The Measurement of Productivity: A Primer with Examples for Small Businesses or Corporate Divisions

By

Thomas A. Barocci*, Mark Soeth, and Kirsten R. Wever

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The Measurement of Productivity: with Examples for Small Businesses or Corporate Divisions

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What the average American small businessperson thinks about that ominous but pervasive concept -- productivity -- is that it's something they have in Japan, something we don't have enough of in the US, and something we can't do much about. So small American businesses very rarely measure their productivity. Unfortunately, these are often the very firms that have no choice but to make productivity their central concern if they want to stay economically viable. The main reason why they don't is that to small businesses the measurement and improvement of productivity appear both confusing and cost-ineffective. True, if each firm had to start from scratch, to collect its own data, to devise its own formulas and indices, and to reach isolated conclusions about how to use these, measuring and improving productivity would be inefficient. But things aren't as complex as most small businesses would have it.

Many authors believe there are few (if any) measures that can be applied to small businesses or corporate divisions which do not require adjustment for the individual characteristics of each firm. The measures presented in the following analysis are intended as tools to help management and staff monitor and analyze productivity. Whether one succeeds in adapting generic measures

* Thomas A. Barocci is Associate Professor of Management, MIT, Sloan School of Management. Mark Soeth is a former graduate student, and Kirsten R. Wever is currently a Ph.D. candidate and research assistant for the Productivity/Quality Project. This report is in part based on Mark Soeth's unpublished thesis, entitled "Productivity Measurement in Residential Construction." The authors gratefully acknowledge the time and financial support of the corporate study participants. Without their time, advice and financial support, this research would not have been possible.
of this type (e.g., for use with incentive pay schemes) depends also on the involvement of the people who are going to be measured (and rewarded) in the process of setting the appropriate productivity/reward standards.¹

This paper prepares a guide to the development of small business productivity measurement systems that can be adapted to a wide range of industries and company types. Contrary to popular opinion, it is possible and often highly cost-effective to compare inputs to outputs over time, and thus to identify trends and pinpoint areas in which productivity can be raised.

The factors that must be considered are illustrated in Figure 1. This paper is composed as follows: first, we discuss basic measures and indices; second, we consider how to measure inputs; the third section considers output measures and the data sources that help define outputs; fourth, we briefly illustrate these measurement principles with reference to a fictional small business; finally, we conclude with a short summary and some suggestions about how a small business or corporate division can most effectively tackle the problem of productivity.²

BASIC MEASURES

There are both total measures and partial measures of productivity. Partial measures consider the productivity of a specific input; e.g., labor.


²For basic background information and more specific guides to the measurement of productivity, we refer the reader to the following: John Kendrick and David Creamer, Measuring Company Productivity, 1961; Leon Greenberg, A Practical Guide to Productivity Measurement, 1980; and The Handbook of Methods for Surveys and Studies, issued by the Bureau of Labor Statistics (BLS), and covering a variety of indices, data gathering methods, sampling methods and specifications.
Figure 1
Productivity Measurement Systems

Outputs
- New Products
  - Specification Changes
  - Multiple Types

Inputs
- Capital
  - Labor
  - Intermediates

Indices
- Types
  - Techniques

Data
- U.S. Government
  - Self-Collection
  - Private Sector
- Paasche
- Laspeyres
- Deflators
- Switching
- Splicing
Total measures take into account the effects of all inputs on aggregate output, including labor, capital, purchased goods and services (intermediates), and (more recently) energy.¹

Since it's impossible to compare all inputs directly, they have to be translated into dollar terms and adjusted to remove the effects of inflation. Each input factor is then measured on the basis of weighted prices. Productivity is measured over a specific time period, so income figures (sales) should be adjusted to reflect the differences between the inventory at the beginning and end of that period. The period being measured is then compared to some previous period, usually called the base period. The point is to figure out rates of return, and see how efficiently inputs are contributing to production. Of course, it is also necessary to take into account capital depreciation. If depreciation in base year terms is greater than book value, the difference should be subtracted from gross income. This is done by dividing output (inventory adjusted) by labor (wages and salaries) plus intermediates (purchased services, materials, supplies) plus capital (capital investment income, interest and depreciation). The base year figure can then be compared with the rates of return for other years.

