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Determining Manufacturing Output
for States and Regions

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I. The Census value added: what is wrong?

Much of what we think we know concerning the changing geography of manufacturing may need to be re-examined. The regional analyst's chief measure of manufacturing output, the Census' "value added", has a strong bias across the U.S. geographic landscape.

The existing method of measuring value added (VA) mis-apportions a large part of manufacturing output to states and regions. The part in question comprises the activity of the "auxiliary" establishments of manufacturing firms—i.e. corporate headquarters functions, research and development activity, data processing, and warehousing. To illustrate, we refer to two examples from the 1982 *Census of Manufacturers*. In Detroit, auxiliary's payroll share in total manufacturing payroll was 28 percent, while in Buffalo, N.Y., this figure was only 4 percent. Being a large center of interstate companies serving the auto industry, the Detroit area conducts R&D and performs headquarters' activities to facilitate operating or production plants throughout the nation. Therefore, VA created by auxiliaries in Detroit is "exported" to other states. However, the Census VA do not account for this exported VA created in Detroit. Conversely, the Census VA in Buffalo will include "imported" VA because operating units there are consuming services from auxiliaries located elsewhere. Manufacturing output is overcounted in Buffalo and undercounted in Detroit.

In the following discussion, the existing Census methodology and data base are explained. In addition, the significance of the auxiliary establishments are illustrated with published statistics and economic literature. In part III, based on a statistical model, the difference between the Census and true VA is found to be highly significant. Further, the role of auxiliaries fluctuates both short and long term, indicating that the bias embedded in

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Census VA will misguide analysts in a wide array of topics, part IV. Part V evaluates two potential methods of correcting the problem. To conclude, the importance of the correctly measured VA for various regional research endeavors is presented.

II. The Census “value added” defined

The Census Bureau does not directly gather and compile information on VA. Rather, the Bureau constructs VA based on the value of manufactured shipments—data which is reported directly by manufacturing operating plants. For purposes of measuring manufacturing output, the value of shipments alone is not useful because it often includes the value of purchased materials and intermediate manufactured goods. Accordingly, if one were to sum up the value of shipments across plants to arrive at total output, one would be double counting. For example, an intermediate good would be counted twice—once at its plant of origin and shipment and once again at the plant where it becomes a component of another manufactured good(shipment). For this reason, the cost of purchased materials and intermediate goods are subtracted from reported values of manufacturing shipments at each plant to arrive at “value added”. VA is, then, a residual, representing the incremental value “added” or contributed to the product by the manufacturing firm.¹ In its favor, summing up VA across plants does not amount to double counting because any intermediate manufactured goods are correctly counted at their plant of origin and henceforth netted out as intermediate goods at later stages of production in other manufacturing plants.

The nub of the measurement problem is that Census VA includes, not only the incremental value made to the product at the production plant, but also the contribution to value made by the *firm* overall. The problem is one of geography and not a problem of summation to national industry totals.² The VA of each firm is allocated to states and regions solely on the basis of where the company’s operating plants are located.³ But the geography of the firm (including its auxiliary establishments) can be quite different from that of operating plants at which the firm’s VA data is reported.

For example, a manufacturing product’s design and engineering may originate at the firm’s R&D center and not at the plant location. Similarly, the product’s advertising and image may be fashioned at an out-of-state sales office or corporate headquarters of the manufacturing firm. All these activities which are attendant to production activity *do* legitimately comprise a product’s value as actually recorded from plant level data. But no VA at all is reported and recorded by auxiliary establishments.

Table 1
Selected statistics of auxiliary establishments
for manufacturing firms—1982

	Establishments*		Employees	
	Number	Share	Number (000's)	Share
Total manufacturing	9,676	100.0	1,276.0	100.0
-Administrative and managerial	7,792	80.5	501.4	39.3
-Office and clerical	6,157	63.6	255.2	20.0
-Research, development & testing	1,967	20.3	158.3	12.4
-Warehousing	2,087	21.6	57.4	4.5
-Electronic data processing	2,357	24.4	56.8	4.5
-Other activities	4,353	44.9	247.0	19.4

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

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

Activities at auxiliary establishments support the manufacturing production activities of the firm. Among the various types of auxiliary activities, administrative and managerial activities were most prominent in 1982, followed by general office and clerical, and thirdly by research, development and testing (Table 1). All of these activities are reflected in the value of product shipments from production plants (i.e. "operating establishments") even though the location of auxiliary establishments is frequently (but not always) located elsewhere. The size of VA originating with auxiliary establishments can be significant. Auxiliary payroll amounted to almost 11 percent of total manufacturing firm payroll in 1986. In individual regions, auxiliary payroll stretched as high as 49 percent for the State of Delaware and 54 percent in the Stamford, Connecticut, SMSA in 1982. For individual industries, the evidence on the significance of auxiliary activities is also striking (Table 2). Disaggregating total manufacturing into its 19 major components, a wide ranging importance of auxiliary payroll is revealed. For example, some industries which fall under the "chemicals industry" banner report over one-fourth of total payroll at auxiliary establishments and some industries in "petroleum and coal products" report over one-third of payroll outside of operating establishments.

