American and European manufacturing practices: An analytical framework and comparisons

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Abstract

This paper presents a general analytical framework for making bilateral comparisons of manufacturing practices. The approach suggests a grouping of the data, defines a conservative test called a pure regional effect, and matches the data types to the appropriate statistical tests. The methodology is used to compare manufacturing practices in North America with those in Western Europe using data compiled by the Global Manufacturing Research Group. The broad hypothesis tested is that the two regions are more similar than different. For the two industries studied (small machine tools and non-fashion textiles), this hypothesis holds. Fewer than 10% of the 119 variables investigated have a significant pure regional effect. This suggests that the lack of success of joint ventures between North American and European firms must be attributed to factors other than differences in manufacturing practices. These variables for which significant effects were found reflect differences in external orientation, asset utilization and the management of details. Despite the overall similarities, differences in these factors could be important for American Managers contemplating partnerships with European companies.

1. Introduction

Documenting and comparing manufacturing practices in various parts of the world has become an important concern. A key driver for this has been the globalization of manufacturing (McGrath and Hoole, 1992). Increasing numbers of manufacturing companies are sourcing, locating plants and establishing joint ventures in other countries, often within very different cultures or economic systems (Anderson, 1990). These differences may be reflected in manufacturing practices that differ sufficiently to frustrate attempts at collaboration between firms. Executives, therefore, have an interest in understanding the manufacturing practices in countries of potential partnerships.

In an effort to provide insights into manufacturing practices in different parts of the world, the Global Manufacturing Research Group (GMRG) administered a survey in several countries. Data were gathered on practices in several areas of management; ranging from forecasting and planning, to shop floor control. Firms in the small machine tool (batch manufacturing oriented) and non-fashion textile (closer to continuous processing) industries were surveyed. In addition to having different manufacturing process, these two industries are found virtually everywhere. The
data base contains responses from Australia, Austria, Belgium, Bulgaria, Canada, Chile, China, Finland, France, Germany, Holland, Hungary, Ireland, Japan, Mexico, South Korea, Sweden, Switzerland, United Kingdom, USA and the USSR. A complete description of the GMRG project, including the data, is found in (Whybark and Vastag, 1993b).

Several analyses of the data have been performed using a variety of techniques to address a number of different questions (Whybark and Vastag, 1992, 1993a). The variety of approaches to analyzing the GMRG data prompted the development of the general analytical framework presented here. The framework is then applied in comparing manufacturing practices in Western Europe with those of North America.

The GMRG studies that have compared manufacturing practices in different parts of the world have generally involved regions expected to be quite different. For instance, South Korean manufacturing practices have been compared to those of China and Western Europe (Rho and Whybark, 1988, 1990). This comparison of Western European and North American practices tests the broad hypothesis that the practices will be quite similar in these two highly developed, industrialized and culturally related regions. Besides, Ferdows and De Meyer (1988) have pointed out that European manufacturing practices have been relatively understudied.

The procedures used to gather data in the two regions is presented next. This is followed by a description of the analytical framework; including the data grouping, the concept of a pure regional effect, and the tests performed to determine statistical significance. Finally, the results of the analysis are presented, followed by a discussion of the findings.

2. Data gathering in Western Europe and North America

The GMRG survey on manufacturing practices was first administered in the People's Republic of China and South Korea. In both these cases, the first attempt at data gathering was a mail survey. The results were dismal! The response rates were less than five percent for any industry-country combination. Despite these results a mail survey was tried in Western Europe recognizing that there was greater experience with survey research among the European practitioners.

To start, the survey was translated into French, German and Italian. Discussions with industry representatives and other researchers indicated that most of the executives in the Benelux and Scandinavian countries (i.e., Belgium, Holland, Denmark, Sweden, Norway) would be able to respond in one of these three languages or English. (Portugal, Spain and Greece were not included in the survey). In all cases the respondents were provided the option of answering the survey in the language they preferred.

The target mailing list was developed by taking a random sample of 800 firms from an industrial data base maintained by the Zurich office of COM-PASS. The data base provides for extracting names, titles and addresses by industry classifications similar to the SIC code in the United States. The response rate was less than one percent for the mail survey, mirroring the experience elsewhere. In addition, the industry classifications were not as fine as originally expected, so some of the responding companies did not fit the target industry description well. That reduced the number of usable surveys even more.

