Knowledge Creation and the Management of Diversity
— Comparative analysis of Kao Corp. and P&G.—

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ABSTRACT

The focus of the paper rests on the relationship between knowledge creation within the product development process and the diversity of context, cognitive approach and culture, as well as with boundary management. This paper examines the relationship between knowledge creation and diversities, through analyzing the outcome of R&D activities of Kao Corp. and P&G. With regard to electronics industries, in particular, open innovation systems have become more or less common. While these industries are rather culture free, such living ware industries as toiletry are quite culture bound. The paper finds the interesting relationship between knowledge creation and diversities in the culture bound industry.

(1) Boundary Management and Knowledge Creation

Radically new insights and developments often arise at the boundaries between communities (Wenger, 2002: 153). This paper is basically based on the concept that the creation of radical insights and knowledge often arise at the boundaries between diverse cultures, and between diverse technological domains. Nonaka and Takeuchi argue that organizational knowledge creation process in the “Ba” consists of five phases; sharing tacit knowledge, creating concepts, justifying concepts, building an archetype, and cross leveling of knowledge (Nonaka and Takeuchi, 1995: 85-89). Through these processes, members are able to recognize their respective differences and share their knowledge. This paper does not use the term “ Ba” , but “boundary” where diverse contexts and domain specific knowledge overlap. On the other hand, D. Leonard (1998) discusses the creation of new knowledge from the perspective of “creative abrasion.” He reasons that it is through this creative abrasion process that individuals integrate their various problem-solving approaches, and that this gives rise to new insights and knowledge. “Innovation rises from the boundaries of diverse mindsets, not within the provincial territory of one knowledge and skill base” (D. Leonard, p.64).

Essentially, the emphasis should be on the elucidation of the mechanisms that generate these innovative insights and knowledge from those boundaries that are the composites of domain specific knowledge of members from specific domains. The matters of discussion here, therefore, are not limited to the scientific and technological knowledge domain of those who participate in the mechanism of knowledge creation at the early product development phase. The paper also discusses the culture-specific context of the affiliated organizations and related departments of the participating members. Regarding the idea of “boundaries,” this paper not only examines the participating members’ scientific and technological domain-specific knowledge, but also the members’ cultural differences that influence their differences in their cognitive approaches and contexts.

Accordingly, the fundamental role of the project leader at the initial stage of the new product development is to fulfill the role of a boundary spanner between the specific domains of knowledge. Hence, keeping all of the above in mind, knowledge creation at the boundaries is further examined here.

New insights and knowledge are often created in overlapping domains of the participating members. The primary reasons for this are that the members shared a common goal, proceeded with serious dialogues, deepened their respective specialty knowledge domains, came to comprehend the differences in their respective perceiving contexts, exchanged knowledge correctly, clarified their ambiguities, acknowledged the meeting points with other knowledge domains, and were able to successfully integrate their knowledge. In other words, the boundary management capability of the project leader is the determining factor in the strategic creation of knowledge. Put another way, only the project leader's dynamic process of structural creation of knowledge can lead to the project members attaining new insights and knowledge (Lester and Piore, 2004: 51-73).

In consequence, the more new R&D capabilities with globally competitive advantages are required, the more technological and cultural requisite diversities of R&D projects expand, the more important relevant designing of "Ba", and the more important management of boundary where domains overlap.

(2) Cultural Diversity of Kao Corporation and Procter & Gamble's (P&G's) R&D Activities

Based on the critical thinking noted above, this study seeks to analyze the results of Kao and P&G's R&D activities to examine the cultural and technological diversity of their project members. The paper also assesses the importance of boundary management, the realm where those diverse cultural and technological elements meet. In conducting these examinations, the report focuses on the following two hypotheses:

Hypothesis 1: To develop products from new concepts, it is necessary to integrate multiple ideas by organizing a wide variety of members who have diverse cultural backgrounds.

Hypothesis 2: To develop products from new concepts, it is necessary to integrate a wide range of technological ideas in an effort to create new technologies, which eventually leads to projects taking on a tone of technological diversity.

Many outcome of R&D projects activities are often published in journals in the form of technological papers or applied for patent. The authors have searched technological papers and patents in which the names of researchers and engineers working for Kao and P&G are specified to check their divisions and technological diversity. The database that the authors have accessed for reference is JSTPlus (database of the Japan Science and Technology Agency) on technological papers and USPATFUL (database of STN International) on U.S. patent information.