This measurement of total productivity is nothing more than a ratio of real outputs to real inputs in terms of the base period rate of return. So the numbers show how efficiently inputs are converted into outputs. Of course this measurement can't take into account all the intangible inputs (e.g., managerial style, government services, technological changes or improved resource allocations) that can crucially affect efficiency. So once

¹Given \( Q = g(K, L, I, E) \), a total measure is \( \frac{Q}{K + L + I + E} \)

A labor partial would read \( Q/L \).
productivity is measured, it's important to look beyond the numbers to the environment for clues about the intangible sources of productivity fluctuations.

Partial measures are based on the same principles: divide base year output by labor input (salaries and wages), and compare over time. (It should be noted that this measure takes no account of variations in the efficiency of labor utilization.) Labor partials can also be obtained in a more direct manner by dividing weighted units by actual hours worked. (See Figure 2) It is important to keep in mind that the productivity increase shown in Figure 2 is probably not solely a result of work force improvements. Again, it is necessary to consider the effects of intangibles on productivity.

An index including output, employment, hours worked and output per hour also offers a labor partial that will reflect variations in the relationship between physical output and employee hours expended to create that output. A perceived change in labor productivity could reflect a series of factors; e.g., a recession, high interest rates, inflation, or, hypothetically, the fact that production workers were laid off while salaried employees were not, leading to an increase in administrative overhead and an inevitable decrease in 'labor productivity'. (See Appendix B for an explanation of how such indices are constructed.)

There are two general sorts of indices. If the base year is also the initial year of the index, the index is base-year-weighted (a Laspeyres index): divide price in a given period times quantity in the present period by present price times present quantity. If the current year is the base year, the index shifts each year to reflect changes in the rates of price movements and in productivity efficiencies (a Paasche index). In this case, divide price in a given period times quantity in that period by present price times
Figure 2 -- Partial Factor Productivity Example

<table>
<thead>
<tr>
<th>Units Produced</th>
<th>Allocated Man-Hours/Units</th>
<th>Weighted Units</th>
<th>Actual Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base Year</td>
<td>Year T</td>
<td>Both Years</td>
</tr>
<tr>
<td>Producer A</td>
<td>4</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Producer B</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Producer C</td>
<td>10</td>
<td>20</td>
<td>2</td>
</tr>
</tbody>
</table>

Labor Productivity in Year T is 1.33, a 33% increase over the base year.
quantity in that first given period.\(^1\) (When inputs and outputs change frequently, Paasche indices are more useful in reflecting the dynamic environment.) To obtain a quantity-weighted (rather than price-weighted) Laspeyres index, divide a value index by a price-weighted Paasche index. (For an explanation of how to do this, refer to Appendix C.)

When indices are maintained over a long time period, the numbers often grow so large that they lose intuitive meaning. But the base year can be shifted to compensate for this problem. The concept can be extended by splicing to take into account technological innovations that make specifications obsolete. Splicing involves calculation of the ratio of new to old index numbers for overlapping years, and multiplication of the conversion factor by new index numbers, so that both indices are expressed in terms of the original one.

When prices move cyclically or seasonally, underlying trends can be identified by taking measurements at identical points in each cycle. If prices do not vary with the number of days per month, and thus are not subject to large or sudden shifts, a seasonal adjustment factor can be multiplied by measured prices to reflect underlying price movements. (See Appendix D for an illustration of this procedure.)

The cost of constructing these productivity indices can appear prohibitive. But price indices are available to the public, and can be adapted relatively easily to an individual firm. In deciding whether to use a general index the businessperson must, of course, consider the costs.

\(^1\)Laspeyres: \(p_i q_i\); Paasche: \(\frac{p_i q_i}{p_0 q_0}\), where 'p' is the price of goods and services represented by quantity 'q', in the present period 'o', or in some other period 'i'.
of labor, equipment, and information gathering, as well as the opportunity
costs of constructing such an index from scratch.

THE MEASUREMENT OF INPUTS

Labor is traditionally measured in hourly terms, either in hours worked
or in hours paid. The input of salaried employees can be estimated by
calculating the ratio of indirect (salaried) to direct (hourly) workers, and
multiplying by direct labor hourly input. Differences in the quality of
various labor inputs should also be taken into account. Factors like age,
education or experience can be measured directly; others, like motivation or
intelligence, cannot.

Capital is defined as all non-human assets, both tangible and
intangible, used in production. Tangible capital consists of fixed structures
and equipment, inventories and land. Intangible (financial) capital includes
working capital (cash and accounts receivable) and portfolio investments
(funds not required by current production). The latter are not considered in
productivity measurements because they do not contribute directly to
production.

