The geography of value added

Marketing, R&D, even accounting and legal departments, add value to a manufacturer's product, but that value is attributed solely to the production site, a practice that distorts our understanding of regional manufacturing activity
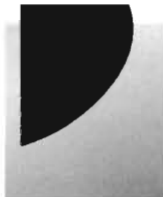
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and William A. Testa

Amoco Corporation, a diversified manufacturer of chemical and petroleum products, refines crude petroleum into gasoline and other products at such locations as Texas City, Texas, and Whiting, Indiana.[1] However, many of the support services which contribute to the value of these refined products are performed at Amoco's corporate headquarters in Chicago, Illinois, and at its research center in Naperville, Illinois.

The sprawling geography of these activities presents a considerable problem in tracking the location of manufacturing across U.S. states and regions. In the case of Amoco, how much manufacturing activity should be attributed to its Chicago area headquarters and R&D center and how much to its refineries in Texas and Indiana?

The U.S. Census Bureau currently attributes all of a company's manufacturing output to the locations of the production plants, i.e., the refineries in the Amoco example. While there may be no one correct method of apportioning output to states and regions, the Census method is clearly inadequate. Consequently, much of what we think we know concerning the changing geography of manufacturing across the U.S. may need to be re-examined.

In this article, the regional biases inherent in the Census measure of manufacturing output, which is called value added (VA), are explained and illustrated. Two potential methods of correcting the problem are evaluated. We conclude by discussing the importance of

correctly measured value added in understanding regional economic behavior.
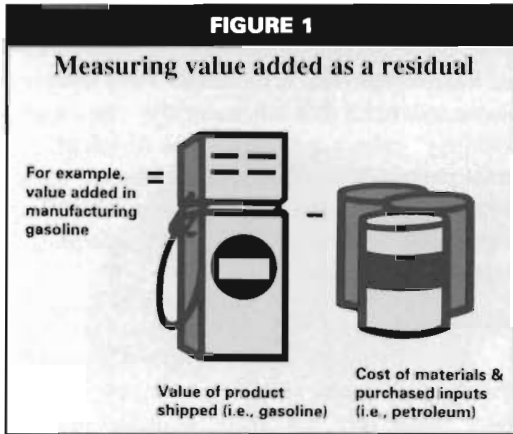
Taking stock of manufacturing

It may come as a surprise to some, but we do not measure manufacturing output by the final sales value of goods such as automobiles, tractors, or refined petroleum. Rather, we count only the value that is added by manufacturing companies to raw materials, such as crude petroleum for gasoline, and intermediate components, such as steel and rubber for autos, in producing these final manufactured products. Companies engaged in the processes of assembling and transforming these intermediate products into finished goods are designated as manufacturers. Their contribution of labor and capital and entrepreneurship to the nation's GNP accordingly becomes the nation's "value added in manufacturing" or manufacturing output.

Formally, value added is the value of products shipped by manufacturers less the value of intermediate goods (which is embedded in the value of the final manufacturing product):

1) Value Added = Value of Shipments – Materials and Intermediate Goods.

Value added is, then, a residual, representing the incremental value contributed to the product by the manufacturing company (see Figure 1). Quite correctly, the value of raw

FIGURE 1

Measuring value added as a residual

For example, value added in manufacturing gasoline =

Value of product shipped (i.e., gasoline) − Cost of materials & purchased inputs (i.e., petroleum)

materials and intermediate products is attributed to the industrial sectors in which they originate, such as mining, construction, services, or agriculture.