Here is one way to verify that the current Census procedure actually allocates VA as we believe it does, in proportion to operating establishments and not to auxiliary activity. Using auxiliary payroll and operating establishment payroll as proxies for their respective overall activity or VA, we

Table 2

**Auxiliary payroll as a percent of total industry payroll
by industry—1986**

Petroleum and coal products	37.9
Chemicals and allied products	27.6
Tobacco products	26.5
Instruments and related products	13.6
Electric and electronic equipment	13.3
Food and kindred products	13.0
Leather and leather products	11.5
Total manufacturing	10.7
Stone, clay, and glass prods.	10.5
Machinery, except electrical	9.4
Miscellaneous manufacturing industries	8.4
Textile mill products	8.2
Transportation equipment	7.6
Rubber and misc. plastic products	7.5
Apparel and other textile products	7.5
Paper and allied products	7.4
Printing and publishing	5.7
Lumber and wood products	5.4
Primary metal industries	5.2
Fabricated metal products	5.1

SOURCE: U.S. Dept. of Commerce, Bureau of the Census, *1986 Annual Survey of Manufactures*, M86(AS)-1, Table 1-6, 1988.

regress both types of payroll on reported VA for the 1982 cross section of states. Similarly, we do the same for the 1982 cross section of SMSAs. As expected we find that reported VA correlates very significantly with operating payroll while auxiliary activity (payroll) has no significant influence:

<u>OLS</u> <u>regression</u>	<u>constant</u>	<u>auxiliary</u> <u>payroll</u>	<u>operating</u> <u>payroll</u>	<u>adj. R²</u>	<u>n</u>
States:	241.8 (.68)	-.42 (-.94)	2.43 (38.10)	.99	47
SMSAs:	5.45 (.08)	.12 (.70)	2.37 (68.17)	.99	172

In studying the corporate organization of the manufacturing firm, some regional analysts have recognized that diverse activities are undertaken

within firms and industries in producing a single product. Moreover, these activities are often sited spatially apart from each other—even across state borders and regional divisions. Industry studies by economic geographers have documented spatial separation of activities within single corporate entities. For example, the R&D functions of pharmaceutical firms in Great Britain have been studied extensively. For this industry, studies report that basic research—that of a generally applicable nature—is frequently undertaken at large centralized R&D facilities of large pharmaceutical firms while, at the same time, specific and applied R&D is overwhelmingly conducted at the production plant site (Howells 1984). Meanwhile, studies of manufacturing establishments have reflected the cumulative importance of such establishment specialization to regions. Jusenius and Ledebur (1976) were among the first to document specialization by the U.S. South Region in branch plant production establishments of U.S. manufacturing firms (1976). More recently, Malecki (1986) has distinguished regional specialization in corporate headquarters versus branch plants across U.S. regions for four high tech manufacturing 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 distributed to U.S. regions according to the location of production activity alone.

III. Statistical evidence of census versus true value added

It is reasonable to expect that the Census VA is underestimated in places such as Detroit and overestimated in Buffalo relative to the “true” (but unknown) VA. However, the problem may be insignificant if certain conditions hold true. Specifically, if the proportion or split of activity between auxiliaries and operating units is largely the same in each SMSA, then the difference between the Census and true VA will be insignificant; i.e. operating plant activity serves as a good “allocator” of total firm activity to SMSAs and states. Accordingly, we will try to determine whether the example of Detroit and Buffalo is generally the case or whether a proportionate distribution of the Census and true VA can be expected.

In estimating VA as the residual between value of shipments and plant materials of operating units, the Census is assuming that:

1. the auxiliaries have no effect on the SMSA VA or
2. the auxiliaries have the same or proportionate effect as the operating unit.

Table 3
Employment and payroll in manufacturing auxiliaries
from 1958 to 1986

	Employees		Payroll	
	Number (000's)	Percent of total mfg.	Dollars (millions)	Percent of total mfg.
1986	1,283.2	7.0	48,292.9	10.7
1982	1,276.0	6.7	38,220.3	10.1
1977	1,074.2	5.5	21,981.2	8.3
1972	994.3	5.2	13,772.3	7.9
1967	830.9	4.3	8,727.9	6.6
1963	726.5	4.3	6,615.5	6.6
1958	602.1	3.8	4,473.7	5.7

SOURCE: U.S. Dept. of Commerce, Bureau of the Census, *Census of Manufacturers* (various issues).