But valuing fixed assets is problematic: economic depreciation measures
economic efficiency, while accounting depreciation is distorted in response to
tax laws. Gross accounting values for depreciable capital stocks also
implicitly assume that capital will function at 100% efficiency over its
service life. This condition is, of course, rarely met, although depreciation
schedules can compensate for this ideal assumption.

The perpetual inventory method is more accurate than any accounting
method. It measures an asset beginning with its purchase price, and makes
annual deductions for declines in economic efficiency. In any given year the
sum of previously acquired asset values and current year purchases equals
current capital, which is deflated to reflect the base year. Another alternative is the book value method, which ceases to count undepreciated value as a capital component once economic efficiency reaches zero.

If service lives are indeterminate, rendering these methods hard to use, it can be helpful to adopt a fictitious leasing method. In this case, you treat fixed assets as being available through lease from other firms. The payment of the lease reflects the assets' value in use. The lessor's rate of return should also reflect business risks and the possibility of technological obsolescence.

The quality of intermediaries can usually be measured by market prices, which can be used directly as a component of total input. Supplier efficiencies can be traced by using a partial measure, including only intermediates in the denominator. While it might seem as though such a partial measurement is uninteresting, since intermediate prices cannot be controlled, the information they yield can indicate areas in which the purchase of intermediate goods and services could be eliminated or cut down to contribute to overall productivity.

Finally, indirect business taxes should also be included in productivity measurement, since they contribute directly to production by allowing for government-provided services.

OUTPUT MEASURES AND DATA SOURCES

Output measurements should consider output flows, rather than stocks. And the outputs under consideration should clearly relate to the operative inputs.

Where changing specifications or new products are involved, measuring output can be particularly difficult because of the dynamic component these
circumstances introduce. But by using a new index, the time at which the new product or specification was introduced can be considered the base year. It is then possible to compare new products with old ones by using the ratio of the man-hours per unit required to produce the new product to the time needed to produce some older product that was manufactured during the base year. This ratio can then be applied to the current year new product unit hours, yielding a corresponding base year new product figure.¹

Hedonic regressions can be the most appropriate measurement technique when each product is unique. Here, you disaggregate a product into its various most crucial attributes (e.g., for a car: horsepower, mileage, size, etc.). Prices can change to reflect the particular combination of characteristics for a given product, with variations in quality across products.

How do you go about collecting all the data necessary to a productivity measurement system? Data-collection may often appear prohibitively time-consuming. But this problem can be off-set at least partially by using deflators constructed for some input (even if it's not actually used in production), and accepting some degree of error. Alternately, you can use publicly available price indices. Neither approach is perfect, but both can be helpful when it's impractical to create individually tailored indices. It can also be helpful to use prepared indices as deflators. But not just any index will do. The choice must reflect the environment in which the

¹Note: This method assumes that productivity changes for the new product equal those for the comparison product, if the new product has been introduced during the base year. This may not always be the case.
data were gathered and the index's specifications.

Information that is generally available can also be used to provide productivity benchmarks, to indicate major productivity problems. Direct comparisons between individual firms can be found in annual reports and the Securities and Exchange Commission's 10-K Forms. But using such data can be quite misleading unless you consider the substantial differences in the accounting processes they reflect.

A PRACTICAL EXAMPLE

This example is designed to illustrate some of the procedures explained in the body of our paper. The firm we considered will be referred to as SoCal Construction, Inc.; 1979 revenues approached $27 million. Productivity trends over time were of particular interest to this company. SoCal uses Laspeyres indices. Rebasings occur every five years, since the technology is relatively stable and changes in input prices are evolutionary.

Output measurements are illustrated in Figure 3, labor inputs in Figure 4. The most important inputs in this industry are purchased goods and services -- intermediaries -- shown in Figure 5. Capital stocks are minimal, since this firm subcontracts so much of its work. Capital input calculations appear in Figure 6. Based on these factors, the firm calculated productivity in the manner shown in Figure 7. The determination of base period equivalents is of particular importance.

\[1\] The Commerce Department price index biases productivity measures downward because it is a base-period-weighted cost index that will not reflect productivity in the quantity being measured; this biases the price index upward, resulting in an overvaluation of inputs. The problem also occurs with Laspeyres indices.
Interpreting productivity measurements is often more difficult than calculating them. It is crucial at the outset to understand the specific components of each number derived. Equally important is an understanding of the environmental factors affecting them. These considerations are particularly important in the evaluation of partial measures, which often fail to reflect efficiency changes in the quantities being measured.