The current Census method inappropriately apportions a large part of manufacturing value added to states and regions. This inappropriately apportioned part is the activity of "auxiliary" establishments of manufacturing firms, i.e., corporate headquarters, research and development labs, data processing centers, and warehouses (see Figure 2). The activities of auxiliary establishments *are*
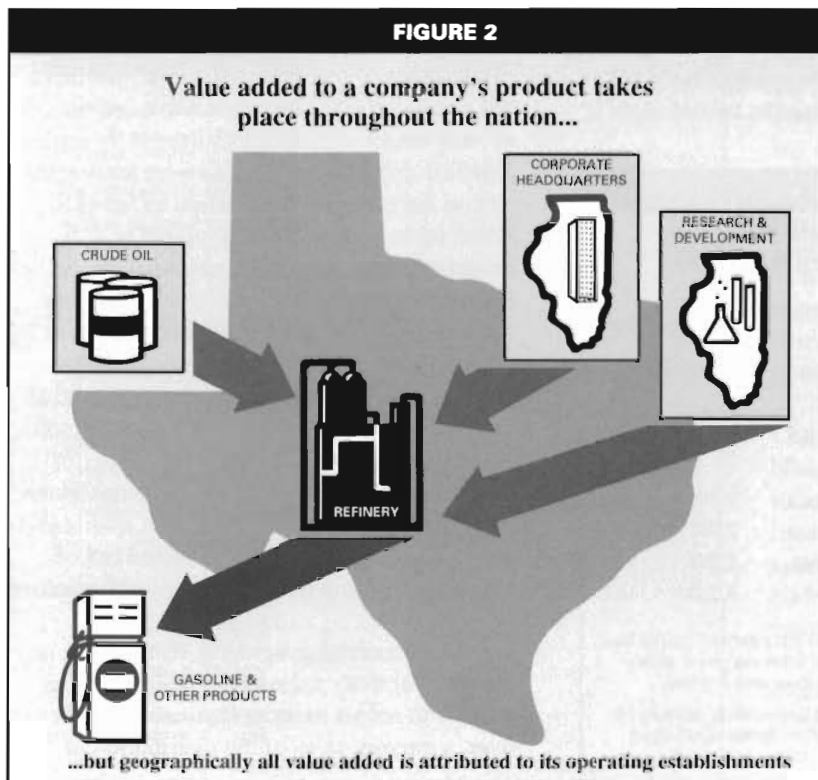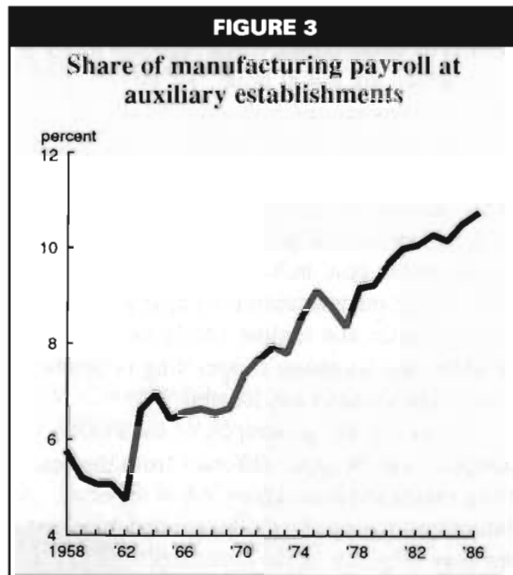
counted (quite correctly) in the national summation of value added.[2] The national totals of value added are not at issue. However, auxiliary activities are wrongly apportioned to states and regions on the basis of operating establishment site while neglecting the location of the auxiliary establishments. The problem is, therefore, one of geography and not of summation to national industry totals.[3] The total VA of each manufacturing company is allocated to states and regions solely on the basis of where the company's operating or production establishments are located.

However, the geography of the overall company can be quite different from the operating establishments where VA is reported. A manufacturing product's design and engineering may originate at the company's R&D center and not at the operating establishment location.[4] Similarly, the product's advertising and image may be fashioned at an out-of-state sales office or corporate headquarters of the manufacturing company. All these activities, which provide services to the operating establishments, *do* legitimately contribute to a product's value. We believe that this contribution to manufacturing output should be counted at the site of the auxiliary activity. In practice, no VA at all is reported and recorded by auxiliary establishments.

The auxiliary economy

It is apparent from the payrolls of auxiliary establishments that the share of VA originating at auxiliary establishments is significant. Auxiliary payroll amounted to almost 11 percent of the nation's total manufacturing payroll in 1986 (see Figure 3 and Table 1). In individual regions, auxiliary payroll ranged from negligible amounts in several states and

FIGURE 2

Value added to a company's product takes place throughout the nation...

CRUDE OIL

CORPORATE HEADQUARTERS

RESEARCH & DEVELOPMENT

REFINERY

GASOLINE & OTHER PRODUCTS

...but geographically all value added is attributed to its operating establishments

FIGURE 3

Share of manufacturing payroll at auxiliary establishments

Standard Metropolitan Statistical Areas (SMSAs) to as high as 49 percent for the State of Delaware and 54 percent in the Stamford, Connecticut, SMSA in 1982.

Among the various types of auxiliary activities, administrative and managerial activities were most prominent in 1982, followed by general office and clerical, and third by research, development, and testing (see Figure 4). For individual industries, the evidence on the significance of auxiliary activities is also striking (see Figure 5). Disaggregating total manufacturing into its 19 major components at

TABLE 1

Auxiliary establishments for manufacturing firms—1982

	Number	Share
Total manufacturing	9,676	100.0
Administrative and managerial	7,792	80.5
Office and clerical	6,157	63.6
Research, development, and testing	1,967	20.3
Warehousing	2,087	21.6
Electronic data processing	2,357	24.4
Other activities	4,353	44.9

NOTE: Detailed establishment data exceed totals and sum to more than 100 percent because some establishments participate in more than one activity.

