.7 | 19.7 | 23.7 | 25.7 |
| Weight of other vehicle materials | MMst | 8.0 | 8.2 | 7.2 | 8.3 | 9.4 | 10.7 | 8.5 | 8.3 | 10.0 | 11.3 | 11.5 | 10.2 | 7.7 | 7.3 | 7.3 | 8.6 | 10.3 | 11.3 |
| Other materials share of total weight | % | 38.0 | 38.2 | 38.4 | 38.5 | 38.6 | 38.7 | 38.8 | 39.2 | 39.4 | 40.0 | 40.4 | 40.2 | 40.7 | 42.0 | 43.7 | 43.6 | 43.7 | 44.0 |
| Steel per motor vehicle, lb: | | | | | | | | | | | | | | | | | | | |
| Domestic steel | | 1,782 | 1,691 | 1,520 | 1,511 | 1,452 | 1,718 | 1,729 | 1,404 | 1,639 | 1,494 | 1,432 | 1,349 | 1,085 | 1,277 | 950 | 1,110 | 994 | 920 |
| Foreign steel | | 479 | 598 | 737 | 642 | 762 | 613 | 595 | 902 | 669 | 778 | 770 | 786 | 880 | 584 | 829 | 698 | 847 | 913 |
| Total | | 2,261 | 2,288 | 2,256 | 2,153 | 2,214 | 2,332 | 2,324 | 2,307 | 2,309 | 2,272 | 2,201 | 2,135 | 1,965 | 1,861 | 1,779 | 1,808 | 1,841 | 1,833 |
| Other materials per motor vehicle, lb: | | | | | | | | | | | | | | | | | | | |
| Plastics | | NA | NA | 99 | NA | NA | NA | NA | 156 | 164 | 174 | 185 | 189 | 192 | 196 | 202 | 199 | 216 | 223 |
| Aluminum | | NA | NA | 62 | NA | NA | NA | NA | 80 | 88 | 98 | 114 | 121 | 129 | 128 | 136 | 138 | 137 | 141 |
| Iron | | NA | NA | 549 | NA | NA | NA | NA | 580 | 568 | 557 | 528 | 510 | 477 | 468 | 468 | 474 | 484 | 481 |
| Other | | NA | NA | 697 | NA | NA | NA | NA | 671 | 681 | 686 | 665 | 615 | 550 | 555 | 575 | 587 | 592 | 596 |
| Total | | 1,388 | 1,416 | 1,407 | 1,348 | 1,392 | 1,472 | 1,474 | 1,487 | 1,501 | 1,515 | 1,492 | 1,435 | 1,348 | 1,347 | 1,381 | 1,398 | 1,429 | 1,441 |
| Real GNP index | | 196.5 | 201.3 | 200.7 | 206.4 | 216.7 | 228.0 | 226.7 | 223.9 | 234.8 | 245.8 | 258.8 | 265.2 | 264.8 | 269.9 | 263.0 | 272.4 | 289.9 | 297.8 |
| FRB index of manufacturing | | 233.9 | 244.2 | 233.3 | 237.0 | 261.8 | 284.8 | 280.6 | 252.7 | 278.5 | 303.0 | 324.5 | 337.9 | 327.9 | 334.8 | 309.7 | 333.9 | 373.9 | 382.7 |
| Population index | | 131.8 | 133.1 | 134.7 | 136.4 | 137.8 | 139.2 | 140.4 | 141.8 | 143.2 | 144.6 | 146.2 | 147.8 | 149.6 | 151.1 | 152.7 | 154.2 | 155.7 | 157.1 |
| Motor vehicle steel demand index | | 133.0 | 135.4 | 118.0 | 136.0 | 153.8 | 174.0 | 137.4 | 131.1 | 157.1 | 172.9 | 173.8 | 154.7 | 115.3 | 102.9 | 96.0 | 114.0 | 136.5 | 147.6 |

FRB Federal Reserve Board. GNP Gross National Product. NA Not available; data not provided for individual categories except for every 5th year.