Analysis of the measurements in Figure 7 indicate that total productivity has fallen, but that the problem is not a serious one. When revenues increased at 10% annually, efficiency increased by 3%. During the 1977-78 period of rapid growth, productivity dropped by 7% in one year, held constant, and rose again in 1979. These results are hardly surprising, since growth rates over 50% are inevitably accompanied by declines in efficiency. Similarly, what looks like a fall in labor productivity is simply a reflection of an unwise decision in 1976 to add workers in anticipation of a boom that never came. And capital productivity rose substantially with increasing growth rates, though the figures are artificially high, since lags in capital acquisition, in conjunction with the fact that there was no need for proportional increases, meant that the relative share of capital as an input decreased sharply.

An example of exogenously affected productivity changes is found in the intermediates category for 1979. Health regulations required a new kind of insulation; replacement material and additional labor costs decreased productivity. Environmental effects (e.g., changes among subcontractors and technological innovations), design alterations, changing accounting practices -- all these factors have an impact on productivity. So it's vital to consider each situation on its own unique merits, to understand the manifold influences of the environment, and to clarify the components of each measurement before jumping to conclusions about what it says about productivity.
FIGURE 3
Output Measurement Calculations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales-Homes</td>
<td>$6,435,000</td>
<td>$7,963,200</td>
<td>$12,826,128</td>
<td>$19,367,567</td>
<td>$27,201,813</td>
</tr>
<tr>
<td>+Finished Inventory</td>
<td>675,000</td>
<td>604,800</td>
<td>654,192</td>
<td>690,939</td>
<td>1,285,125</td>
</tr>
<tr>
<td>-Units sold not</td>
<td>135,000</td>
<td>675,000</td>
<td>604,800</td>
<td>654,192</td>
<td>690,939</td>
</tr>
<tr>
<td>built current year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Value</td>
<td>7,983,000</td>
<td>12,875,520</td>
<td>19,404,314</td>
<td>27,795,999</td>
<td></td>
</tr>
<tr>
<td>Base Equivalent</td>
<td>6,975,000</td>
<td>6,945,840</td>
<td>10,557,926</td>
<td>14,364,155</td>
<td>21,541,190</td>
</tr>
<tr>
<td>Work in Process</td>
<td></td>
<td>198,240</td>
<td>923,194</td>
<td>1,070,937</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>168,167</td>
<td>609,965</td>
<td>901,836</td>
<td></td>
</tr>
<tr>
<td>Sales Apartments</td>
<td>1,295,078</td>
<td>1,875,000</td>
<td>4,813,689</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Equivalent</td>
<td>1,156,320</td>
<td>1,537,500</td>
<td>3,342,840</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Base Period</td>
<td>6,975,000</td>
<td>8,102,160</td>
<td>12,263,893</td>
<td>18,316,960</td>
<td>22,443,026</td>
</tr>
<tr>
<td>Equivalent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### FIGURE 4

**Input Calculations - Labor**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Managers Base Equivalent</td>
<td>3,760</td>
<td>$21,600</td>
<td>5,640</td>
<td>$38,102</td>
<td>9,200</td>
<td>$71,123</td>
<td>14,400</td>
<td>$152,000</td>
<td>18,400</td>
<td>$215,000</td>
</tr>
<tr>
<td>Administrative</td>
<td>1,850</td>
<td>8,000</td>
<td>1,880</td>
<td>8,690</td>
<td>3,680</td>
<td>19,987</td>
<td>3,600</td>
<td>23,984</td>
<td>3,710</td>
<td>31,215</td>
</tr>
<tr>
<td>Interior Designer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16,856</td>
</tr>
<tr>
<td>Owner</td>
<td>1,764</td>
<td>21,625</td>
<td>1,764</td>
<td>31,000</td>
<td>1,840</td>
<td>46,750</td>
<td>1,825</td>
<td>53,810</td>
<td>1,790</td>
<td>62,500</td>
</tr>
<tr>
<td>Total Base Period Equivalents</td>
<td>51,225</td>
<td>68,581</td>
<td>104,774</td>
<td>152,667</td>
<td>174,914</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
FIGURE 5

