Inter-Industry Wage Structures: New Evidence from the OECD

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Abstract

This paper presents an analysis of the evolution of industrial wages in a selection of OECD countries, using data drawn from the Structural Analysis Database and a sequence of techniques that apply cluster and discriminant analysis to time-series of wage change by industry. The principal finding is that a small number of well defined groups of industries usually exist, whose cross-group differences account for almost all inter-industry wage variation. While the specific structure of groups varies according to patterns of natural resources, comparative advantage and trade union organization within each country, the between-group variation across time usually reflects the movement of macroeconomic variables, some of them internal and other external, such as inflation and exchange rates. In other words, individual countries appear to be able to control their internal institutional structures, perhaps best understood as pattern bargains, wage contours, or industrial sectors distinguished by type and degree of exposure to international trade. But they do not exercise internal control over the evolution of wage differentials across these groups, except insofar as they can manipulate the macro conditions to which the groups are differentially sensitive.

> The chaos which *seems* to prevail in the labor market conceals a pattern of order which can be explained and which sheds light on the influences that determine the inter-industry wage structure of the community.
>
> *Slichter*

I. Introduction

Since Slichter's (1950) ground-breaking work, the literature on wage structures has often deployed the concept of rent-sharing to explain differences in pay between similar workers in different industries.[1] In a recent paper, Blanchflower, Oswald and Sanfey (1996) reaffirm Slichter and Lester's (1952) analysis, that the distribution of profits to workers accounts for almost a quarter of inter-industry wage differentials. And yet, although (as Blanchflower *et al.* delicately put it) rent-sharing is inconsistent with conventional competitive models, the literature continues to rely largely on the competitive framework to interpret changes in the distribution of pay.

This paper develops and extends an alternative approach, based on the insight that changes in degrees of market power must lie behind changes in the distribution of rents, and that macroeconomic and specifically Keynesian forces -- changes in consumption, investment, commodity prices and exchange rates -- often lie behind the rise or decline, over time, of a group of industries and their place in the wage structure. Galbraith (1998) has summarized the theory behind this argument. Our present work extends its empirical application to a selection of countries outside the United States. We show that while details of institutional structure differ from case to case, the idea that just a few macro forces drive the wage structure has wide application. In fact, we have yet to encounter an exception.

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[1] Studies of inter-industry wage differentials by Dickens and Katz (1987), Krueger and Summers (1987, 1988), Katz and Summers (1989), and Carruth and Oswald (1989) have all used the idea.

The order within is often simple. The long lists of industrial categories, so characteristic of standard industrial classification schemes, are usually redundant when it comes to explaining patterns of wage change. Instead, the differential movement between three or four large, well-chosen *groups* of industries can usually capture most of the evolution of the wage structure. Equally, one can usually reduce the between-group changes to an even smaller number of component forces; taken together these explain a very high proportion of between-group variations. Finally, it is often possible to make an intelligent judgment as to the economic nature of those forces. In other words, by reducing a complex, redundant, multi-variate and inchoate block of historical data to its essential informational content, one may frequently arrive in the end at a reasonable assessment of the major sources of change in the distribution of industrial pay.

Galbraith and Lu (1999) present detail on the combination of cluster and discriminant analysis applied to blocks of time series as a research tool in social science. Cluster analysis applied in this way groups variables that behave similarly. Discriminant analysis develops lineally independent weighting functions that expose the principal between-group differences. It also evaluates the relative importance of each such function (eigenvector), and permits the calculation of scores that show the relative influence of each function on each industry.

In this paper, we identify groups of industries -- defined by similar patterns of wage behavior -- for Germany, Japan and Italy. We then develop the functional scores that differentiate these groups. Finally, we compare these to economic time series drawn from the historical record, to arrive at inferences about the forces that influence the evolution of wage differentials.

Clear group structures can be identified in each of the countries we examined; industries group into recognizable clusters according to natural resources, technological process, comparative advantage, and sectors linked by bargaining or as the common targets of industrial policy. While different countries display individual structures, these groupings and between-group characteristics are evident in all the OECD countries that we have examined so far. The key sources of between-groups variation, on the other hand, appear to be exogenous, macroeconomic forces such as commodity prices, interest rates, inflation, or changes in gross national product, to which the groups are differentially sensitive.