After the disappointing results of the mail survey, a telephone solicitation was conducted using trade association directories to select a sample of companies in each country. An experienced consultant with good language skills called the appropriate person in each of the companies and asked their cooperation. Even with follow-up only about 25% of the firms that agreed to return the survey did so. The data gathering took place in the spring and summer of 1988. A total of 34 usable responses from machine tool firms and 24 from textile firms were finally obtained from nine countries, all from Northern Europe as seen in Table 1.

Having learned from the experience in other countries, data gathering in North America (Canada and the United States) was not initiated with a mail survey. The first thing done was to get
support for the project from officers of the trade association for each industry. Next, directories of the trade association members were used to determine which firms to contact by randomly selecting each nth firm from the alphabetical listing. A manufacturing executive from each of selected companies was then contacted by telephone. The executive was made aware of the trade association support and was asked to participate in the study. As an incentive, firms were told that if they filled out the questionnaire, the average responses for the firms in their industry would be provided to them. Follow-up phone calls were made to answer questions and remind them to complete and return the form. About 50% of the companies that agreed to participate actually returned the completed form (after three to four follow-up phone calls). The first pass through this process provided slightly fewer completed questionnaires than targeted. In order to increase the sample size, a second pass was made through the process, omitting firms that had previously been selected.

The data gathering took place in the summer and fall of 1989. Completed questionnaires came from four regions of the United States (Northeast, Southeast, Midwest and Western) and Canada. All completed questionnaires were usable, although some information was missing on some of the responses. The final sample includes 45 machine tool firms and 50 textile firms. Canada and the US West are slightly underrepresented in the sample, as seen in Table 1.

The sample used for this study (153 firms from two regions and two industries) is consistent with other studies of manufacturing activity. Kim and Miller (1992) use 111 United States firms from five industries to draw conclusions on manufacturing strategies. Ferdows and De Meyer (1988) use a sample of 222 firms, from 14 countries and multiple industries, to describe European manufacturers.

### 3. The analytical framework

Much of the research on the GMRG data has shown that differences in manufacturing practices between companies can largely be explained by regional or cultural differences, differences in the industry and/or whether the market is market oriented or centrally planned. The analysis in this paper explores regional differences, although the framework is valid for the other two as well. The comparison of Western European and North American practices does not consider industry differences and, since both North America and Western Europe are market economies, the nature of the economy does not apply.

The framework is presented as a comprehensive approach to the comparison of two regions. There is no intention to claim an exclusive, 'correct' way of performing the analysis, but simply, to document a method that is technically sound and provides useful results. The framework presented here groups the data into basic units for statistical comparisons, uses a conservative test called a pure regional effect, and matches the statistical approaches to the assumptions required of the data and the type of variable.

#### 3.1. Grouping the data

The distribution of the totals by region and industry shown in Table 1 represents a natural way to group the data, although it is not an exclusive way. Other detailed subsamples could...
be developed (size of firm, export orientation, portion of production in house, etc.) based on the responses to the questionnaire. The analytical framework reported here uses the North American, Western European and industry groups which permit five types of comparisons:
(A) Comparisons of manufacturing practices between North America and Western Europe to determine regional effects (with industry data pooled).
(B) Comparisons of manufacturing practices between the machine tool and textile industries (with regional data pooled).
(C) More detailed comparisons:
(CA) Comparisons of regions within an industry (e.g., compare the North American machine tool or textile companies with the Western European ones) or
(CB) Comparisons of the industries within a region (e.g., compare the North American machine tool companies with the North American textile companies) or
(CC) Comparisons crossing industries and regions (e.g., compare the North American machine tool companies with the Western European textile companies).

The analysis in (A) emphasizes the regional differences and eliminates the industrial ones by combining the two types of industries (this analysis is stronger if it has been determined that the industries can be pooled for the statistical analysis). The analysis for (B) combines different regions in order to focus on the industrial characteristics (again, stronger if the regions can be pooled). The types of comparisons in (C) are the most elemental. Any industrial differences are not considered in (CA) and regional ones are not considered in (CB). In (CC) the regional and industry differences are mixed.