Input Calculation- Intermediates

<table>
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<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundations Base Equivalent</td>
<td>$ 71,518</td>
<td>$ 90,241</td>
<td>$ 141,857</td>
<td>$ 203,505</td>
<td>$ 227,205</td>
</tr>
<tr>
<td>$ 101,071</td>
<td>$ 180,159</td>
<td>$ 290,402</td>
<td>3,109,340</td>
<td>5,011,996</td>
<td>6,252,055</td>
</tr>
<tr>
<td>Glazier/Framing/Insulation</td>
<td>$ 1,136,382</td>
<td>$ 1,430,039</td>
<td>$ 2,428,339</td>
<td>$ 3,297,366</td>
<td>$ 4,156,320</td>
</tr>
<tr>
<td>(Includes Floors and Roof)</td>
<td>1,606,762</td>
<td>3,109,340</td>
<td>5,011,996</td>
<td>6,252,055</td>
<td></td>
</tr>
<tr>
<td>Plumbing</td>
<td>241,276</td>
<td>338,274</td>
<td>684,553</td>
<td>1,102,442</td>
<td>1,375,895</td>
</tr>
<tr>
<td>304,438</td>
<td>543,295</td>
<td>714,520</td>
<td>733,925</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>129,497</td>
<td>180,309</td>
<td>364,886</td>
<td>588,167</td>
<td>740,198</td>
</tr>
<tr>
<td>163,399</td>
<td>289,591</td>
<td>377,440</td>
<td>476,319</td>
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<td></td>
</tr>
<tr>
<td>Roofing</td>
<td>134,361</td>
<td>189,880</td>
<td>368,005</td>
<td>593,193</td>
<td>492,198</td>
</tr>
<tr>
<td>168,902</td>
<td>289,514</td>
<td>414,820</td>
<td>562,731</td>
<td></td>
<td></td>
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<tr>
<td>Floor Finishes</td>
<td>148,538</td>
<td>209,915</td>
<td>408,548</td>
<td>658,546</td>
<td>821,746</td>
</tr>
<tr>
<td>187,424</td>
<td>316,703</td>
<td>454,169</td>
<td>637,285</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiling and Wall Finishes</td>
<td>179,119</td>
<td>253,131</td>
<td>492,753</td>
<td>794,277</td>
<td>991,113</td>
</tr>
<tr>
<td>226,009</td>
<td>389,528</td>
<td>555,437</td>
<td>637,285</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior</td>
<td>267,883</td>
<td>378,574</td>
<td>734,233</td>
<td>1,185,133</td>
<td>1,477,829</td>
</tr>
<tr>
<td>Partition and Sheetrock</td>
<td>338,012</td>
<td>573,400</td>
<td>828,764</td>
<td>986,378</td>
<td></td>
</tr>
<tr>
<td>HVAC</td>
<td>270,790</td>
<td>378,574</td>
<td>734,233</td>
<td>1,185,133</td>
<td>1,477,829</td>
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<tr>
<td>242,016</td>
<td>424,389</td>
<td>633,900</td>
<td>658,826</td>
<td></td>
<td></td>
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<tr>
<td>Fixed Equipment</td>
<td>191,614</td>
<td>430,488</td>
<td>837,662</td>
<td>1,350,853</td>
<td>1,708,357</td>
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<tr>
<td>384,363</td>
<td>649,125</td>
<td>944,352</td>
<td>1,157,490</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>304,618</td>
<td>41,206</td>
<td>60,638</td>
<td>97,745</td>
<td>121,968</td>
</tr>
<tr>
<td>Civil Works Base Equivalent</td>
<td>977,023</td>
<td>1,306,762</td>
<td>2,651,984</td>
<td>4,262,451</td>
<td>5,319,720</td>
</tr>
<tr>
<td>1,232,794</td>
<td>2,413,827</td>
<td>2,959,972</td>
<td>3,455,760</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advertising</td>
<td>6,508</td>
<td>9,922</td>
<td>15,994</td>
<td>19,958</td>
<td></td>
</tr>
<tr>
<td>4,689</td>
<td>7,751</td>
<td>11,107</td>
<td>13,572</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>29,688</td>
<td>41,206</td>
<td>60,638</td>
<td>97,745</td>
<td>121,968</td>
</tr>
<tr>
<td>37,459</td>
<td>47,374</td>
<td>67,878</td>
<td>82,938</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

