EMPIRICAL STUDIES OF CAPACITY UTILIZATION†

Segment Shifts and Capacity Utilization in the U.S. Automobile Industry

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An important school of thought argues that sectoral shifts may account for a substantial portion of aggregate fluctuations (e.g., David Lilien, 1982; Fischer Black, 1987; Steven Davis, 1987). Events such as the oil shocks of the 1970's, exchange-rate fluctuations, and shifts in government spending have their direct effect on the *composition* of economic activity. The sectoral-shift literature argues that they may affect the *level* and the *dynamics* of output and employment as well. The typical story is of a slowly functioning labor market. After a sectoral shock, search behavior, matching problems, and a time cost of switching sectors slow the reallocation of workers across sectors. This focus, however, misses important elements of the reallocation problem. As Black (1987) has argued, not only sector-specific human capital, but also complementary *physical and managerial* (engineering, organization, etc.) capital must be reallocated or recreated in response to sectoral shocks. If jobs are linked to capital, then the slow adjustment of labor may be attributable in part to the sluggishness in the adjustment of capital.

This paper presents an empirical study of the impact of oil-shock sectoral shifts within the U.S. automobile industry. From an analytical perspective, a "sectoral shift" is any event that raises desired output and employment in some "sectors" and lowers them in others. For our purposes, a "sector" is a size class of automobiles. Within the automobile industry, we will be able to study two distinct questions. First, did the oil-price-induced shocks to the composition of demand interact with short-run rigidities in supply to limit industry-wide capacity utilization? We will quantify the extent to which the changing composition of demand was reflected in a lower aggregate output level, with obvious consequences for the employment of capital and of labor and for the return to firms' knowledge capital. Our second question concerns the pace of the intermediate-run adjustment to sectoral shocks. How rapidly could capital and labor be reallocated to new demand conditions? Such considerations determine the impact of sectoral shocks on employment and capacity-utilization dynamics.

I. Demand Shifts and the Composition of Automobile Output

The direct impact of the oil shocks on automobile demand was a change in the desired composition of the fleet of vehicles in use. More expensive fuel implied a smaller, lighter desired fleet. This was reflected in the demand for new vehicles in an exaggerated fashion in the short-run, as the stock of young used vehicles was largely fixed.

The oil shocks of the 1970's have already been well documented (James D. Hamilton, 1983), but it is useful to briefly review the timing of the changes. In early 1973, there were rumors of impending gasoline price increases and shortages. Between October 1973 and May 1974, real gasoline prices rose 28 percent. After falling 14 percent by 1978, they rose 42 percent from February

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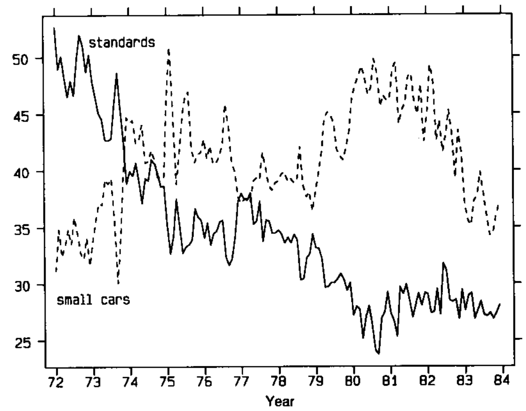

FIGURE 1. DOMESTIC SALES SHARES (PERCENTAGES)

1979 to March 1980. In 1982, real gasoline prices began to fall once again.

Figure 1 shows standard-size cars and small cars as a fraction of total sales of domestic cars.[1] Small cars consist of compact and subcompact cars. The excluded classes are intermediate-size cars and luxury cars. Standard-size cars accounted for half of all domestic car sales at the beginning of the period. Starting in 1973, the standard-size market share began to fall, reaching a trough in 1975. The standard-size car share stayed approximately constant with about 35 percent of the market until 1979, when it dipped again to just over 25 percent of the market. The story for small-car market share is just the opposite, with the share rising sharply after the two oil shocks.