[1] Percentage of shipments from steel service centers for automotive use is assumed to equal the same percentage of total shipments going to automotive sector.

[2] 29.5% of total steel shipments, automotive.

[3] 0.333 for 1950–70 and $0.333 \times 0.996586^{N}$ for 1971–85 where N = the number of years following 1970.

[4] Based on percentage of domestic motor vehicle production exported.

[5] 1950 data are based on domestic production because retail sales data were not available. 1951 imports were used for 1950 imports.

[6] Includes imports from Canada.

[7] Less than 100,000 vehicles.

NOTE—Data may not add to totals shown because of independent rounding.

## Table A-2.—Motor vehicle weight and content data

| | Auto curb weight, lb | | Domestic and imported truck curb weight, lb | Imported autos as a % of total auto retail sales | Total auto sales as a % of total retail sales | Total truck sales as a % of total retail sales | Av vehicle weight,[1] lb | Steel | | Plastics | | Aluminum | | Iron | | Other | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Domestic (production weighted) | Imports | | | | | | Content, % | Weight, lb | Content, % | Weight, lb | Content, % | Weight, lb | Content, % | Weight, lb | Content, % | Weight, lb |
| 1950 | 3,538 | 2,000 | 4,562 | 0.4 | 82 | 18 | 3,717 | 70.8 | 2,632 | 0.5 | 19 | 1.4 | 52 | 14.3 | 532 | 13.0 | 483 |
| 1951 | 3,546 | 2,000 | 4,809 | .4 | 82 | 18 | 3,768 | 70.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1952 | 3,577 | 2,000 | 4,890 | .7 | 83 | 17 | 3,791 | 70.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1953 | 3,548 | 2,000 | 4,772 | .6 | 86 | 14 | 3,711 | 70.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1954 | 3,627 | 2,000 | 4,748 | .6 | 87 | 13 | 3,764 | 70.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1955 | 3,634 | 2,000 | 4,792 | .8 | 88 | 12 | 3,761 | 70.8 | 2,663 | .5 | 19 | 1.4 | 53 | 14.3 | 538 | 13.0 | 488 |
| 1956 | 3,625 | 2,000 | 5,124 | 1.6 | 87 | 13 | 3,797 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1957 | 3,827 | 2,000 | 4,869 | 3.4 | 87 | 13 | 3,908 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1958 | 3,572 | 2,000 | 4,975 | 8.1 | 86 | 14 | 3,659 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1959 | 3,578 | 2,000 | 5,009 | 10.1 | 86 | 14 | 3,641 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1960 | 3,690 | 2,000 | 4,791 | 7.5 | 87 | 13 | 3,723 | 64.7 | 2,409 | .5 | 19 | 1.4 | 52 | 14.5 | 540 | 18.9 | 703 |
| 1961 | 3,493 | 2,000 | 4,731 | 6.4 | 87 | 13 | 3,571 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1962 | 3,442 | 2,000 | 4,812 | 4.8 | 86 | 14 | 3,574 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1963 | 3,446 | 2,000 | 4,771 | 5.0 | 86 | 14 | 3,569 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1964 | 3,514 | 2,000 | 4,695 | 6.0 | 85 | 15 | 3,614 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1965 | 3,482 | 2,000 | 4,674 | 6.1 | 86 | 14 | 3,571 | 62.5 | 2,232 | .8 | 29 | 1.4 | 50 | 14.3 | 511 | 21.0 | 749 |