SOURCE: U.S. Department of Commerce, Bureau of the Census, *1982 Census of Manufacturing Subject Series,* Vol. 1, p. 1-100.

the 2-digit SIC (Standard Industrial Classification) code level, the wide-ranging importance of auxiliary payroll is revealed. For example, some industries that fall under the "chemicals industry" banner report over one-fourth of total payroll at auxiliary establishments; some industries in "petroleum and coal products" report over one-third of payroll outside of operating establishments.
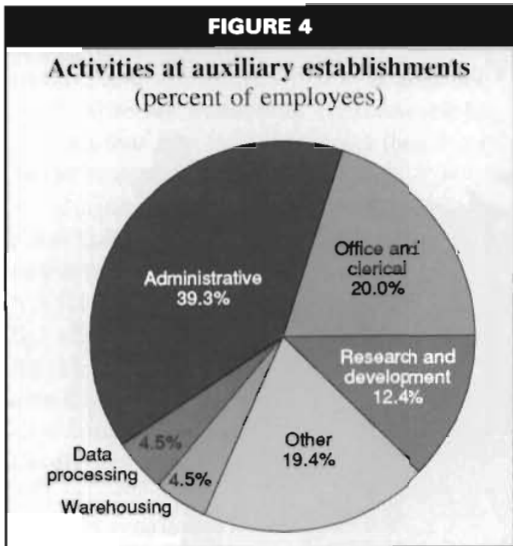
Auxiliaries and regions

In studying the corporate organization of the manufacturers, some regional analysts have recognized that diverse activities are undertaken within companies and industries in producing a single product. Moreover, these activities are often located at sites away from each other—even across state borders and regional divisions.

Industry studies by economic geographers have documented the spatial separation of activities within single corporate entities. For example, the R&D functions of pharmaceutical companies in Great Britain have been studied. One study reports that basic research—that of a generally applicable nature—is frequently undertaken at large centralized R&D facilities of large pharmaceutical companies. At the same time, specific and applied R&D is overwhelmingly conducted at the production plant site (Howells 1984).

Studies of manufacturing establishments have also reflected the cumulative importance of such establishment specialization to regions. Jusenius and Ledebur (1976) were among the first to document specialization in the U.S. South by branch production plants of U.S. manufacturing companies. More recently, Malecki (1985) has examined regional specialization in corporate headquarters versus branch plants across U.S. regions for four high-tech industries: computers, semiconductors, medical instruments, and computer software. But despite this wide recognition of regional specialization in diverse manufacturing activities, data covering VA in manufacturing has continued to be allocated to U.S. regions according to the location of production activity alone.

The observed geographic distribution of auxiliary activity varies quite widely across states and across metropolitan areas.[5] Moreover, a cursory view of the distribution of

FIGURE 4

Activities at auxiliary establishments
(percent of employees)

- Office and clerical 20.0%
- Administrative 39.3%
- Research and development 12.4%
- Other 19.4%
- Data processing 4.5%
- Warehousing 4.5%

FIGURE 5

Auxiliary payroll share by industry

percent

- Petroleum and coal products
- Chemicals and allied products
- Tobacco products
- Instruments and related products
- Electric and electronic equipment
- Food and kindred products
- Leather and leather products
- Total manufacturing
- Stone, clay, and glass products
- Machinery, except electrical
- Misc. mfg. industries
- Textile mill products
- Transportation equipment
- Rubber and misc. plastic products
- Apparel and other textile products
- Paper and allied products
- Printing and publishing
- Lumber and wood products
- Primary metal industries
- Fabricated metal products

SOURCE: U.S. Department of Commerce, Bureau of the Census.