The first assumption can be rejected since the auxiliaries payroll comprises a sizable part of total VA (Table 3).

The second assumption can be tested if we assume that the changes in VA of both types of units, operating plants and auxiliary establishments, can be approximated by changes in their respective payroll. Based on assumption (2), we formulate the following null hypothesis.

H_0 : the Census determined VA and true VA are the same.

The verity of this hypothesis implies that the elasticities of the VA with respect to auxiliaries and operating units payrolls are the same. A dollar of either auxiliary payroll or operating payroll will contribute equally to a region's manufacturing VA.

This statement can be formally tested as the following regression equation:

$$(1) V = c + b_a A + b_o O$$

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 (12.3)	b_a = 0.031 (2.4)	b_o = 0.941 (49.3)	adj. R^2 = 0.97
States:	c = 1.197 (9.5)	b_a = 0.006 (0.3)	b_o = 0.961 (39.3)	adj. R^2 = 0.99

For SMSAs, coefficients for auxiliary and operating units payrolls are both significant and strongly different (b_a is 30 times smaller than b_o). Therefore the H_o hypothesis is rejected. 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 (i.e. the hypothesis that b_o is infinitely larger than b_a cannot be rejected). Formal tests on the equality of the two coefficients lead to the same conclusion.⁴

To test the H_o hypothesis, we had to assume that the payrolls of operating plants 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 payroll/value added could offset the large differences between elasticities of auxiliary and operating unit payrolls which were uncovered in the regression estimation.

The observed geographic distribution of auxiliary activity varies quite widely across states and across metropolitan areas. Here are the summary statistics for state and SMSAs in 1982:

<u>States</u>	<u>Mean</u>	<u>Standard deviation</u>	<u>High</u>	<u>Low</u>	<u>n</u>
auxiliary payroll/ total payroll	.083	.080	.498	0	46
<u>SMSAs</u>					
auxiliary payroll/ total payroll	.099	.088	.534	.005	172

Moreover, a cursory view of the distribution of auxiliary payroll suggests a systematic bias across the U.S. landscape (Figure 1). States in the New England and Middle Atlantic regions are domicile to inordinately large

numbers of auxiliary establishments. Similarly, several Northern states including Delaware, 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, tending instead to specialize in operating establishments. Accordingly, we would expect that, in measuring manufacturing output data, *the North and Midwest actually have greater levels than currently reported while manufacturing activity in the South is overstated.*

IV. Secular and cyclical behavior of auxiliary activity: two sources of bias

The payroll of employees at auxiliaries has been growing steadily over the past 25 years, now accounting for almost 11 percent of the total industry payroll in comparison to 6 percent in 1958 (see Table 3). To the extent that auxiliary activity is skewed toward particular regions, then, long run growth in manufacturing across regions will be biased. For example, in a region experiencing rapid growth in auxiliary establishments, output growth will be biased downwards over time.

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 plants over time. But operating or production activities will likely be more cyclical than the manufacturing sector overall, thereby overstating cyclical swings. This also implies that a greater intensity of auxiliary activities in a region will magnify the cyclical bias.

One hypothesized reason for heightened volatility of operating plants in comparison to auxiliary establishments concerns widely-held beliefs about segmented labor markets between the skilled and the highly skilled worker. With downturns in sales, production workers are more likely to be laid off in comparison to more highly skilled 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 plants, 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 such workers during downturns for fear that they will need to retrain new workers once economic conditions improve.

Evidence to this effect can be seen by regressing business cycle measures on the percent of the nation's manufacturing payroll or employment at auxiliary establishments (Table 4). The business cycle effect emerges quite clearly once the secular time trend of auxiliary employment is taken into account. Using the change in real gross domestic product to measure the national business cycle, it is seen that business downturns tend to raise the share of manufacturing employment at auxiliaries. Apparently, employees at operating establishments are "last hired-first fired" in relation to employees of auxiliaries.

A binary variable was also included to test the hypothesis that reporting of auxiliary activities by establishments differs in *Census* years (1958, 1963, 1967...) from *Annual Survey of Manufactures* years (1959, 1960, 1961...). It is apparent that the self-identification of auxiliaries is consistent in this respect.

In both the long run and the short run, the Census VA has a strong regional bias relative to the true but unknown manufacturing output.

V. Correcting the problem: Two Approaches

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. Nothing short of overhauling the Census methodology itself will settle the ultimate questions concerning the actual geography of U.S. manufacturing in comparison to its currently reported value. Two approaches can be identified. We will argue that one of them, which is now in operation, is deficient while the third, which is now prospective, holds great promise.