| 1966 | 3,553 | 2,000 | 4,806 | 7.7 | 85 | 15 | 3,639 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1967 | 3,547 | 2,000 | 4,769 | 9.2 | 84 | 16 | 3,623 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1968 | 3,630 | 2,000 | 4,662 | 10.7 | 84 | 16 | 3,649 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1969 | 3,674 | 2,000 | 4,806 | 11.7 | 83 | 17 | 3,704 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1970 | 3,664 | 2,000 | 4,817 | 15.3 | 82 | 18 | 3,663 | 61.6 | 2,256 | 2.7 | 99 | 1.7 | 62 | 15.0 | 549 | 19.0 | 697 |
| 1971 | 3,483 | 2,000 | 4,687 | 15.2 | 83 | 17 | 3,501 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1972 | 3,572 | 2,000 | 4,734 | 14.7 | 81 | 19 | 3,606 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1973 | 3,840 | 2,000 | 4,673 | 15.3 | 78 | 22 | 3,804 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1974 | 3,783 | 2,000 | 4,791 | 15.8 | 77 | 23 | 3,798 | 61.2 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1975 | 3,898 | 2,028 | 4,684 | 19.0 | 78 | 22 | 3,794 | 60.8 | 2,307 | 4.1 | 156 | 2.1 | 80 | 15.3 | 580 | 17.7 | 671 |
| 1976 | 3,795 | 2,074 | 4,665 | 14.8 | 76 | 24 | 3,810 | 60.6 | 2,309 | 4.3 | 164 | 2.3 | 88 | 14.9 | 568 | 17.9 | 681 |
| 1977 | 3,752 | 2,120 | 4,801 | 18.6 | 75 | 25 | 3,787 | 60.0 | 2,272 | 4.6 | 174 | 2.6 | 98 | 14.7 | 557 | 18.1 | 686 |
| 1978 | 3,459 | 2,166 | 4,914 | 16.8 | 73 | 27 | 3,693 | 59.6 | 2,201 | 5.0 | 185 | 3.1 | 114 | 14.3 | 528 | 18.0 | 665 |
| 1979 | 3,324 | 2,178 | 5,057 | 21.8 | 75 | 25 | 3,570 | 59.8 | 2,135 | 5.3 | 189 | 3.4 | 121 | 14.3 | 510 | 17.2 | 615 |
| 1980 | 3,003 | 2,188 | 5,183 | 26.7 | 78 | 22 | 3,313 | 59.3 | 1,965 | 5.8 | 192 | 3.9 | 129 | 14.4 | 477 | 16.6 | 550 |
| 1981 | 2,891 | 2,234 | 5,074 | 27.3 | 79 | 21 | 3,208 | 58.0 | 1,860 | 6.1 | 196 | 4.0 | 128 | 14.6 | 468 | 17.3 | 555 |
| 1982 | 2,859 | 2,295 | 4,610 | 27.9 | 76 | 24 | 3,160 | 56.3 | 1,779 | 6.4 | 202 | 4.3 | 136 | 14.8 | 468 | 18.2 | 575 |
| 1983 | 2,967 | 2,332 | 4,417 | 26.0 | 75 | 25 | 3,206 | 56.4 | 1,808 | 6.2 | 199 | 4.3 | 138 | 14.8 | 474 | 18.3 | 587 |
| 1984 | 2,874 | 2,385 | 4,585 | 23.5 | 72 | 28 | 3,270 | 56.3 | 1,841 | 6.6 | 216 | 4.2 | 137 | 14.8 | 484 | 18.1 | 592 |
| 1985 | 2,892 | 2,438 | 4,438 | 25.7 | 70 | 30 | 3,274 | 56.0 | 1,834 | 6.8 | 223 | 4.3 | 141 | 14.7 | 481 | 18.2 | 596 |

NA Not available.

[1] $((100 - E)/100 \times B + E/100 \times C) \times F/100 + (G/100) \times D$ where B = domestic automobile weight, C = imported automobile weight, D = truck weight, E = imported automobiles as a percent of total automobile retail sales, F = automobile sales as a percent of total retail sales, and G = truck sales as a percent of total retail sales.