(2)-1. Diversity of organizational affiliations to which authors of scientific papers belong

This section examines what category those papers are grouped into: the papers by individual researchers, the papers written jointly within a department or division of a particular institute, the papers written in collaboration with other divisions within a particular institute, and the papers written in collaboration with other research organizations (universities and private companies). In addition, the section identifies the number of papers whose projects were participated in by female researchers (and engineers) and foreign nationalities. Through these processes, the authors intend to examine the diversity of organizational culture characterizing the participants at the initial stage, the cultural diversity of sub-systems inherent to their specific organizations, genders and nationalities. By searching the papers, the paper also categorizes their technological fields and evaluates the degree of their diversity.

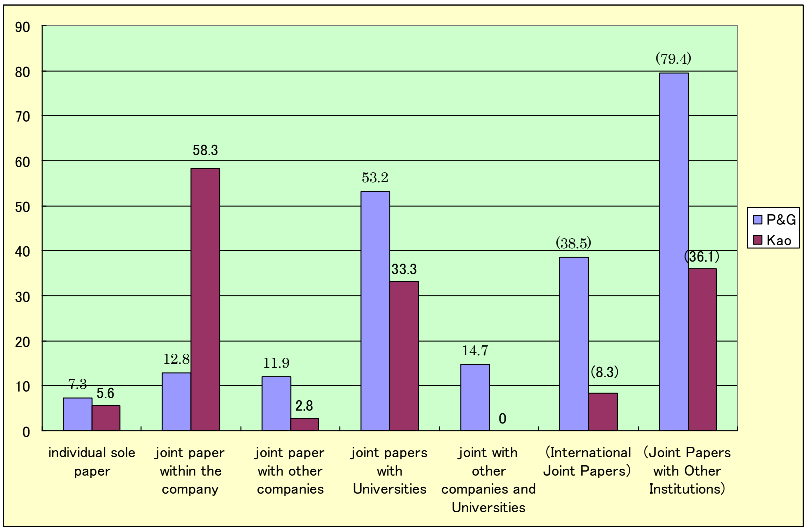
This study examines the search results on Kao and P&G's papers and then conducts a comparative analysis of both companies.

(2)-2 Comparison of the R&D Styles and the Diversity Between Kao and P&G

In examining the technological papers authored or coauthored by the researchers and engineers of the two corporations, this section compares their characteristics with a particular focus on papers published in the United States during the period of 2005–2006. As Figure 1 illustrates, the international collaborative works and the joint works with outside organizations exhibit major differences between the two toiletry companies.

Of all the papers that P&G's researchers and engineers authored, the international works made up 38.5%, whereas the equivalent figure was just 8.3% with Kao. In addition, with regard to the joint works with other organizations, P&G marked an exceedingly high percentage of 79.5%, but Kao scored just 36.1%. However, the joint works inside the company displayed a strikingly different landscape. In the case of the American company, the joint papers within the company made up just 12.8% (six papers); the joint works by a particular division within the company accounted for 12.2% and the interdivisional joint works constituted only 2.4%. In sharp contrast, the group works within the Japanese counterpart tallied 58.3%; the joint works by researchers(or engineers) in a particular division of the company made up 36.1% and the interdivisional joint works accounted for 22.2%. This shows that Kao has intentionally employed the R&D strategy of utilizing a wide variety of know-how within the organization.

Figure 1 : Breakdown of Papers by the Affiliation of Authors that P&G's and Kao's Researchers and Engineers are involved (published in the United States in 2005–2006 : %)