auxiliary payroll suggests a systematic bias across the U.S. (see Figure 6). States in the New England and Middle Atlantic regions are home to very large numbers of auxiliary establishments. Similarly, individual Northern states including Illinois, New Jersey, Michigan, Ohio, and Pennsylvania display manufacturing sectors which are highly intensive in auxiliaries. Meanwhile, states in the South and especially those of the East South Central Region have a dearth of auxiliary locations, tending instead to specialize in operating establishments. Accordingly, we would expect that, in measuring manufacturing output, *the North and Midwest actually have greater levels than currently reported while manufacturing activity in the South is overstated.*
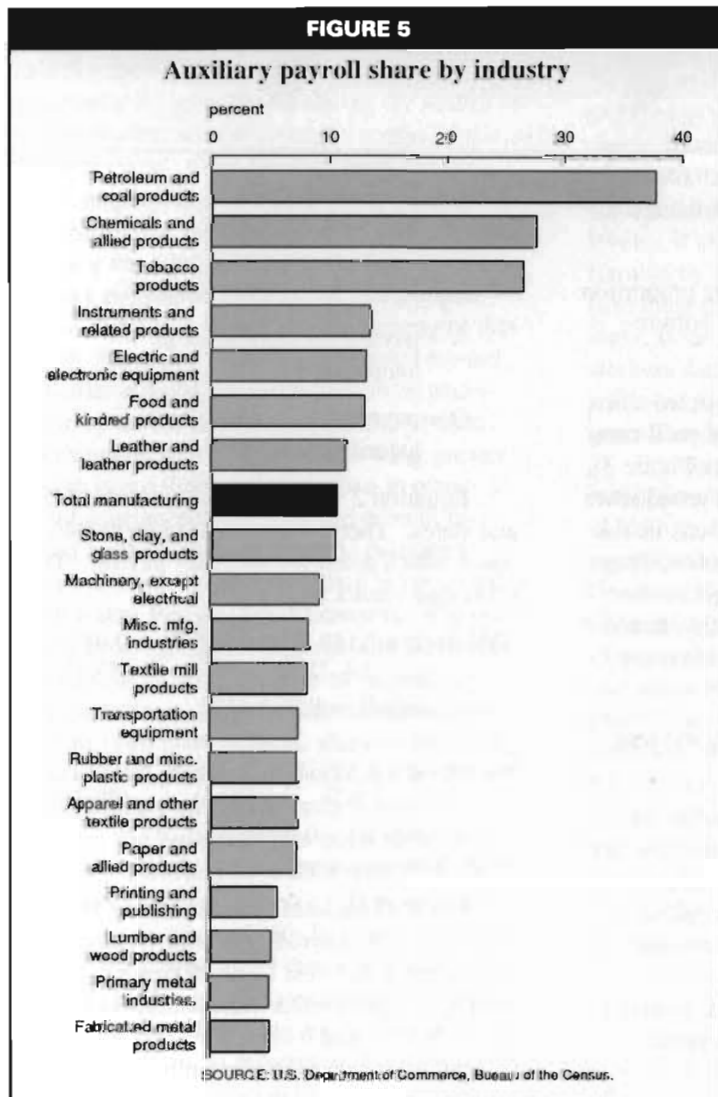
A formal test

It is reasonable to expect that the Census VA is underestimated in states which specialize in auxiliary establishments and overestimated in states with high concentrations of operating establishments. However, the problem may be insignificant if the proportion or split of activity between auxiliaries and operating units is largely the same in each state and SMSA. If such is the case, the difference between the Census and true VA will be insignificant; i.e., operating establishment activity serves as a good allocator of total manufacturing output of companies to SMSAs and states.

To test whether the Census method has a strong bias in overlooking the site locations of auxiliary establishments, a formal hypothesis can be constructed. The current Census method of estimating VA as the residual between value of shipments and materials at operating establishments is equivalent to assuming that either:

FIGURE 6

Ratio of auxiliary payroll

Legend:
- Less than 3%
- 3 - 5%
- 5 - 10%
- Greater than 10%
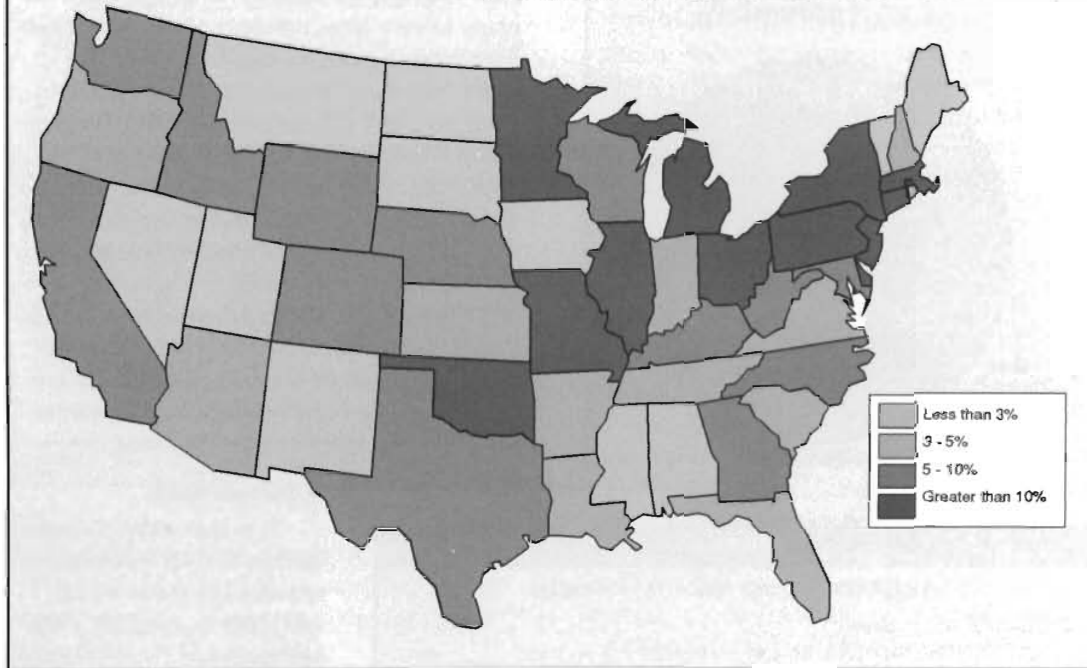
1. the auxiliaries make no contribution to VA; or