II. Data and Method

We apply cluster and discriminant analyses to time series of changes in average annual earnings by industrial category. We investigate three developed countries that differ from each other in many ways: Germany, Italy, and Japan, and we provide summary information on three others: Canada, New Zealand and Norway. Some of these countries are large, others small, some diversified, others specialized, they are spread across the globe and they have widely differing patterns of trade. Our data are drawn from the OECD's Structural Analysis (STAN) Database using a non-overlapping subset of that database's 49 ISIC Revision 2 industries.[2]

Our method follows the Galbraith-Lu procedure. First, we compute a matrix of percentage changes in nominal average earnings by industrial category. We then apply cluster analysis to the resulting *paths* of wage change, a procedure that for most countries permits us to

[2] Missing observations are filled in using cross-country averages for the relevant year.

reduce twenty or thirty industrial categories to between four and six groups; these groups experience small-to-negligible within-group wage variation over time. Discriminant function analysis then permits reduction of the pattern of between-group variations to a small number of lineally independent canonical forces, or eigenvectors of a standardized matrix of between-group variations.[3] These eigenvectors may be used to compute canonical scores for each industry in the original data set, and the pattern of scores can be examined in several ways to arrive at an interpretation of each root.[4]

Our preferred device is simply to report scatter plots of two kinds. First, we plot canonical scores of the first two roots, ranked by their explanatory power, against each other; this device illustrates the effectiveness of the cluster and discriminant procedure in constructing change as a comparatively simple between-group phenomenon. The distribution of industries along the scale of scores often also provides clues as to the nature of the economic forces that are differentiating wage performance along that dimension. These may have to do with technology, patterns of unionization, patterns of trade, or other factors.

Second, for each root we seek actually to identify, we plot the calculated canonical scores against what might be termed a "pseudo-score" derived from candidate variables in the historical

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[3] The canonical score for each industry on a particular root is simply the vector product of the eigenvector associated with that root, and the time-vector of wage changes for that industry.

[4] In addition, the eigenvectors themselves take the form of a time-series, which can in some cases be compared directly to historical time series to obtain a visual or statistical matching of time-patterns. However, to execute this step effectively usually requires more detailed historical evidence on each country under study than we were able to muster in this study.

record. The pseudo-score is computed in a way analogous to that of the original canonical score.[5] Where the fit between scores and pseudo-scores is good, one may reasonably infer a relationship -- not necessarily causal, but plausibly indicative -- between the root and the historical variable from which the pseudo-score is computed. We are able to provide reasonable identification of three roots in this manner, one each for Germany, Italy and Japan.

III. Results

The application of the method described above is uniformly successful in two key respects. First, for each country we examine, nearly all of the inter-industry pay variations can be isolated into the between-group differentials for a small number of groups. The Wilks' Lambda statistic -- the ratio of the determinant of the within-groups variance-covariance matrix to the determinant of the total variance-covariance matrix -- is below .005 in every case. Second, we find that the first two eigenvectors of the discriminant matrix account for more than 75% of the between-groups variation in all cases. This suggests that knowledge of just two external influences on the wage structure is usually sufficient for an understanding of the most important sources of interindustry wage change. These results are summarized in Appendix 1.

Scatter plots of the scores on the first and second roots are found in Figures 1a through 3a. These provide a kind of profile of industrial structure and wage bargaining in each country

[5] The pseudo-score is the vector product of percentage wage changes for each industry against the time vector of changes in the candidate explanatory variable, which may be the path of consumption spending, exchange rate, commodity price, or some other variate drawn from the historical record.

examined. The very tight clusters found in, for example, Japan, indicate the close conformity of wage settlements by group membership in that country. Industrial specialists may recognize these groups as wage bargaining units, national monopolies or protected sectors, import-sensitive industries, advanced technology and export industries, and so on.

The relative wage performance of each group is depicted in Figures 1b through 3b; in each case the figures show average earnings for the cluster in relation to the average for manufacturing as a whole. Thus, the figures provide a capsule history of inter-industry wage changes; movements toward the average (as in Italy in the 1970s) indicate a general compression of the wage structure, whereas movements away from the average (as again in Italy in the 1980s) not only indicate expanding inequality but also point to the industrial groupings that are most responsible for it (in the Italian case, advanced technologies and oil).

The remaining Figures, 1c through 3c, show our preferred identifications of selected roots. This project remains the most challenging aspect of the present research, yet we remain convinced that the other identifications are out there, waiting to be made. Discriminant plots for Canada, New Zealand and Norway are provided in the appendix.

Germany

The German industrial wage structure resolves itself into three distinct groups (Figure 1a). One group represents all the transportation industries, irrespective of mode: aerospace, rail, shipping and automotive, even motorcycles. A second is a machinery and technology sector, including computers, machinery, professional goods, iron and steel, and oil. The third comprises

the balance of Germany's industries, including chemicals. Of these three groups, Germany's transportation sector has traditionally had the highest wages, and this remains the case to the end of our data. The machinery/technology sector has also paid an above average wage, but its position has been eroding, and is almost convergent with the general manufacturing sector as of 1992 (Figure 1b).