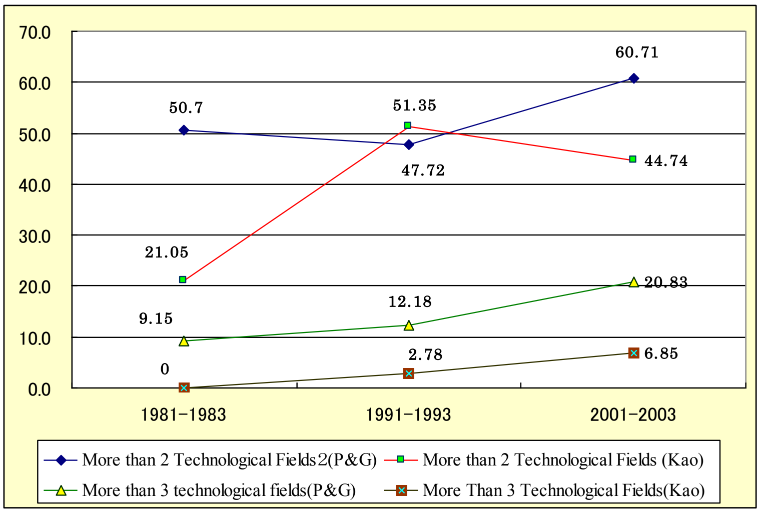
Source: JSTPlus

(2)-3. Technological Diversity of P&G and Kao in Terms of Their Technological Papers

The authors have examined how U.S.-published papers involving multiple technological areas have changed along with the current of the times. The authors have found out that the number of papers involving multiple areas increased as time went by (See Figure 2).

These increases in the number of papers involving multiple technological areas are suggestive of the greater diversification of technological fields because of the closer associations of multiple technological areas. To explore this tendency, the authors focused on whether the papers focusing on particular technological areas had been adopted or the papers involving multiple technological areas had been adopted. From this perspective, the authors examined P&G and Kao's papers involving multiple technological areas published in the United States using the Lorenz curve.

Figure 2: The Percentage Ratio of Papers Involving Multiple Technological Fields (P&G and Kao): (Published in the United States)



Source: JSTPlus

The Lorenz curve is a graphical tool to display statistical gaps and bow-shaped curves bending downward farther from the diagonal line suggest greater gaps. That is, the larger area between the perfect equality line and the observed Lorenz curve shows greater gaps. The Gini coefficient is the numerical representation of these gaps. This coefficient is defined as follows:

$$G = \frac{\sum_{i=1}^{n}\sum_{j=}^{n}\left|Y_i - Y_j\right|}{2\bar{Y}n^2}$$

In this formula, n refers to the number of technological areas, Y_i refers to the number of papers involving multiple technological areas, which is placed in the order of i (i=1・・・n), and $\bar{Y}$ refers to the average number of papers involving multiple areas. The Gini coefficient is 1 when the gap is the largest and the value is 0 when perfect equality is obtained. The coefficient represents the rate of the area shaped between the curve and the perfect equality line to the area of a triangle shaped by the perfect equality line and both axes.

Figure 3
The Lorenz Curve of P&G's US published papers involving multiple technological areas

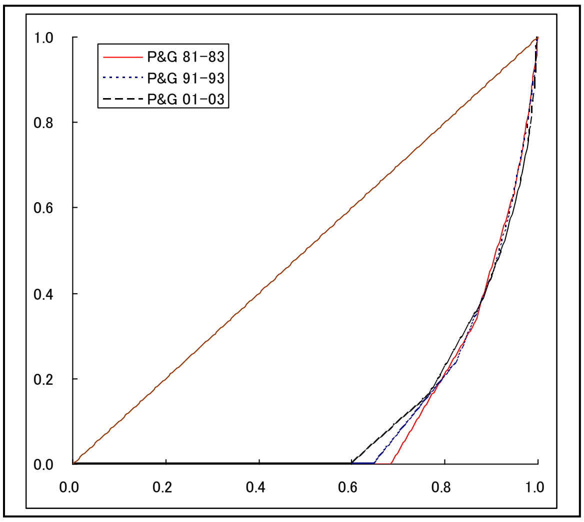


Figure 4
The Lorenz Curve of Kao's US published papers involving multiple technological areas

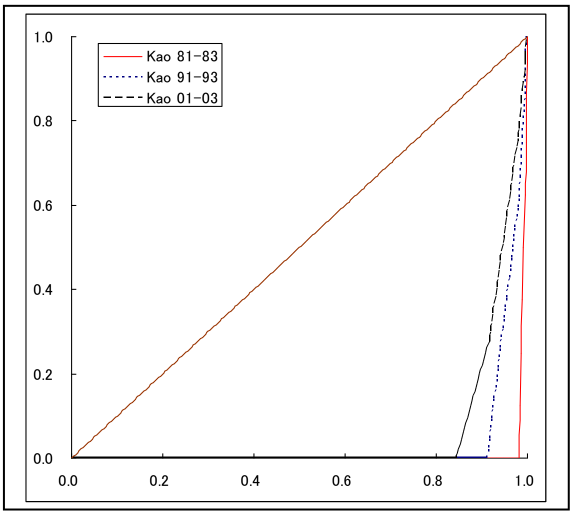


Figure 3 and Figure 4 illustrate that the curves are getting closer to perfect equality line from 1981–1983 to 1991–1993, and to 2001–2003 with only moderate changes.