3.2. The concept of a pure effect

In this paper the summary groupings of Table 1 are used to make regional comparisons within each industry (the (CA) type of analysis). This does not require any prior determination of whether the industry data can be pooled. The concept of a 'pure' regional effect is used to make the comparisons. The concept is illustrated in Fig. 1 for export sales. Export sales (in millions of US$) are shown on the vertical axis and the lengths of the bars represent the averages for each group.

The differences between the regions in each industry are significant using a 95% confidence limit (compare 'nam' to 'wem' and 'nat' to 'wet') and they are in the same direction. This defines a 'pure' regional effect. Obviously, a pure industry effect can be defined by direct analog, but industry differences have no bearing on the regional effect. As long as both regional differences are significant and in the same direction, there is a pure effect regardless of the direction or significance of the industry values.

Only those variables for which there is a pure regional effect are used to describe differences in manufacturing practices between North America and Western Europe in this paper. Using the pure effect to define differences is very conservative and it may overlook some interesting interactions between industry and region. However, since the effect is 'pure', it makes the description and interpretation of the differences straightforward. On the other hand, a firm considering a joint venture might be very interested in some of the other

![Fig. 1. A pure regional effect. The titles nam and wem stand for North American and Western Europe machine tool companies; nat and wet are for the textile companies.](image-url)
combinations, particularly those that involve regional differences for their industry, regardless of the other effects.

3.3. Matching the variables and the analysis

The questionnaire used for gathering the data on manufacturing practices contains 65 questions, mainly concerned with material planning and control. There are 95 original variables and others were derived for the study. Some of the derived variables describe relationships between the original variables (for example, sales per employee or inventory turnover). Others result from individually analyzing each possible response of a multiple response question (for example, how is capacity increased, overtime, hire workers, etc.).

There are five sections in the questionnaire and the variables associated with them fall into three measurement categories (ratio scaled, ordinal, and nominal), as shown in Table 2. Each category requires different methods for determining statistical differences between the responses. Since only the differences that result from a 'pure' effect are of interest, this means determining when the regional comparisons for both industries are significant.

The method for making these comparisons differs with the type of measurement scale.

A common method of testing for statistically significant differences between mean responses of two groups of ratio scale data (e.g., annual export sales), is the Student's t-test. A preliminary analysis of the North American and Western European data revealed obvious non-normality and unequal variances for many ratio scaled variables. To overcome this problem the Kruskal-Wallis one way analysis of variance of ranks is used. This nonparametric counterpart of the t-test evaluates differences in the location parameter (the nonparametric equivalent of mean or median) of ratio scale variables (see (Daniel, 1990) or (Siegel, 1956) for details).

Discovering that responses from the two regions are significantly different is the first part of determining whether a pure regional effect exists. The second is determining whether the differences are in the same direction. This is easily determined for ratio variables, since the mean or median values can be consulted directly or a plot can be used to visualize the data.

The largest number of variables from the questionnaire are ordinal scaled (e.g., who does production planning: vice president or president?). Considering that the responses are ordered (the variable is measured on an ordinal scale), a meaningful cumulative distribution can be developed. A test for determining a significant difference between these cumulative distributions is the Kolmogorov-Smirnov test. The test is based on the maximum difference between the cumulative distributions of the two groups of interest. Stacked bar charts can be used to determine the 'direction' of the differences in the responses of the two groups.

The question of interest in analyzing nominal scale data (e.g., what group does the forecasting: marketing, production or finance?) is whether there is a significant difference between the response patterns of the regions. Two procedures are used for making this comparison of nominal variables. The first is the chi-square test of homogeneity. This approach tests the hypothesis that the distribution of the responses to the question is the same in both groups. The rule of thumb for the chi-square test is that no more than 20% of the cells should have fewer than five expected responses. One way to attempt to meet this restriction is to combine several response categories into one 'other' category to create cells of sufficient sample size. Although some data is lost in doing this, the response patterns in the remaining cells can still be tested.