2. the auxiliaries locate in close proportion to operating establishments with respect to their effect on VA.

The first assumption can be rejected since we have seen that the auxiliaries' payroll comprises a sizable part of total VA (see Figure 3).

The second assumption can be tested if we assume that region-to-region variations in VA of both types of units, operating and auxiliary establishments, can be approximated by the variations in their respective payrolls. Based on assumption 2, we then can formulate the following null hypothesis:

H_o: the Census-determined VA and true VA are the same.

If true, this hypothesis implies that the elasticities of VA with respect to auxiliary unit and operating unit payrolls are the same. A dollar of either auxiliary payroll or operating payroll will contribute equally to a region's manufacturing VA.

The null hypothesis can then be formally tested using the following ordinary least squares (OLS) regression equation:

2) $V = c + b_a A + b_o O$

where:

V = VA in logarithmic form.

A = payroll for auxiliaries in logarithmic form.

O = payroll for operating units in logarithmic form.

Equation 2 was estimated for both SMSAs and states. There were 172 SMSAs and 46 states which disclosed auxiliary payroll. The estimated results are:

SMSAs: $c = 1.149$ $b_a = 0.031$ $b_o = 0.941$
(12..3) (2.4) (49.3)
adj. $R^2 = 0.97$ n=172

States: $c = 1.197$ $b_a = 0.006$ $b_o = 0.961$
(9.5) (0.3) (39.3)
adj. $R^2 = 0.99$ n=46

NOTE: Numbers in parentheses are t-statistics.

For SMSAs, coefficients for auxiliary and operating units payrolls are both significant and strongly different (b_a is 30 times smaller than b_o). This means that estimated elasticities of VA (b_a and b_o) with respect to payroll in auxiliaries and operating units are very different. This leads to the rejection of the H_o hy-

pothesis.[6] For states the rejection of the H_o hypothesis is even more obvious, since b_o is positive and significant while b_a is insignificantly different from zero. Therefore the hypothesis that b_o is infinitely larger than b_a cannot be rejected.

To test the H_o hypothesis, we had to assume that the payrolls of operating and auxiliary establishments parallel their respective VA for each state and metro area. However, if this assumption is relaxed, it is still evident that the H_o would be rejected. It is inconceivable that differences in the payroll/value-added ratio could offset the large differences between the elasticities of auxiliary unit and operating unit payrolls that were uncovered in the regression estimation.

Secular and cyclical bias

There are reasons to believe that manufacturing value added, as currently measured, distorts our view of both long-term regional manufacturing growth and also of the nature of manufacturing activity over the course of the business cycle. Over the long term, the payroll of employees at auxiliaries has been growing steadily for the past 25 years, now accounting for almost 11 percent of the total industry payroll in comparison to 6 percent around 1960 (see Figure 3). To the extent that growth in auxiliary activity is skewed toward particular regions, long-run growth in manufacturing across regions will be biased there. For example, in a region experiencing greater growth in auxiliary activities than in other manufacturing activities, output growth reported by the Census is likely to be biased downwards over time. As a case in point, the Great Lakes Region, i.e., Minnesota, Wisconsin, Illinois, Michigan, Indiana, and Ohio, has maintained its national share of payroll at manufacturing auxiliary establishments from 1963 to 1986 even while its share of national share of total payroll and output declined.

Distortion of output changes over the course of the business cycle can also be demonstrated. Analysts have long puzzled over the severity of the business cycle in manufacturing regions (Borts 1960; Bolton 1978). In general, they have found that, due to the sensitivity of durable goods sales during business downturns, manufacturing regions undergo wide fluctuations in economic activity over the course of the business cycle.