The market-share story is familiar, and it underscores the demand-side origin of the shifting composition of motor-vehicle production. Market quantity outcomes do not, however, provide a good measure of supply–demand imbalances. The primary reason is that quantities reflect the shortage of capacity in the size classes to which demand is shifted; production (and therefore sales) of newly scarce models is truncated above by capacity. Other economic adjustments, such as changing prices of vehicles of different sizes, or imports of vehicles in the newly scarce size classes, make quantity data an even less revealing measure of demand shocks.

A more direct measure can be constructed using the stock of inventories relative to sales. In particular, a high dispersion of "days-supply" (DS) across segments is an indication of a short-run misalignment between the composition of capacity and the composition of demand.[2] Thus, our measure of supply and demand mismatches is the variance in days-supply (V^{DS}) across size categories and is defined as follows:

$$(1)\quad V_t^{\mathrm{DS}} = \sum_{i=1}^{5} \frac{\mathrm{INV}_{it}}{\mathrm{INV}_t^{\mathrm{A}}} \left(\mathrm{DS}_{it} - \mathrm{DS}_t^{\mathrm{A}}\right)^2$$

where INV denotes inventories, $\mathrm{INV}^{\mathrm{A}}$ denotes aggregate inventories, DS^{A} denotes aggregate days-supply, and i from 1 to 5 denotes five different size classes: subcompact, compact, intermediate, standard, and luxury.

Figure 2 shows the variance of days-supply over the sample period. The peaks in the dispersion of days-supply coincide exactly with the two oil crises. In both cases, days-supply in the small size classes was low relative to days-supply in the large size classes. Another period when the dispersion of days-supply rose somewhat was in 1977 and 1978. During this period, demand shifted partially away from small cars to intermediate-sized cars. The result was high days-supply in small cars and low days-supply in the intermediate category.

[1]The sales and production data are only for models produced by General Motors, Ford, and Chyrsler. See Bresnahan and Ramey (1992) for more details about the data.

[2]Days-supply, which is defined as the stock of inventories at the end of the month divided by daily sales during the month, is the most closely watched number in the automobile industry. Days-supply data for every product line are reported in *Automotive News*.

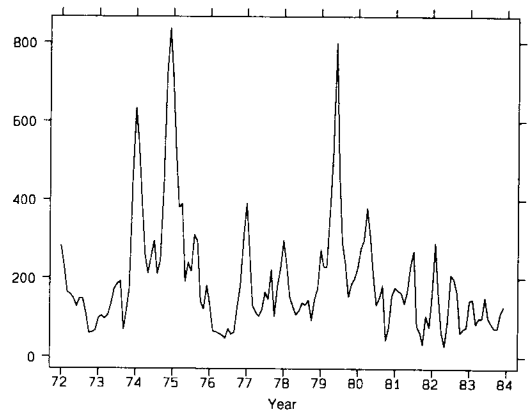

FIGURE 2. VARIANCE OF DAYS-SUPPLY ACROSS SEGMENTS

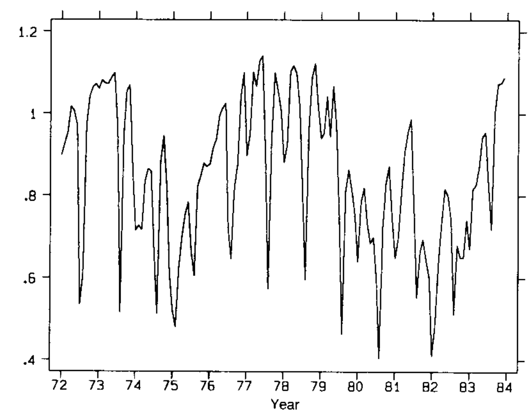

FIGURE 3. AUTOMOBILE INDUSTRY CAPACITY UTILIZATION

II. The Response of Capacity Utilization

In this section, we investigate the effect of segment shifts brought about by oil shocks on industry-wide capacity utilization. To the extent that marginal costs increase at high levels of capacity utilization, an increase in the dispersion of days-supply across size classes would be expected to decrease aggregate capacity utilization. To study fluctuations in aggregate capacity utilization, we use the following definition of capacity. Capacity (CAP) at a given plant is defined as the number of cars that can be produced in a week without using overtime hours. The formula is as follows:

