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1998

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J.G. Wacker
Iowa State University

Danny J. Johnson
Iowa State University, danjohns@iastate.edu

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Abstract

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Disciplines

International Business | Operations and Supply Chain Management | Other Business

Comments

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MEASURING INTERNATIONAL PRODUCTIVITY: A COMPARISON OF SIXTEEN COUNTRIES

John G. Wacker and Danny J. Johnson, Department of Management, College of Business, Iowa State University
Ames, IA 50011, Phone (515) 294-8116

ABSTRACT

During the last several decades productivity improvement measures have received increased recognition as important performance measures. This study analyzes and empirically estimates traditional productivity measures. Using data from sixteen countries, the results of this study indicate that the Hayes and Clark total factor productivity measure [2] is weakly associated with labor and investment in equipment, but more strongly associated with material productivity.

INTRODUCTION

The international importance of productivity stems from competitive cost advantage in marketplaces that enables countries to have higher standards of living. Although the source of competitive advantage is individual firms, most international productivity studies use aggregate data that fails to capture the variances from individual firms. A second difficulty with these studies is that they must make the data compatible between countries. This study analyzes individual firms' productivity and makes cross-country comparisons. In order to make cross-country comparisons, there are theoretical and empirical measurement considerations that need to be addressed. The theoretical differences stem from both macro-economic as well as manufacturing management literature.

The manufacturing management theoretical differences stem from the productivity studies conducted analyzing differences in how organizations manage their resources. Therefore, these studies are strategic in nature. An early study by [2] illustrated how organizations analyzed 12 factories for 3 companies over time using a total factor productivity measure [value-added/(total factor cost)]. Their findings gave clear indications of the importance of capital investment, waste reduction, and improved learning. In short, their results suggest that investment in both human and equipment resources tends to improve productivity. Schmenner's [10] study suggests that plant investment and newer equipment tend to increase plant productivity. However, his study did not directly statistically test for the relative productivity of individual factors of production. A third study by [5] directly tested the productivity of plants with human resource factors of a) well-defined tasks, b) employees' manufacturing improvement suggestions, and c) increasing factory employees' interaction with equipment/tooling engineers.

All of these studies suggest that factory employees, administrative employees, and equipment have different productivities. To determine these productivities, it is necessary to determine which measures to use for productivity measure and to correct for individual country financial differences.

The primary purpose of this study is to analyze between country differences in factor productivity. The secondary purpose of this study is to determine if different measures of productivity give the same results. So the two research questions are: 1) What are the differences in between country plants? and 2) Does it make any difference in the productivity measure used to make the comparisons?

LITERATURE REVIEW

There has been considerable interest in productivity dating from Adam Smith's pin factory in the *Wealth of Nations* in 1776. Not surprisingly, there are numerous productivity measures offered as "true" measures of productivity. Naturally, each measure is usually classified into two categories: "partial" productivity measures and "total" productivity measures. Most companies utilize partial productivity measures in order to analyze specific target areas within the organization. Of these partial productivity measures, the most common has been labor productivity. Multi-factor measures, such as total factor productivity, include capital and other non-labor inputs, which make it a closer measure of the overall efficiency of production [2]. However, the use of these larger, more encompassing measures has been met with some resistance due to their complexity. Instead, most comparisons use individual factors, such as number of workers or simply the amount of investment [1].

Exchange Rate Corrections

In many cases, the nominal exchange rate is used for conversions and is subject to biasedness caused by protection policy differentials as well as financial capital flows among countries. These flows cannot be easily adjusted to represent commodity exchange rate changes since these adjustments require elasticity estimates of changes in currency volumes with respect to prices. Several other methods have been suggested to adjust for differences in quantities. One method, the direct approach, divides the total revenues by the physical volumes to determine the price of each unit. Therefore, every unit produced in the country has the same price (it is called the "law of one price"). This method suffers unreliability since the

"law of one price" can most appropriately be applied in industries where the output is homogenous such as steel, petroleum, and bricks, but does not apply to industries where the output is heterogeneous. Hence, it is not considered a good method for about 75% to 80% of manufacturing industries [13].