In measuring the volatility of *any region* with the Census VA, cyclical volatility will be overstated. VA is based on fluctuations in activity at operating establishments over time. But operating or production activities will likely be more cyclical than the manufacturing sector overall, thereby overstating cyclical swings. This further implies that a greater intensity of auxiliary activities in a region will magnify the cyclical bias.

One hypothesized reason for heightened volatility of operating establishments in comparison to auxiliary establishments concerns the differing firm behavior affecting semi-skilled versus highly-skilled workers over the course of the business cycle. With downturns in sales, production workers are more likely to be laid off in comparison to more highly skilled or white collar workers at auxiliary facilities (Williamson, et. al. 1975). If employees at auxiliary establishments acquire "firm-specific" skills to a greater extent than production workers at operating establishments, it will be advantageous for the firm to retain auxiliary workers even when their presence is not required by current production levels. If skills are firm-specific and not transferrable by the employee to other firms, the firm must partly pay for training. Accordingly, firms will be reluctant to lay off these workers during downturns for fear that they will need to train new workers once economic conditions begin to improve.

For the problem at hand, this means that manufacturing activity appears to be more volatile than it actually is because manufacturing shipments gyrate with the business cycle. However, the presence of auxiliary workers (who tend to be retained during downturns) suggests that actual manufacturing activity (including R&D, strategic planning, etc.) continues even while production activities are curtailed. From a geographical perspective, this cyclical reporting bias would tend to be greater at locations of higher auxiliary concentrations where a higher percentage of auxiliary activity fails to be recorded.

Evidence to the effect that auxiliary activity undergoes milder cyclical swings than overall manufacturing activities can be seen by regressing the share of the nation's employment at auxiliary establishments on the business cycle and other variables:

3) $AUX = c + b_t T + b_g G + b_y Y$

where :

$AUX =$ current year share of auxiliary employment in total manufacturing employment.

$T =$ annual time trend 1958 to 1986.

$G =$ year-over-year percentage growth in U.S. gross domestic product in constant dollars (1982=100).

$Y =$ a binary variable; one for census year, zero otherwise.

$RHO =$ autoregressive parameter.[7]

Results of the maximum likelihood estimation procedure are:

$c = 2.48$ $b_t = 0.0013$ $b_g = -0.42$ $b_y = -0.0006$
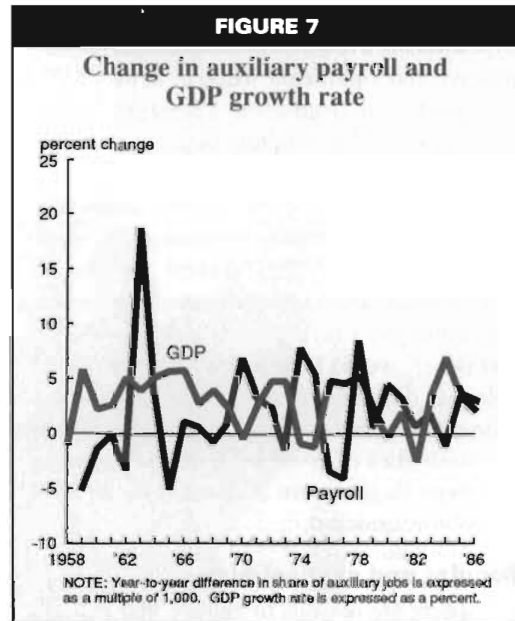$\quad(-17.7)\qquad\ (18.1)\qquad\ (-2.3)\qquad\ (-0.06)$

$RHO = 0.34$
$\qquad(1.72)$

$n = 29$ adj. $R^2 = 0.97$ D-W $= 1.83$.

We included the binary variable Y for two reasons. During census years, questionnaires are addressed to each establishment while, during non-census years, *Annual Survey of Manufactures* (ASM) questionnaires are addressed to company headquarters. Second, during census years the entire population is observed, while in an ASM year observations are sampled. For these reasons one could argue that these two types of observations would have different results.

The regression does not confirm this argument. The regression does confirm that there is a significant positive linear relationship between the share of auxiliary employment and time which means that the demand for auxiliary services increases in the long run for total manufacturing.

In addition, a significant negative sign for the variable G, a proxy for the business cycle (i.e.,the short run effect), lends support to the hypothesis that *business downturns tend to raise* the share of manufacturing employment at auxiliaries (see also Figure 7). Apparently, the employees of operating establishments are more likely to be laid off than the employees of the auxiliaries.