-16-
**FIGURE 5**

Input Calculation - Intermediates (Continued)

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Accounting</td>
<td>$3,209</td>
<td>$4,170</td>
<td>$5,202</td>
<td>$6,978</td>
<td>$7,858</td>
</tr>
<tr>
<td>Land</td>
<td>336,027</td>
<td>425,260</td>
<td>750,554</td>
<td>1,010,537</td>
<td>1,140,619</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>11,372</td>
<td>14,349</td>
<td>23,687</td>
<td>33,938</td>
<td>41,469</td>
</tr>
<tr>
<td>Direct Charge</td>
<td>3,168</td>
<td>3,998</td>
<td>5,684</td>
<td>8,144</td>
<td>9,952</td>
</tr>
<tr>
<td>Taxes</td>
<td>39,806</td>
<td>50,228</td>
<td>91,321</td>
<td>130,847</td>
<td>159,877</td>
</tr>
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</table>

Total Base Period Equivalent Intermediates:

$4,209,788 $5,312,727 $9,381,141 12,653,682 $15,107,706
FIGURE 6

Input Calculations - Capital

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>$157,044</td>
<td>$200,871</td>
<td>$392,244</td>
<td>$641,142</td>
<td>$796,617</td>
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<tr>
<td>Deflated Equivalent</td>
<td>182,610</td>
<td>306,441</td>
<td></td>
<td>442,167</td>
<td>501,017</td>
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<tr>
<td>Accounts Receivable</td>
<td>209,250</td>
<td>272,232</td>
<td>485,637</td>
<td>851,737</td>
<td>1,110,928</td>
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<tr>
<td></td>
<td>243,065</td>
<td>367,907</td>
<td></td>
<td>549,508</td>
<td>673,290</td>
</tr>
<tr>
<td>Inventory</td>
<td>675,000</td>
<td>604,800</td>
<td>654,192</td>
<td>690,939</td>
<td>1,285,125</td>
</tr>
<tr>
<td></td>
<td>540,000</td>
<td>495,600</td>
<td></td>
<td>445,767</td>
<td>778,863</td>
</tr>
<tr>
<td>Work in Process</td>
<td>198,240</td>
<td></td>
<td>923,194</td>
<td>1,070,937</td>
<td></td>
</tr>
<tr>
<td></td>
<td>156,094</td>
<td></td>
<td>650,136</td>
<td>649,052</td>
<td></td>
</tr>
<tr>
<td>Notes</td>
<td>675,000</td>
<td>665,280</td>
<td>906,240</td>
<td>2,636,700</td>
<td>3,269,358</td>
</tr>
<tr>
<td></td>
<td>604,800</td>
<td>708,000</td>
<td></td>
<td>1,818,414</td>
<td>2,056,200</td>
</tr>
<tr>
<td>Implicit Leases; Structures and Land</td>
<td>3,000</td>
<td>3,000</td>
<td>3,000</td>
<td>4,700</td>
<td>4,700</td>
</tr>
<tr>
<td>(Base Period Equivalents)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment Leases</td>
<td>12,680</td>
<td>8,000</td>
<td>21,960</td>
<td>28,200</td>
<td>24,020</td>
</tr>
<tr>
<td>Total- Base Period Equivalents</td>
<td>1,731,974</td>
<td>1,581,475</td>
<td>2,059,148</td>
<td>3,938,892</td>
<td>4,687,142</td>
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<tr>
<td>Investor's Capital Input</td>
<td>2,719,199</td>
<td>2,482,887</td>
<td>3,232,862</td>
<td>6,184,060</td>
<td>7,829,813</td>
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</tbody>
</table>

Calculation of Base Period Rate of Return = Net Income/Capital

\[
= \frac{\$2,713,987}{\$1,731,974}
\]

= 1.57

Sample Calculation Investor's Capital Input =

Capital period \( t \times \) Base Period Rate of Return

For 1977 = \( \$1,581,457 \times 1.57 = \$2,482,887 \)

NOTE: Equipment Leases include office equipment, furnishings, and vehicles.
## FIGURE 7