A second method uses the accounting data and deflates volume by the specific price index for a specific industry. Yet, these measures do not directly reflect the change in the absolute prices, but appear to reflect basic levels of price differences among countries. (For example, differences in the price of a loaf of bread between the U.S. and Japan.) Consequently, there does not appear to be a satisfactory method to make between country comparisons of levels of productivity [13].

Still many researchers believe that the best alternative is the use of Purchasing Power Parities (PPP) or the closely related Unit Value Ratios (UVR) [1] [14]. These ratios are computed for an assortment of identical products between each country and the United States. For some industries, there are individual PPPs, but in most cases, the overall PPP should be used due to the heterogeneity of manufacturing. The PPPs are generally more stable over time when compared to exchange rates, since they do not reflect the radical fluctuations caused by financial and political activity [14].

However, PPPs have some drawbacks. The large number of product comparisons necessary to derive each country's PPP makes it difficult to get an accurate measurement for specific products that may not have a comparative product in all countries. Additionally, regulations and product information may not be fully disclosed. Even when corresponding products can be found, the level of quality or product variety may make direct price comparisons questionable. Consequently, the inability to match products among countries presents a difficult problem for the derivation of the PPP.

Measures of Productivity

Because of these difficulties with PPPs and UVRs, some authors suggest that rates of productivity change should be used for comparisons [10]. There are several important difficulties. Usually, the most important difficulty is the base used for determining productivity. For example, Bulgaria may have a higher productivity change than the U.S. Yet, this does not imply that Bulgaria has or will have an economic advantage over the U.S., since the U.S. has a higher base. Additionally, although Bulgaria may have a higher productivity percentage increase, in absolute terms, the U.S. may have higher increase in productivity (5% of 1,000 is greater than 10% of 100). Another important consideration is the time-phasing of investment present in all measures of productivity.

Investment in equipment usually does not improve productivity in the same period as the investment. Thus, measuring the percentage change in productivity does not seem to have any inherent advantage for making international productivity comparisons.

In order to accurately compare the productivity levels of international manufacturing firms, it will be necessary to use a currency conversion tool other than the basic exchange rate. The common exchange rate is inadequate because it is too easily influenced by between-country capital flows. It is also subject to a great deal of subjective speculation. Consequently, it doesn't indicate the real price difference among countries.

This study uses six traditional measures of productivity: *total factor, total labor, factory worker, non-factory worker, investment,* and *material*. The theoretical intent of each measure carries important interpretations, since each measure is numerically different.

From a theoretical perspective, it seems that *total factor productivity* is the most important since it measures the overall productivity of the firm. Total factor productivity measures the total amount of productivity of all factors. For comparability, the output measure (value-added) is divided by the sum of all inputs. Since the labor resource (labor hours) and investment, as well as material inputs (currency measures), are not numerically compatible, labor input is converted to wages for computational purposes. *Labor productivity* measures are the most common. These measures evaluate how much output (value-added) is contributed by each labor hour and are estimated by output (value-added) divided by labor hours. *Investment* and *material productivity* measures indicate the ratio of outputs to inputs. Since both outputs and inputs are in monetary units, these productivity measures end up unit free.

The Sample

The data used in this study are collected by the Global Manufacturing Research Group (GMRG). The questionnaires were translated and back-translated for each of the countries. The United States' data were gathered by the Manchester Manufacturing Management Center and in western United States by GMRG members. The survey was pre-tested using personal interviews with respondents at Cranfield University.

Sixteen countries' data are used for analysis. These countries (sample sizes) are: Bulgaria (32), England (18), Germany (18), Hungary (76), Ireland (20), Japan (91), Mexico (42), New Zealand (18), Northern Ireland (16), People's Republic of China (17), Poland (30), Russia (94), Spain (42), Sweden (20), United States (165), and Wales (69) for an overall sample size of 768 factories. The breadth of the countries studied provides cross- sectional validity and, therefore, increases the generality of the findings. In short, the empirical results are representative of manufacturing effectiveness in the world economy.