## Table A-3.—Salient domestic steel and automotive statistics

| | Steel mill shipments, st | | | | Automotive shipments as a % of total shipments | U. S. motor vehicle production | | | Total U. S. automotive exports | Exports as a % of total production |
|---|---|---|---|---|---|---|---|---|---|---|
| | Automotive | Service center | Other steel mill products | Total | | Passenger cars | Other | Total | | |
| 1950 | 14,472,707 | 13,359,724 | 44,399,861 | 72,232,292 | 20.04 | 6,628,598 | 1,377,261 | 8,005,859 | 251,662 | 3.14 |
| 1951 | 12,982,356 | 14,399,432 | 51,547,162 | 78,928,950 | 16.45 | 5,338,436 | 1,418,578 | 6,757,014 | 434,659 | 6.43 |
| 1952 | 10,850,797 | 13,328,642 | 43,824,173 | 68,003,612 | 15.96 | 4,320,794 | 1,241,002 | 5,561,796 | 296,493 | 5.33 |
| 1953 | 14,663,775 | 14,878,859 | 50,609,259 | 80,151,893 | 18.29 | 6,116,948 | 1,232,175 | 7,349,123 | 288,894 | 3.93 |
| 1954 | 11,792,989 | 11,999,470 | 39,360,267 | 63,152,726 | 18.67 | 5,558,897 | 977,832 | 6,536,729 | 356,529 | 5.45 |
| 1955 | 18,721,880 | 15,758,005 | 50,237,559 | 84,717,444 | 22.10 | 7,950,377 | 1,253,672 | 9,204,049 | 386,782 | 4.20 |
| 1956 | 14,141,887 | 16,752,233 | 52,357,048 | 83,251,168 | 16.99 | 5,806,756 | 1,112,002 | 6,918,758 | 372,442 | 5.38 |
| 1957 | 14,227,096 | 14,507,308 | 51,160,173 | 79,894,577 | 17.81 | 6,120,029 | 1,100,402 | 7,220,431 | 335,785 | 4.65 |
| 1958 | 10,125,034 | 10,902,283 | 38,887,116 | 59,914,433 | 16.90 | 4,247,427 | 873,842 | 5,121,269 | 268,092 | 5.23 |
| 1959 | 14,213,875 | 13,048,754 | 42,114,438 | 69,377,067 | 20.49 | 5,599,492 | 1,124,096 | 6,723,588 | 266,318 | 3.96 |
| 1960 | 14,610,424 | 12,479,830 | 44,058,964 | 71,149,218 | 20.53 | 6,703,108 | 1,202,011 | 7,905,119 | 322,526 | 4.08 |
| 1961 | 12,593,946 | 12,364,604 | 41,166,955 | 66,125,505 | 19.05 | 5,522,019 | 1,130,919 | 6,652,938 | 258,975 | 3.89 |
| 1962 | 15,181,184 | 12,268,921 | 43,102,333 | 70,552,438 | 21.52 | 6,943,334 | 1,253,977 | 8,197,311 | 231,977 | 2.83 |
| 1963 | 16,889,048 | 13,149,453 | 45,516,641 | 75,555,142 | 22.35 | 7,644,377 | 1,464,399 | 9,108,776 | 267,781 | 2.94 |
| 1964 | 18,387,333 | 15,563,738 | 50,993,805 | 84,944,876 | 21.65 | 7,745,492 | 1,562,368 | 9,307,860 | 320,169 | 3.44 |
| 1965 | 20,122,817 | 16,368,628 | 56,174,737 | 92,666,182 | 21.72 | 9,335,227 | 1,802,603 | 11,137,830 | 167,724 | 1.51 |
| 1966 | 17,984,312 | 16,399,899 | 55,611,180 | 89,995,391 | 19.98 | 8,604,712 | 1,791,586 | 10,396,298 | 256,529 | 2.47 |
| 1967 | 16,487,821 | 14,862,864 | 52,546,655 | 83,897,340 | 19.65 | 7,412,659 | 1,611,077 | 9,023,736 | 363,165 | 4.02 |