Thus, in both the long run and the short run, the Census VA may exert a strong re-

FIGURE 7

Change in auxiliary payroll and GDP growth rate

NOTE: Year-to-year difference in share of auxiliary jobs is expressed as a multiple of 1,000. GDP growth rate is expressed as a percent.

gional bias relative to the true but unknown manufacturing output.

Correcting the problem

Since the strong statistical difference between the Census and true VA is evident and important, the next question is whether the true VA can be estimated with greater accuracy. Two approaches can be identified. We argue that one of them, already being used, is deficient while the other holds great promise.

The Bureau of Economic Analysis, U.S. Dept. of Commerce, attempts to rectify the misapportionment of VA by manipulating aggregate regional data with national ratios (BEA 1985). However, their methodology to do so can only be correct under some highly stringent assumptions.

As their first step, BEA multiplies each state's VA (for a given industry) by a national factor which nets out the VA contribution made by auxiliary establishments. This adjustment can only be correct if the proportion of total VA contributed by auxiliaries is identical for each state.

In a second stage of estimation, the BEA method re-allocates the nation's VA of auxiliaries to states, adding it back into the estimated VA of operating establishments. For each industry, the method assumes that each state or region has the same relation between auxiliary VA and auxiliary payroll as the nation. Then the re-allocation of VA to states and regions is

performed according to the reported payrolls of auxiliaries of each industry in the state.

The key assumption of this second stage, that VA can be spatially allocated in proportion to payroll for broad industry categories, is not necessarily erroneous. But it is an assumption that remains untested. Only an analysis using the micro data can validate or reject the second BEA assumption.

The deficiencies of using aggregate data strongly suggest the use of Census data at the establishment level to re-compile VA for states and regions. One obvious but unworkable method would be to sum the factor payments at each establishment—both operating and auxiliary establishments alike. (VA is equivalent to the sum of factor payments including wages, rental, capital costs, and profits.) Unfortunately, this approach must be discarded because several individual data items on factor payments are not gathered by the Census.

However, using existing data from the Census, the analysis can be conducted at the company level. The Census collects payroll and other data on each establishment. The Enterprise Statistics Division subsequently combines these data to portray company structure. Each company can be viewed as a unit of observation composed of both operating and auxiliary facilities. The true VA for the overall company (and each product) is known from existing data (using the residual method). The remaining problem is to apportion each company's VA according to the contribution of each of its establishments.

For the companies with an intricate and integrated structure, the flow of services from auxiliary to operating units may be difficult to determine. This problem is compounded because many operating establishments are defined by a single industry code, yet produce products outside that industry as well. Therefore, an auxiliary service provided to an operating unit will have to be subdivided into as many components as there are products produced by the operating unit. No data series of such detail exists to determine service correspondence between operating and auxiliary units. However, by combining companies into an industry sample set, one can estimate the relationship between auxiliary and operating units in creating VA using econometric techniques. Finally, stepping back once again and viewing each establishment separately, data

can be recombined to arrive at better estimates of VA for SMSAs and states according to the locations of their auxiliary and their operating establishments.

Implications for regional research

A correct accounting of manufacturing output will significantly affect the outcome of current regional research on the existing distribution of manufacturing in the U.S.; on the importance of manufacturing to regional economic bases; on the movement of manufacturing activity across regions over time; on regional productivity differences; and finally, on the determination of the linkages between auxiliary services and operating units located in different regions.

To illustrate, a heated debate focuses on whether the nation's manufacturing sector has been diminishing in recent years. The question has been raised, in particular, for the nation's manufacturing intensive regions—especially the Midwest (Hill and Negrey 1987; Schnorbus and Giese 1987). As evidenced by declining shares of employment and income, the Midwest has lost a significant share of the nation's manufacturing activity. However, revised VA may indicate that the losses have been overstated. If, as several studies have suggested, the older industrial belt has retained auxiliary activities even while production operations have decentralized (Jusenius and Ledebur 1976; Giese and Testa 1988), the method by which VA is currently reported would have failed to notice it.

Generally speaking, regions which have witnessed a relative decline (or rise) in the share of manufacturing *vis à vis* other industry sectors probably are understating (or overstating) the extent that manufacturing fortunes influence the regional economy.