Productivity Calculations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Productivity</td>
<td>1.00</td>
<td>1.03</td>
<td>.96</td>
<td>.96</td>
<td>.97</td>
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<tr>
<td>Index Value</td>
<td>100</td>
<td>103</td>
<td>96</td>
<td>96</td>
<td>97</td>
</tr>
<tr>
<td>Value Added Productivity</td>
<td>1.97</td>
<td>1.09</td>
<td>.86</td>
<td>.88</td>
<td>.92</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>55</td>
<td>44</td>
<td>45</td>
<td>47</td>
</tr>
<tr>
<td>Capital</td>
<td>2.57</td>
<td>3.26</td>
<td>3.79</td>
<td>2.96</td>
<td>2.87</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>127</td>
<td>147</td>
<td>115</td>
<td>112</td>
</tr>
<tr>
<td>Labor</td>
<td>136.2</td>
<td>118.1</td>
<td>117.1</td>
<td>120.0</td>
<td>128.3</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>92</td>
<td>79</td>
<td>87</td>
<td>90</td>
</tr>
<tr>
<td>Intermediates</td>
<td>1.66</td>
<td>1.53</td>
<td>1.31</td>
<td>1.45</td>
<td>1.49</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>92</td>
<td>79</td>
<td>87</td>
<td>90</td>
</tr>
<tr>
<td>Selected Intermediates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civil Works</td>
<td>7.14</td>
<td>6.57</td>
<td>5.10</td>
<td>6.19</td>
<td>6.49</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>92</td>
<td>71</td>
<td>87</td>
<td>91</td>
</tr>
<tr>
<td>Glaze/Frame/Insulate</td>
<td>6.13</td>
<td>5.64</td>
<td>5.05</td>
<td>5.56</td>
<td>5.40</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>92</td>
<td>82</td>
<td>91</td>
<td>88</td>
</tr>
<tr>
<td>Plumbing</td>
<td>28.91</td>
<td>26.61</td>
<td>22.57</td>
<td>16.60</td>
<td>25.15</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>92</td>
<td>78</td>
<td>57</td>
<td>87</td>
</tr>
<tr>
<td>HVAC</td>
<td>36.40</td>
<td>33.48</td>
<td>28.83</td>
<td>28.85</td>
<td>20.98</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>92</td>
<td>78</td>
<td>79</td>
<td>58</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct Charge</td>
<td>613.4</td>
<td>564.7</td>
<td>517.7</td>
<td>539.7</td>
<td>541.2</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>92</td>
<td>84</td>
<td>88</td>
<td>86</td>
</tr>
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CONCLUSIONS

This paper has illustrated that there isn't anything mysterious about the measurement of productivity at the level of the firm. A manager applying the following steps can construct an effective measurement system:

1) Determine the objectives, the quantities to be measured, and the reasons for measuring them;

2) Thoroughly consider the costs and benefits of adapting vs. creating appropriate indices;

3) Don't lose sight of intangibles that affect or are affected by productivity and the measurement process
   - in the creation of measurements
   - in the measurement process
   - in the interpretation of index numbers;

4) Were there are incentive schemes or other programs to raise productivity, allow management style to include and involve the people affected
   - in the program's formulation
   - in its maintenance
   - in its evaluation.

Used in conjunction with more traditional financial reporting systems, productivity measurements can provide the small business with the knowledge required to reverse the disquieting trend of decreasing productivity. The measurement of productivity should be undertaken only after a thorough cost-benefit analysis has been conducted. This analysis should clarify trade-offs between different measures, between different types of data, and
between the adaptation versus creation of productivity indices. The decisions that follow will have to reflect the manager's individual experience and discreet judgment. This element of subjectivity carries through to the final stages of measurement and, of course, pervades the interpretation of results. A clear understanding of how a particular measurement system works is the most basic ingredient for its flexibility and usefulness.
### APPENDIX A