| 1968 | 19,269,373 | 16,099,078 | 56,487,443 | 91,855,894 | 20.98 | 8,848,620 | 1,971,790 | 10,820,410 | 422,629 | 3.91 |
| 1969 | 18,276,409 | 17,565,472 | 58,034,990 | 93,876,871 | 19.47 | 8,224,392 | 1,981,519 | 10,205,911 | 437,802 | 4.29 |
| 1970 | 14,475,207 | 17,677,519 | 58,645,400 | 90,798,126 | 15.94 | 6,550,128 | 1,733,821 | 8,283,949 | 379,089 | 4.58 |
| 1971 | 17,482,869 | 16,184,332 | 53,370,571 | 87,037,772 | 20.09 | 8,583,653 | 2,088,001 | 10,671,654 | 486,780 | 4.56 |
| 1972 | 18,216,755 | 18,597,876 | 54,989,937 | 91,804,568 | 19.84 | 8,828,205 | 2,482,503 | 11,310,708 | 531,009 | 4.69 |
| 1973 | 23,216,542 | 22,704,769 | 65,509,186 | 111,430,497 | 20.83 | 9,667,152 | 3,014,361 | 12,681,513 | 661,006 | 5.21 |
| 1974 | 18,928,237 | 23,178,785 | 67,364,547 | 109,471,569 | 17.29 | 7,324,504 | 2,746,538 | 10,071,042 | 815,507 | 8.10 |
| 1975 | 15,214,232 | 15,622,315 | 49,120,280 | 79,956,827 | 19.03 | 6,716,951 | 2,269,562 | 8,986,513 | 864,050 | 9.61 |
| 1976 | 21,351,002 | 14,615,136 | 53,480,443 | 89,446,581 | 23.87 | 8,497,893 | 2,999,703 | 11,497,596 | 880,778 | 7.66 |
| 1977 | 21,490,171 | 15,346,024 | 54,311,072 | 91,147,267 | 23.58 | 9,213,654 | 3,489,128 | 12,702,782 | 899,116 | 7.08 |
| 1978 | 21,253,393 | 17,333,328 | 59,347,985 | 97,934,706 | 21.70 | 9,176,635 | 3,722,567 | 12,899,202 | 954,609 | 7.40 |
| 1979 | 18,620,960 | 18,246,243 | 63,394,926 | 100,262,129 | 18.57 | 8,433,662 | 3,046,331 | 11,479,993 | 1,047,944 | 9.13 |
| 1980 | 12,123,989 | 16,172,333 | 55,556,256 | 83,852,578 | 14.46 | 6,375,506 | 1,634,335 | 8,009,841 | 807,169 | 10.08 |
| 1981 | 13,153,806 | 17,636,618 | 56,223,707 | 87,014,131 | 15.12 | 6,253,138 | 1,689,778 | 7,942,916 | 718,426 | 9.04 |
| 1982 | 9,288,393 | 13,067,027 | 39,211,882 | 61,567,302 | 15.09 | 5,073,496 | 1,912,099 | 6,985,595 | 506,659 | 7.25 |
| 1983 | 12,320,351 | 16,709,874 | 38,553,302 | 67,583,527 | 18.23 | 6,782,061 | 2,443,637 | 9,225,698 | 687,775 | 7.45 |
| 1984 | 12,882,398 | 18,364,218 | 42,492,913 | 73,739,529 | 17.47 | 7,773,342 | 3,165,716 | 10,939,058 | 772,223 | 7.06 |
| 1985 | 12,950,381 | 18,438,723 | 41,654,219 | 73,043,323 | 17.73 | 8,186,034 | 3,467,922 | 11,653,956 | 869,428 | 7.46 |

Sources: American Iron and Steel Institute, Statistical Yearbooks, 1950–85 issues; Motor Vehicle Manufacturers' Association, Motor Vehicle Facts and Figures, various issues; Motor Vehicle Manufacturers' Association, World Motor Vehicle Data, 1984–85 issue.

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