If the chi-square test cannot be used, the binomial test is appropriate, since the responses to each category are either yes or no. This test compares the percentage of each group's

<table>
<thead>
<tr>
<th>Questionnaire section</th>
<th>Ratio</th>
<th>Ordinal</th>
<th>Nominal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company profile</td>
<td>16</td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Sales forecasting</td>
<td>4</td>
<td>3</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Production planning</td>
<td>10</td>
<td>8</td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td>Shop floor control</td>
<td>6</td>
<td>30</td>
<td>11</td>
<td>47</td>
</tr>
<tr>
<td>Materials management</td>
<td>6</td>
<td>2</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>43</td>
<td>34</td>
<td>119</td>
</tr>
</tbody>
</table>

Table 2 Distribution of measurement scales in the questionnaire sections
responses in a single category (i.e., what portion of each group responded marketing as opposed to the other choices, production or finance). There is an implicit combination of the remaining categories into a single 'other' category for this test. Stacked bar charts can be used to illustrate the differences in direction between the groups with either the chi-square or binomial tests.

4. Results

The analytical approach described in the framework was applied to all 119 variables to compare manufacturing practices between North America and Western Europe. Only those variables that have a pure regional effect will be discussed here. Complete details of the analysis can be found in (Vastag and Whybark, 1992). The results will be presented in the order of the sections of the questionnaire (see Table 2).

The company profile section contains general data on the companies. Of the 16 variables, only the three shown in Table 3 have a pure regional effect. The questions from which the data were taken are shown in Table 4.

The Western European companies' export sales are greater, on average, than the North American ones (e.g., nam<wem and nat<wet) as seen in Fig. 2. Similarly a higher portion of total sales is exported by Western European firms than those in North America and the capacity utilization is higher in Western Europe as well. The box plots in Figs. 2 and 3 show these latter results. The box plots also show that the confidence limits around the medians of the regional groups do not overlap corroborating the Kruskal-Wallis results shown in Table 3.

None of the 15 variables in the forecasting section have a pure regional effect. However, there was both an ordinal and a nominal variable in the production planning section that did. Table 5 shows the two variables, their modal responses, and the significance levels. Figs. 4 and 5 show the stacked bar charts for each. From these charts we see that the directions of the differences in the regions are the same for both industries. The data came from the questions in Table 6.

![Fig. 2. Export sales/total sales.](image-url)
North American firms have significantly more production planners with college training than Western European companies (using a Kolmogorov-Smirnov test). There are also regional differences in what the firms consider the two most important uses of the production plan. (For this variable a binomial test was required since the assumptions were not met for the chi-square test.) In North America, operations scheduling is combined with inventory or manpower planning while facility planning is combined with subcontracting or operations scheduling in Western Europe. Strengthening the pure regional effect is the observation that the combination of subcontracting and facility planning is not mentioned by North American firms while being the modal choice for the Western European textile firms.

Of the 47 variables in the shop floor control section of the questionnaire, only two nominal variables had pure regional effects. Their modal values are indicated in Table 7. The questions that provided these data are seen in Table 8.

Even though the modal choices for time standard accuracy are the same in three groups, the Western European firms perceive their time standards to be more accurate than the North American ones. This can be seen in the stacked bar chart shown in Fig. 6.

'Lay off extra workers' was one of the responses to the question concerned with reducing the capacity of the firm. The modal choice and distribution of the importance (high, moderate, not useful) of this response are shown in Table 7 and Fig. 7. Lay-offs are an important alternative in the North American firms, while they are not useful in the Western European ones.

No variable from the materials management section of the questionnaire has a pure regional

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### Table 5

<table>
<thead>
<tr>
<th>Variable</th>
<th>nam</th>
<th>wen</th>
<th>sigM</th>
<th>nat</th>
<th>wet</th>
<th>sigT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production planner's education</td>
<td></td>
<td></td>
<td>College High school 0.000</td>
<td>College High school 0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two uses of the production plan</td>
<td>Manpower, inventory planning &amp; operation scheduling</td>
<td>Facility planning &amp; operation sched.</td>
<td>0.000</td>
<td>Operation sched. &amp; inventory planning &amp; facility planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Note: The Kolmogorov-Smirnov test was used for education and the binomial test for production plan use.
Table 6
Significant production planning questions

The education of the person responsible for production planning?
- Primary school
- High school
- College graduate
- Advanced degrees

What are the two most important uses of the production plan?
- Budget preparation
- Operations scheduling
- Subcontracting
- Material/inventory planning
- Manpower planning
- Purchasing/procurement
- Facilities planning
- Other

5. Summary and discussion

Perhaps the most important observation is that fewer than 10% of the 119 variables analyzed meet the pure regional effect criterion for regional differences. Furthermore, of the seven variables that did, three come from the general data section, two from the production planning and two from the section of the questionnaire covering the most detailed aspects of manufacturing practices, shop floor control. No differences at all were found for any of the variables in the sales forecasting or materials management sections. Thus the manufacturing practices of Western Europe and North America are more similar than different.