The revised VA may also contribute to a better understanding of the growth process among regions. Some analysts believe that the spread of manufacturing from the Northeast–Midwest manufacturing belt to outlying U.S. regions has taken place within a "product cycle" process (Norton and Rees 1979).[8] Historically, the Northeast–Midwest served as the nation's innovative center, creating new technologically-advanced industries. Over time, in order to economize on costs, these industries have decentralized their routine production operations to the peripheral regions of the South

and West. Initially, growth in peripheral regions was composed of branch plant openings—usually production plants of companies headquartered in the Northeast and Midwest Regions. A recent acceleration in manufacturing growth in peripheral regions may reflect a reversal in regional roles; the Southwest and West finally having reached a critical mass of technology and infrastructure so as to spawn their own high-growth industries. The division between VA attributable to auxiliaries versus operating establishments for each region could be used to test for the changing specializations of regions over time.

A more precise measure of output may also change conclusions of papers devoted to measuring regional productivity (Hulten and Schwab 1984; Beeson 1987). While several different measures of productivity have been examined, they all focus on a region's manufacturing output in relation to inputs such as labor and capital. To the extent that the observed output trends are not reliable, conclusions regarding regional performance and competitiveness will not be reliable. Our data, for instance, suggests that productivity in a number of Northeast and Midwestern states is understated, i.e., the numerator, VA, is underestimated, in these studies.

One of the more intractable problems in modeling regional economies has been the observation of the economic linkages and trade flows between regions in services. The interregional flow of goods can be observed from *Census of Transportation* data while the flow of services cannot. The corporate linkages between operating establishments and auxiliaries of manufacturing companies would fill in part of this puzzle. Accordingly, interregional input–output models, which attempt to examine the economic linkages across regions, could be specified more fully. Estimated relationships can be expressed in the form of exports flowing from regions with auxiliary services to regions with operating units. This information can be incorporated into the multiregional input–output model, which would allow analysts to estimate the effect of the change in the output of the operating units for one region on the auxiliary employment for another region.

In a broader context, observing whether these operating–auxiliary linkages are increasing in distance over time would reflect on the question of whether, because of enhanced transportation and communication ability, the service sector can be thought of as an "export base" for regions. Over time, are regions with specialized service sectors serving customers that are farther and farther apart?

FOOTNOTES

[1]Amoco's activities are also large in energy exploration and development. These activities constitute value added in the mining, services, and other sectors.

[2]Another problem, which we will not address in this essay, concerns the fact that this Census Bureau definition of VA also includes the value of services purchased by the manufacturing company from either outside service companies or other manufacturers. Also, the Census does not subtract the materials costs of auxiliary establishments. Both of these practices lend an upward bias to the Census concept of VA.

[3]Others have taken up the possible biases in the national measures of manufacturing output (Mishel 1988). Mishel argues that manufacturing growth has been overstated at the national level by the BEA. This results from a failure to properly deflate the value of intermediate components in manufacturing over time. Foreign-source components are routinely deflated by a domestic price deflator—a procedure that Mishel believes has understated the foreign content of domestically manufactured goods and concurrently overstated the value of domestic manufacturing activity.

[4]With existing data collection procedures, distinguishing auxiliaries from similar activities that take place at operating establishments is somewhat capricious. Often, by the choice of the survey respondents, auxiliary activities that take place at the same site as the operating establishment can be combined and reported as one. In this paper, we single out auxiliary establishments because they are most likely to be located at different sites from operating establishments; the nature of the problem is most easily communicated by making the auxiliary versus non-auxiliary distinction. However, a skewed distribution of support activities versus operating establishments of multi-plant manufacturing companies across the U.S. would result in the same problem. Support services are often located at the same site as production activities.

[5]Here are the summary statistics for states and SMSAs in 1982:

Auxiliary payroll / total payroll

	Mean	Std. deviation	High	Low	n
States	0.083	0.080	0.498	0	46
SMSAs	0.099	0.088	0.534	0.005	172

[6]For formal testing of the equality between b_a and b_a coefficients, we proceed as follows. Equation 2 can be rewritten as:

$$V = c + b_a(A + O) + y_oO = c + b_aA + (b_a + y_o)O.$$

It is obvious that the equality between two coefficients cannot be rejected if y_o is insignificantly different from zero. [See Pindyck and Rubinfeld (1981)]. In both SMSAs and states y_o had t-statistics of 30 and 23 respectively, which strongly rejects the hypothesis of equality between two coefficients in both cases.

[7]OLS estimation resulted in a D-W statistic of 1.33, falling within the uncertain region. After first-order correction for serial correlation, the D-W statistic was 1.83.

[8]Some analysts have long maintained that regional economies can be understood by focusing on "export base", the key industries for which the region produces and trades with the rest of the nation or world. Typically, the export base has comprised manufacturing, mining, and agriculture although many service sectors are now also receiving such recognition. For seminal discussions see Andrews (1953), North (1955), and Tiebout (1956).

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