#### A Labor Partial

<table>
<thead>
<tr>
<th>Year</th>
<th>Output (Millions)</th>
<th>Employment (Thousands)</th>
<th>Hours Worked All Persons (Millions)</th>
<th>Output Per Hour (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>$26,441</td>
<td>1,147</td>
<td>2,332</td>
<td>98.8</td>
</tr>
<tr>
<td>1967</td>
<td>26,385</td>
<td>1,095</td>
<td>2,222</td>
<td>100.0</td>
</tr>
<tr>
<td>1968</td>
<td>31,464</td>
<td>1,194</td>
<td>2,396</td>
<td>105.4</td>
</tr>
<tr>
<td>1970</td>
<td>34,204</td>
<td>1,264</td>
<td>2,569</td>
<td>98.4</td>
</tr>
<tr>
<td>1970</td>
<td>33,058</td>
<td>1,221</td>
<td>2,437</td>
<td>97.0</td>
</tr>
<tr>
<td>1971</td>
<td>44,418</td>
<td>1,477</td>
<td>2,943</td>
<td>102.5</td>
</tr>
<tr>
<td>1972</td>
<td>55,206</td>
<td>1,692</td>
<td>3,337</td>
<td>106.0</td>
</tr>
<tr>
<td>1973</td>
<td>58,613</td>
<td>1,678</td>
<td>3,317</td>
<td>101.6</td>
</tr>
<tr>
<td>1974</td>
<td>48,086</td>
<td>1,406</td>
<td>2,767</td>
<td>90.4</td>
</tr>
<tr>
<td>1975</td>
<td>44,070</td>
<td>1,197</td>
<td>2,338</td>
<td>90.5</td>
</tr>
<tr>
<td>1976</td>
<td>57,844</td>
<td>1,220</td>
<td>2,407</td>
<td>104.8</td>
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</table>

Output is in constant 1967 terms.
APPENDIX B

Index Construction - Base Case

A. Given Indices

<table>
<thead>
<tr>
<th>Value</th>
<th>Base Year Value</th>
<th>Year T Value</th>
<th>Year T+1 Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Output (Q)</td>
<td>100</td>
<td>105</td>
<td>110</td>
</tr>
<tr>
<td>2) Labor (L)</td>
<td>100</td>
<td>130</td>
<td>160</td>
</tr>
<tr>
<td>3) Capital (C)</td>
<td>100</td>
<td>135</td>
<td>138</td>
</tr>
<tr>
<td>4) Intermediates (I)</td>
<td>100</td>
<td>130</td>
<td>145</td>
</tr>
</tbody>
</table>

B. Deflation to base year dollar values

<table>
<thead>
<tr>
<th>Value</th>
<th>Base Year Value</th>
<th>Year T Deflated Value</th>
<th>Year T Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>$5,000,000</td>
<td>$7,320,000</td>
<td>$6,971,428</td>
</tr>
<tr>
<td>L</td>
<td>800,000</td>
<td>960,000</td>
<td>738,461</td>
</tr>
<tr>
<td>K</td>
<td>480,000</td>
<td>520,000</td>
<td>355,555</td>
</tr>
<tr>
<td>I</td>
<td>3,720,000</td>
<td>4,120,000</td>
<td>3,169,230</td>
</tr>
</tbody>
</table>

C. Index Construction

\[
\text{TFP} = \left(\frac{Q}{(K+L+I)}\right) \times (\text{Index #}) \times (100)
\]

<table>
<thead>
<tr>
<th>Year</th>
<th>Base Year T</th>
<th>Year T</th>
<th>Year T+1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.74</td>
<td>174</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.63</td>
<td>163</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Deflated Year T Value = Year T Value / (Index Number) (.01)
APPENDIX C

Quantity-Weighted Index

\[ \frac{p_1 q_1}{p_0 q_0} \]

Therefore:

Value Index: Output Index = (Laspeyres) Output Index (Paasche)

divided by is equal to

\[ \frac{p_1 q_0}{p_0 q_0} \quad \frac{p_1 q_0}{p_0 q_0} \quad \frac{p_1 q_1}{p_1 q_0} \]
APPENDIX D

Cyclical or Seasonal Adjustment

1. A four quarter centered moving average is calculated for the formula:

\[ \overline{M}_t = \frac{1}{8} (X_{t-2} + 2X_{t-1} + 2X_t + 2X_{t+1} + X_{t+2}) \]

2. Specific seasonals are then obtained:

\[ SI = \frac{X_t}{\overline{M}_t} \]

3. Average seasonals result from:

\[ S_q = \frac{\sum_{i=1}^{N} SI}{N}, \text{ where } N \text{ is # of years.} \]

4. Primarily because of rounding error, these numbers do not add to four (the number of seasons), so a further adjustment is made:

Let \( z = \frac{4}{\sum \overline{S}/q} \), then \( \widehat{S_q} = zS_q \)

5. Seasonally adjusted figures are then developed:

\[ \widehat{x}_{i} = \frac{x_i}{\widehat{S}_q} \]