The differences that were found, however, could be of importance to firms trying to establish joint ventures or other forms of manufacturing cooperation. They seem to reflect three general attributes that may be more important than any specific manufacturing practice. The three attributes are: external orientation, asset (including human) management and management of details. Each of these three attributes will be discussed after presenting some of the implications of the findings for theory.

5.1. Some implications for theory

Performance of joint ventures and other forms of alliance has long been of interest to scholars and practitioners alike. Although measurement of performance is an issue, longevity is one clear criterion of success (Geringer and Hebert, 1991). On this dimension, however, failure within the first few years seems to be the rule, even between organizations from similar cultures (Savona, 1992). A part of the theory explaining these
failures suggests that a mismatch of manufacturing practices can thwart noble strategic objectives.

The similarity of manufacturing practices between North America and Western Europe found in this study suggests that mismatches of manufacturing practices would not be a major factor in failures of joint ventures between firms in these two regions. It also suggests that the theory concerning the manufacturing aspects of joint venture failures needs to be enriched, at least for culturally similar situations. Both operational and strategic aspects outside the dimensions of the GMRG survey need to be studied and other disciplines may be needed as well. On the other hand, it appears that the concern about European manufacturing practices being understudied has partially been redressed by the observations of this study. The documentation of North American manufacturing practices should, at the very least, provide a good starting point for understanding those of Western European firms.

5.2. External orientation

It is not surprising that the Western European
firms have both higher proportions and absolute levels of export sales. This focus on international markets is a product of geographical proximity to other countries, small domestic markets and the long history of international commerce among the European nations. The advent of the European Common Market and the interest of other European countries in joining, further underscores the external orientation of the European companies. This experience can be an advantage to North American partners, provided they are willing to engage in the international activities that the European managers find natural. On the other hand, the language skills and day-to-day cross-border activities of the European manager could be a threat to managers from North America.

5.3. Asset management

European firms have always had a concern for the design, maintenance and use of capital equipment. This is illustrated, for example, by the historical quality image of European machine tools, the cleanliness of their factories and technical competence of the factory management. It is not surprising, therefore, to see higher levels of capacity utilization in the European plants. It seems this concern for asset management extends to human capital as well. The use of layoffs is not even entertained in more than 50% of the European companies sampled. European managers may find their American counterparts more callous than they would be in this regard.

The production planner is more likely to have a college degree in North American firms, while a high school degree (with knowledge of the manufacturing details) will suffice in Western Europe. This is partly a workplace reflection of the differences between the formal education systems, where the Europeans have an advantage. Another reason, however, may relate to the European apprentice system that places young people in a program of practical skills training and work experience as preparation for a job in a manufacturing company. People from this program would be classed as primary or, at best, high school graduates, which would greatly understate their true manufacturing skills.

5.4. Management of details

The orientation to external markets and concern for asset management among Western European firms is enhanced by their attention to manufacturing details. For example, the accuracy of time standards is higher there than in North America. While the production plan is used for detail inventory planning in both regions, in North American firms it is used for short-term internal operational concerns, like scheduling and manpower planning. Those internal details are worked out by manufacturing managers in the Western European firms. In contrast the production plan is used for longer term aggregate issues like facility planning and subcontracting by Western European firms.

In setting expectations for collaborative relations with European firms, American managers should expect their European counterparts to be more willing and able to deal in the details of manufacturing than they might be. This is a product of the technical capability of European managers and their factory floor experience. In addition, American managers must be prepared to learn from the international experience of their European counterparts and not be threatened by it. Finally, although there are not many differences in manufacturing practices disclosed by this study, those that exist should not be minimized.

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