The comparison of both companies' curves hints that P&G's is closer to the perfect equality line than that of Kao and that the U.S. company has smaller gaps in the development of technological areas. Although the authors could gain only a limited number of data for this survey, updating data and conducting follow-up surveys and further analyses will result in obtaining new insights into the technological development diversity between the two companies.

The value went down slightly in 2001–2003, compared with fewer changes from 1981–1983 to 1991–1993. This implies that gradual decreases emerged in the gap of the number of papers involving multiple technological areas along with the trends of the times. This analysis shows the growing trend of the papers involving multiple areas being adopted rather than the papers concerning particular areas.

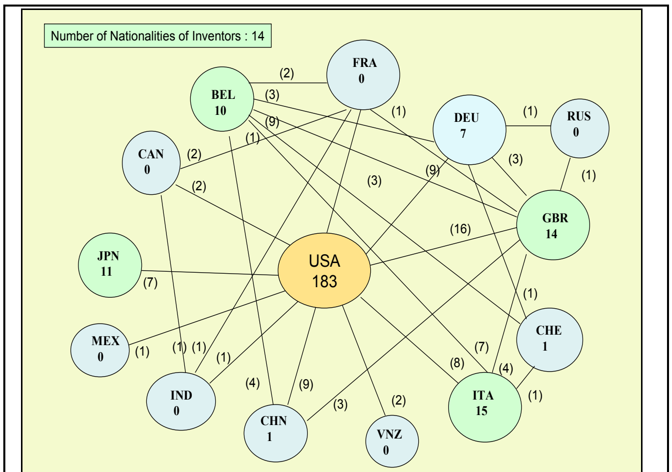
As noted above, both graphical data and numerical figures show that the area gaps of papers involving multiple technological areas are moderately shrinking and that more papers involving multiple areas are being gradually adopted rather than the papers concerning particular areas. Behind this lies the trend of diversification in which more emphasis is placed on R&D activities with broader technological areas than on the intensive development of particular areas. That is, the active and diverse combination of multiple technologies has been taking place in recent years. The authors could gain only a limited number of data for this survey, but updating data and conducting follow-up surveys and further analyses will result in obtaining new insights into the technological development diversity between the two companies.

(3) Diversity of Nationalities of Inventors and Their Technological Areas in Terms of U.S. Patent

Generally speaking, the more important their successful technological outcomes are in their international strategy, the more companies try to secure the exclusive rights of those technologies by applying for patents in major overseas countries, especially in the United States, where the market is vast and a large number of competitors are running their activities. Considering this fact, the authors focused on the patents that Kao and P&G had filed with the U.S. Patent Office, and examined the diversity of the nationalities of those inventors.

(3)-1 Comparison of the Diversity of P&G and Kao's Inventors' Nationalities in Terms of U.S. Patent

Figure 5:
Nationality of inventors and the number of US patents obtained by P&G (2005)



Note 1: The numbers in the circles show the inventions by single nationalities. For example, DEU(Germany) 7 means seven inventions by researchers of German nationality. As for the parenthesized numbers beside the lines.
Note 1: The nationality codes are as follows: BEL (Belgium), CAN (Canada), CHE (Switzerland), CHN (China), DEU (Germany), FRA (France), GBR (Great Britain), IND (India), ITA (Italy) JPN(Japan), MEX (Mexico), RUS (Russia),
VNZ (Venezuela) and USA (America).

Source: USPATFUL.

As Figure 5 illustrates clearly, P&G's R&D activities involve researchers of various nationalities who have a high standard of capability for obtaining U.S. patents. For its patents granted in 2005, the U.S. company had inventors of 13 nationalities, excluding American; in contrast, in the case of KAO, its inventors were of only three nationalities, excluding Japanese, which are German, Spanish and the US. In addition, P&G's R&D activities are based on its global networks, while Kao's activities are conducted according to the stand-alone model with its base in Japan. That is, P&G has established the global system to fully utilize a wide variety of high-level researchers, but Kao's personnel management system is largely domestically-oriented.