$$(2)\quad CAP_t = LS_t \times SHIFTS_{max} \times (40 \text{ hours} - \text{holiday closings})_t$$

where LS denotes line speed and $SHIFTS_{max}$ is the maximum number of shifts the factory has ever had. Our earlier work, Bresnahan and Ramey (1992), explains this formula in more detail. Aggregate capacity is the sum of capacity over all plants that have not been permanently shut down or converted to light-truck production. Capacity utilization is defined to be actual aggregate number of cars produced divided by aggregate capacity. Note that utilization can exceed unity when overtime hours are used.

Figure 3 shows the aggregate capacity utilization series on a monthly basis. Utilization drops every July and August, typically from shut-downs at annual model changeover. Aggregate utilization was greater than unity until December 1973 and then fell to a low of 50 percent in the first quarter of 1975. Utilization began to rise and remained around unity from 1977 through 1978. In 1979, capacity utilization began to drop and reached a low just over 40 percent in the first quarter of 1982. Utilization then climbed back up to unity by the end of 1983.

To investigate the determinants of capacity utilization, we estimated a simple descriptive model for aggregate utilization. Although the nature of the capacity-utilization variable suggests that the response of capacity utilization to the explanatory variables should depend on whether utilization rates are high, preliminary investigation suggested that these effects were not significant. Thus, we used a simple linear specification. The general specification included the following variables: lagged capacity utilization, to allow for adjustment lags; current and lagged units lost due to supply disruptions, as a percent of capacity; current and lagged units lost due to model changeovers, as a percentage of capacity; lagged aggregate days-supply; lagged changes in aggregate personal income; the lagged variance of days-supply across size classes; and monthly dummy variables. Several lags of each variable were included in the general specification, and insignificant lags were progressively eliminated. Because we are interested in determining the impact of demand-shift-induced changes in the variance of days-supply, we instrumented the variance of days-supply with 12 lags each of real gasoline prices and of real gasoline consumption relative to real total consumption expenditures. The latter variable captures information not available in prices because of the price controls on gasoline in effect during part of the sample period. The first-stage regression had an adjusted R^2 of 0.37.

The estimates of the capacity equation using monthly data from 1972 to 1983 are:

$$\text{(3)}\quad \text{CU}_t = \text{seasonal dummies} + \underset{(17)}{0.753\text{CU}_{t-1}} \underset{(-2.6)}{-0.002\text{DS}_{t-1}} + \underset{(2.4)}{2.57\Delta\text{INC}_{t-1}} \underset{(-2.1)}{-0.00011V_{t-1}^{\text{DS}}} \underset{(-4.6)}{-1.050\text{SDIS}_t} + \underset{(4.6)}{1.06\text{SDIS}_{t-1}} \underset{(-8.5)}{-1.01\text{CH}_t} + \underset{(1.8)}{0.235\text{CH}_{t-1}}$$

where CU denotes capacity utilization, INC denotes income, SDIS denotes supply disruptions, and CH denotes model changeovers ($R^2 = 0.926$; t statistics are given in parentheses). All of the coefficient estimates are of the expected sign. Lagged capacity utilization enters positively, most likely because it captures adjustment costs. Days-supply, current supply disruptions, and current model changeovers have a negative impact on capacity utilization, while lagged income growth has a positive impact, presumably because it is a predictor of future sales. The interesting result for the analysis of the impact of demand shifts is the significant negative effect of the lagged oil-shock-induced variance of days-supply on capacity utilization. Even after accounting for the effects of aggregate days-supply and expected sales, increased dispersion of days supply across size classes has a negative impact on capacity utilization.

To calculate the magnitude of the impact, we compared the dynamic simulation of capacity utilization when the variance of days-supply remained equal to its mean with the dynamic simulation using the fitted values of the variance of days-supply from the projection of the gasoline variables. According to the estimates, increases in the variance attributable to the oil shock in 1973 led the capacity-utilization variable to be 0.1 lower during the trough in 1975 than it would have been had the variance of days-supply remained at its sample mean; that is, if the variance of days-supply had no effect on capacity utilization, capacity utilization would have been 60 percent rather than 50 percent.