The Bureau of Economic Analysis, U.S. Dept. of Commerce, attempts to rectify the mis-apportionment of VA by manipulating aggregate regional data with national ratios (1985). However, their methodology to do so can only be correct under some highly stringent assumptions—assumptions which existing evidence suggests are not valid.

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. But this adjustment can only be correct if the proportion

Table 4

**OLS regression equation: auxilliary
share of manufacturing payroll and employment 1958-86**

	<u>Payroll</u> (PCTAUXP)	<u>Employment</u> (PCTAUXJ)
Intercept	-4.03 (-22.19)	-2.51 (-24.46)
YEAR	.0021 (22.65)	.0013 (25.01)
CHGGDP	-.046 (-1.44)	-.042 (-2.31)
CENS YEAR	.001 (.77)	-.0002 (-.08)
Number of Observations	29	29
\bar{R}^2	.951	.960
Durbin-Watson	1.43	1.33

Glossary of Variables

PCTAUXP	- percent of total manufacturing payroll (all industries) occupied by auxiliary establishments
PCTAUXJ	- percent of total manufacturing employment (all industries) occupied by auxiliary establishments
YEAR	- a time trend; value equal to current year
CHGGDP	- percentage growth in U.S. gross domestic product in constant dollars (1982=100)
CENS YEAR	- a binary variable, one if census year, zero otherwise

of total VA contributed by auxiliaries is identical for each state. But this is the problem itself! As we have demonstrated earlier in this paper, regional specialization in auxiliary versus operating establishments can be quite sharp.

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 on the company level. The Census collects payroll and other data on each establishment which the Enterprise Statistics Division subsequently combines to portray a company structure. Each company can be viewed as a unit with observation comprised of both operating and auxiliary facilities. The true VA for the 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 will be difficult to determine. This problem is compounded because many operating plants are multi-product units—defined by a single industry code, yet producing 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 re-combined once again to estimate true VA for an SMSA or state.

VI. Conclusions: implications for regional research

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

To illustrate, a heated debate currently focuses on whether the nation's manufacturing sector has been diminishing over time while a parallel question has been raised 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 undoubtedly lost a significant share of the nation's manufacturing activity. However, revised data may indicate that the losses have been overstated. If the older industrial belt has retained auxiliary activities even while production operation has decentralized, the method by which VA is currently reported would have failed to notice it.

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

Revised data 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).⁵ 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 outsourced their routinized 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 firms headquartered in the Northeast and Midwest Regions. A recent acceleration in manufacturing growth in peripheral regions is seen as 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.

A more precise measure of output may also change conclusions of papers devoted to the regional productivity measurement (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 re-

lation to input such as labor and capital. To the extent that the observed output trends are not reliable, conclusions regarding regional performance and competitiveness will neither be reliable. Our data, for instance, suggests that *productivity in a number of Northeast and Midwestern states is understated* (the numerator, VA, is underestimated) in these studies.

One of the more intractable problems in modelling regional economies has been trying to observe 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 plants and auxiliaries of manufacturing firms 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 export from regions with auxiliary services to regions with operating units. This information can be incorporated into the multiregional input-output model, which will allow analysts to estimate the effect of the change of the output of operating units in one region on the auxiliary, say, employment in another region.

In a broader context, observing whether these operating-auxiliary linkages are widening 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.⁶ Over time, are regions with specialized service sectors serving customers which are farther apart in distance?

Footnotes

¹ Another problem which we will not address in this essay concerns the fact that this Census Bureau definition also includes the value of services purchased by the manufacturing firm outside the company from either service firms or other manufacturing firms. Also, the Census does not subtract out the materials costs of auxiliary establishments. Both of these practices lend an upward bias to the Census concept of VA.

² 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 which Mishel believes has understated the foreign content of domestically manufactured goods and concurrently overstated the value of domestic manufacturing activity.

³ With existing data collection procedures, the distinguishing of auxiliaries from similar activities which take place at production plants is somewhat capricious. Often, by the choice of the survey respondents, auxiliary activities which take place at the same site as the production plant can be combined and reported with the activities of production plant activity. In this paper, we single out auxiliary establishments because they are most likely to be located at disparate sites from production plants...the nature of the problem is most easily communicated by making the auxiliary vs. non-auxiliary distinction. In much of our other work, we will rather distinguish nonproduction activity from production activity regardless of whether the nonproduction activity is reported by auxiliary or by production establishment.

⁴ Equation 1. 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 can not be rejected if y_o is insignificantly different from zero. See Pindyck and Rubinfeld (1981). In both cases of SMSA and states y_o had t-statistics 30 and 23 respectively.

⁵ In this instance, the division between VA attributable to auxiliaries vs. operating plants for each region could be used to test for "role reversal" or changing specialization of regions over time.

⁶ 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 farming although many service sectors are now also receiving such recognition. For seminal discussions see North, (1955) and Tiebout (1956).

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