(3)-2. P&G's and Kao's Technological Diversity in Terms of U.S. Patent Granted

Next, the authors focused on both companies' percentage and number of patents involving multiple technological areas. Then, the authors have found out that the number of patents involving multiple areas increased from 1990 to 2000. Considering these data, with regard to patents involving multiple technological areas, the authors compared their numbers by area to examine whether those patents are centered intensively on particular areas or they spread across a wide range of areas. If there are patents combining multiple technologies in various fields, it means that development projects involving technological diversities are underway.

That is, it can be speculated that there is growing interconnectedness among various technological areas, which creates technological diversities. In line with this assumption, the authors conducted the above-mentioned comparative analysis to examine the gaps among technological areas. The authors calculated the cumulative percentages of patents involving multiple areas with a focus on the period from 1980 to 1990 and compared the values graphically by the Lorenz curve.

Figures 6 and 7 illustrate the Lorenz curves depicting the number of P&G's and Kao's technological areas, respectively. Figures 7 illustrates that P&G's curves of 1980 and 1990 got closer to the perfect equality line. However, the company's curve of 2000 was farther away from the perfect equality line than those of 1980 and 1990. The curve suggests that in comparison with the cumulative percentages of technological areas, the higher percentages of patents involving multiple areas marked remarkable increases. These noticeable increases result from patents increasing in the fields of A61K[i] and C11D[ii] more dramatically than in other technological areas. (A61K scored a 8.5-fold increase from 1980 and a 5.6-fold increase from 1990; C11D marked a 7.9-fold increase from 1980 and a 510.7-fold increase from 1990.)

In this way, many patents involving multiple technological areas, including these two specific fields, were obtained in 2000. P&G has been producing numerous patents combining multiple technological areas with a particular emphasis on A61K and C11D, which boosts technological diversities.

Moreover, with a focus on the initial stages of P&G's Lorenz curve of 2000, the curve clearly shows a gradual increase relatively with other periods. This suggests that in this year, P&G obtained more patents involving multiple areas than in other years. That is, in recent years, patent acquisitions have focused not on particular areas but on combined wider areas, which contributes not only to the expansion of technological diversities but also to the closer linkage of individual areas.

In contrast, in Kao's case, the Lorenz curves consistently got closer to the perfect equality line from 1980 to 2000 (See Figure 6). These data show that the company's gaps by area in the number of patents involving multiple areas narrowed. With respect to the Japanese company's patent acquisitions involving multiple technological areas, there was a noticeable shift from an intensive focus on particular areas to a broader focus on various areas. This is probably because the company has launched joint research and development projects well beyond the walls of technological fields.

In addition, Kao also came to place a stronger focus of attention on A61K and C11D, which form the core of P&G's patent acquisitions. In this case, it can be said that in recent years, patent acquisitions have focused on combined wider areas with a remarkable emphasis on A61K and C11D, which contributes not only to the expansion of technological diversities but also to the closer associations of individual areas.