These results indicate that segment misalignments caused by oil shocks have a substantial impact on the industry-wide utilization of capital. Thus, shifts in the *composition* of demand impact on the *level* of activity in the industry. Because changes in capacity utilization in this industry result directly in changes in hours and employment, the underutilization of capital following the oil shocks also represented underutilization of workers, typically in the form of temporary or indefinite layoffs.

III. Reallocations of Capital

We now document how the domestic automobile companies responded in the intermediate run by reallocating their capacity across size classes. Figure 4 shows graphs of capacity by each of the five segments. It is clear that the industry dramatically reduced its capacity for producing standard-size cars, first in 1973 and then again in 1979. On the other hand, capacity increased in the compact and subcompact categories over much of the period. During the period 1976–1978, the capacity for producing intermediate-size cars increased while capacity for the smaller

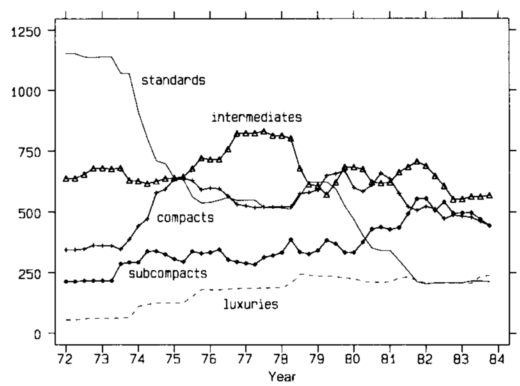

FIGURE 4. CAPACITY BY SEGMENT (THOUSANDS OF UNITS PER QUARTER)

cars decreased. However, this pattern reversed starting in 1979.

The industry changed its capacity in three ways: (i) by building new plants or permanently shutting down plants; (ii) by converting existing plants to a new size class; (iii) by changing the line speed. Much of the change in capacity occurred through changing the number of plants. For example, the number of plants producing standard size cars fell by 83 percent between 1972 and 1983, while the number of plants producing small cars doubled during the same period. Since only three new plants were built during this period, most of the increases in small-car capacity were achieved by converting existing plants.

What is particularly striking is the apparent speed with which the companies changed capacity. For example, the number of plants producing compacts and subcompacts rose from nine in the first half of 1973 to 16 by the end of 1974, a 78-percent increase. The number of plants producing standard-size cars fell from 23 in the first half of 1973 to 14 by the end of 1974. Furthermore, when demand shifted away from small cars to intermediate-size cars in 1976 and 1977, the automobile companies converted two of their small-car plants to intermediate-size-car plants. Finally, after the oil shock of 1979, the firms once again converted some plants back to small-car plants.

Several special factors aided the rapid conversion. First, in early 1973 the automobile companies already had plans to introduce some new small car models in 1975, in order to respond to a rise in the import share. Thus, some of the plant conversions were achieved by introducing the new models early, while other conversions represented increasing the output of models already in existence. Second, the oil-price shocks were believed to be permanent, so the firms did not delay their actions as they might have done had they believed the shocks to be temporary.

IV. Conclusions

The oil shocks led to significant changes in automobile demand over a ten-year period. For domestic producers, the rapidly changing composition of desired sales led to substantially lowered capacity utilization. This empirical finding demonstrates the practical importance of short-run rigidities in physical and engineering capital in the overall "sectoral shifts" story. It seems unlikely that the currently important sectoral shifts, such as defense conversion and rapidly moving exchange rates, are free of these effects.

Automobile firms reacted very quickly to the shocks by shifting capacity among size classes, so that capacity misallocation was a much less severe problem in the intermediate run. Other capital assets, such as vehicle designs, took longer to adjust to the new composition of demand, resulting in inferior-quality cars in the intermediate run. For example, many of the new compact cars were considered to be of inferior quality. In general, these kinds of microeconomic effects, the sunkness of capital and the shortage of engineering knowledge, are the determinants of the speed of the macroeconomic response to sectoral shocks.

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