METHODOLOGY

International price and volume comparisons are gathered by OECD countries in developed countries and the European Comparison Program (ECP) for transition economies. Using this data, the OECD develops, among other statistics, a set of PPPs for a number of different countries. The most recent comparison released by the OECD covers 24 OECD countries and 15 transition countries of Central and Eastern Europe and the former Soviet Union.

Productivity measures were tabulated for all 16 countries using the common exchange rates. However, because of the limited PPP data available, only 11 countries could be analyzed using PPP conversions. For the first set of comparisons, monetary conversions are made by dividing annual sales, both domestic and exports, by the exchange rate. The other quantity converted directly was investment level, which was found in the same manner. The second set of comparisons involved dividing the original quantities (sales and investment) by the PPPs for each country. After these raw comparisons, correlations among the different measures are estimated to determine the relationships among different measures. These estimates answer the critical question of which productivity measure to use for between country comparisons at the plant level.

RESULTS

Table 1 presents the results of a raw comparison of the relative productivity between the 16 countries. Before discussing these comparisons, it is important to state that total factor, investment, and material productivities are exactly the same using either the exchange rate or the PPP conversion method since the numerator of value-added and the denominator are in monetary units. Thus, when both are divided by the exchange rates or purchase price parity, they reveal the same numerical answer for the measures. Therefore, total factor, investment, and material productivity measures are not included in the table under the PPP conversion method.

As the table shows, if the exchange rate is used, the total labor productivity in the U.S. and Japan are very similar. However, using the PPP, the U.S. total labor, administrative labor, and factory labor productivities are nearly twice that of Japan. Also quite noteworthy is that U.S. labor productivities increased when using the PPP versus exchange rate method compared to all other advanced economies. However, the total factor productivity measure seems to have serious limitations since the same results are obtained using either the PPP or the exchange rate conversion method. For investment productivity, the raw exchange rate productivities indicate that Spain has the most investment productivity. Although there are some differences among countries on their material productivity, it appears to be fairly similar among countries.

Noteworthy, are the PPP productivity measures for developing or economies in transition. The developing countries of Mexico and Spain, as well as the transition economies of Poland and Russia, all had higher investment productivity rates than the U.S. These results could be interpreted to mean that these economies are investment poor and any investment tends to reap large productivity improvements. A much more sanguine picture is painted for Bulgaria where investment does not seem to be very productive. (All resources are not very productive in Bulgaria). Also on the low end of investment productivity are the countries that may be investing in their future. One could speculate that these countries (Japan, China, and Northern Ireland) are investing in their future.

As previously mentioned, the PPP adjusts the outputs to make the countries comparable on the outputs. These outputs are adjusted to be comparable to the U.S. On all PPP productivity measures, the U.S. is the most productive country in the world. All three labor productivity measures reveal that U.S. workers are roughly twice as productive as workers in any other country (including Japan). The low labor productivity in Spain is also rather surprising. One can only hypothesize that the low productivity of labor is offset by its extremely high productivity of investment. The resolution of this issue is certainly a topic for future research.

Table 2 presents some interesting results from the correlations among the different productivity measures within each country. The general conclusion drawn from this analysis is that factory labor, investment, and materials productivities are tied to total factor productivity. As to the different labor resources, there is little difference among the labor productivity measures since they are all highly correlated within each country.

Table 3 compares the different measures across all countries. First, little overall correlation exists between the total factor productivity variable and any labor productivity variables regardless of whether the exchange rate or the PPP is used. Of the labor productivity measures, only factory workers are weakly related to total factor productivity. Second, investment is weakly related to total factor productivity. Finally, materials productivity has the highest correlation with total factor productivity. Overall, these results suggest that total factor productivity is weakly related to factory labor and investment, but is more strongly related to material productivity. This result seems to be quite consistent with what might be expected *a priori* since the manufacturing function is expected to have higher value of outputs when factory labor, investment, and materials productivities are higher.

Tables and references available upon request.