Figure 6: P&G's Lorenz Curve

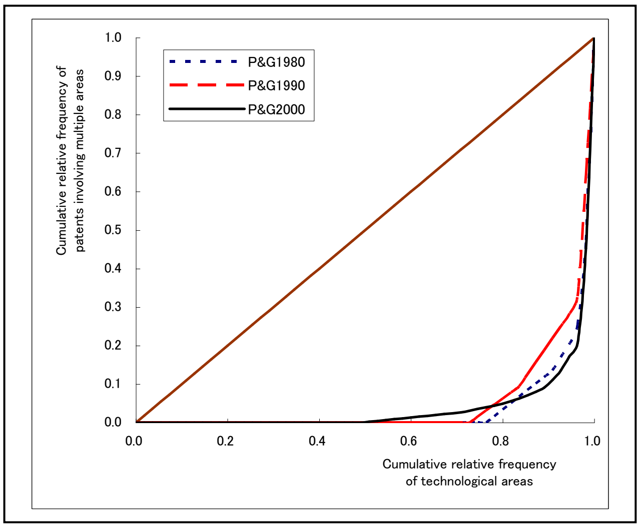
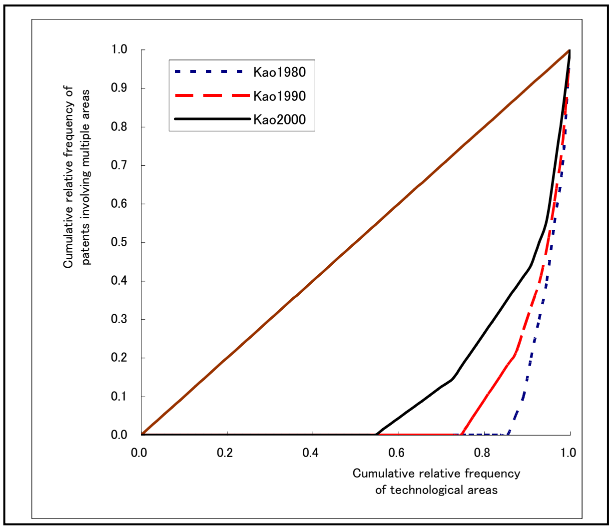


Figure 7: Kao's Lorenz Curve



Source: USPATFUL.

To summarize the insights into both companies' patent acquisitions in the United States in recent years, patent innovations involving multiple technological areas, including A61K and C11D, have been aggressively conducted, which boosts technological diversification and interconnectedness among various areas. This growing interconnectedness has provided more necessity for research and development activities.

(4) Analysis Results and the Evaluations of the Hypotheses

This paper has searched papers and patents reflecting the results of Kao and P&G's R&D activities and has analyzed the specific divisions, organizations and nationalities to which authors and /or inventors belonged, and the technological areas with which papers and patents are associated. Through these analyses, the study has confirmed that R&D activities of the companies have become more culturally diverse in terms of the organization, sections and nationalities of their members over the last 20 years amid the acceleration of collaborative works. The paper has also verified that the R&D areas have been diversified and have become more interconnected. The analysis of the data on the two companies' US patents indicates that the number of patents involving multiple related technological areas has been increasing, which is suggestive of growing technological diversity. Based on these examinations, the authors have noted that the development of products with new concepts involves the necessity of combining diverse technological ideas to create new technologies, which results in devising development projects of technological diversity. In addition, the growth of technological diversification has boosted the interconnectedness among individual technologies and this closer technological association has promoted R&D activities. Through these evaluations, the authors have verified that the two hypotheses are valid. This means that strategic knowledge creation in this "boundary" where multi-cultures and multiple technological areas meet, that is, the boundary management of knowledge creation, is becoming increasingly significant.

(5) Conclusion

This study has examined the impact of cultural and technological diversity on corporate R&D activities that can be regarded as knowledge creation processes. As a result of the analysis, the authors have noted that there is increasingly dynamic interconnectedness between knowledge creation and cultural and technological diversity. This means that the boundary management of strategic knowledge creation combining multi cultural and technological areas is becoming increasingly important. To conclude the paper, the organizational knowledge creation with a focus on the close interconnectedness between knowledge creations and cultural and technological diversities forms the foundation for organizational dynamic capabilities enabling entities to evolve on their own in response to highly competitive global environments. That is, in an era when global competitive conditions are changing rapidly, corporate competitive advantage can be attributed primarily to the management of diversities to fully utilize cultural and technological diversities, especially the boundary management capability to handle strategic knowledge creation in the boundary where multi technological areas meet.

The paper, however, still remains following several issues to be solved. In addition to the drawback that the number of companies analyzed is limited only to two which belong to the toiletry industry, it does not yet demonstrate the knowledge creation mechanism in the boundary between project members which consist of diverse cultural and technological backgrounds.

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[i] A61K includes the following areas: dental pharmaceuticals, cosmetics and other related pharmaceuticals, medical pharmaceuticals characterized by special physical forms, medical pharmaceuticals with organic and inorganic active materials and so forth.

[ii] C11D is the code of the following areas: cleansing composites, the use of single materials as washing agents, soap and soap manufacturing and so on. For details on these patent fields, refer to http://www.ipdl.inpit.go.jp/Tokujitu/tokujitu.htm compiled by the National Center for Industrial Property Information and Training.