What to make of this? Figure 1a provides certain clues. We see that the Mach/tech sector ranks highest on both roots, while the transportation groups ranks lowest on the first root and the Chem/gen sector ranks lowest on the second. We do not have a statistical interpretation for the first and dominant root, which accounts for 80 percent of between-group variations and may be related to the investment cycle in Germany. But as for the second root, which accounts for 19 percent of the between group variations, we notice that both the Mach/tech and transportation sectors are advanced exporters. Meanwhile the comparatively low-tech, and low-scoring, members of the Chem/gen group tend not to be. This suggests a trade-related source of wage differentiation. One may further notice that the Mach/tech group contains a number of industries which have come under particularly intense competition in world markets from Japan.

We choose the change in the Yen/Deutsche Mark exchange rate as our candidate explanation. We find a .75 correlation between scores on the second canonical root and this variable. This is illustrated by the scatter plot in Figure 1c. As the Yen depreciates relative to the Deutsche Mark, industrial wages come under pressure to a degree determined by the extent that the industry competes with Japanese exports. This is most true of the Mach/tech sector, which includes the manufacture of computers, machine equipment, iron and steel, and optical products

such as cameras and microscopes. It is also true, to a much smaller degree, of the transportation sector. It is not true at all in the food, textile, leather and chemicals sectors, where Japanese and German industries do not go head to head for world markets.

Italy:

Cluster analysis on patterns of industrial earnings change for Italy reveals five distinct groups, which we denote as oil, transport, fashion, communications and computers (including computers and Radio-TV) and, as in Germany, a chemical/general sector covering the rest of manufacturing.[6]

The oil sector is the wage leader, with wages almost twice the average at the start of our observations. But oil sector wages decline relative to the average through the 1970s and early 1980s, recovering in part in the late 1980s and early 1990s. The transportation sector also records above average earnings that converge gradually towards the average over this period. The Comm/comp group is represented by state controlled and/or protected industries that are average wage performers until the mid-1980s, at which time relative earnings in these sectors rise sharply. The Chem/gen sector, in contrast, sees only modest improvement in its relative wage position at a few moments during the period under study. Italy's fashion sector, though renowned, is not well-paid by national standards, as Figure 3b shows.

The first two canonical roots of the Italian wage structure account for 46 and 31 percent

[6] For reasons we do not attempt to fathom, the sin sector (beverages and tobacco) group with the otherwise homogeneous transport industries in Italy. Meanwhile wage change in motor vehicle production in Italy groups with non-transport sectors such as chemicals and food.

of the total between-group variations, respectively. Once again, the first root appears to separate industries along some criterion of capital-intensity in the production process, with process industries such as beverages and non-ferrous metals scoring high while hand-crafts such as footwear and pottery score low. But we have been unable (so far) to identify a time-series variable in the Italian accounts that effectively replicates the time-series pattern of the first eigenvector.

The second root, which strongly distinguishes the oil sector from the rest of manufacturing in Italy, provides a more clear-cut clue. Relating this root to the change in the nominal refiner's acquisition price of oil (in lire) yields a significant -.46 correlation. But this relationship is almost completely driven by the oil sector and virtually disappears if the sector is eliminated from the analysis. Thus, oil prices alone cannot account for the considerable discriminating power of this root across the remaining groups.

What about inflation? During the period under study, oil prices and inflation were closely related. And indeed, if we substitute the rate of inflation in Italy for the oil price, we find a differentiator closely associated with the pattern of second-root scores. The correlation between our inflation-wage scores and the second canonical root is -0.70; if the calculation is run without the oil sector the correlation is a still-significant -0.59.[7]

[7] Since inflation also affects the exchange rate, we test to see if this, and not inflation *per se*, might have been the more important force. (For instance, the primary driver could be the inflated cost of intermediate imports as a result of a devalued lire.) Although we find a significant relationship between the lira exchange rate and second-root scores, -0.6 and -0.4 with and without the oil sector, the relationship to supply-price inflation appears to be stronger.

How does inflation affect wage differentials? We think the mechanism must essentially be one of a squeeze on supply prices. Italy is a medium-sized open economy, and notwithstanding the fact that high average rates of lira inflation were endemic in the pre-euro period, *changes* in the Italian inflation rate were driven substantially by external events -- such as changes in oil prices. For domestic industry, an increase in external supply prices means a squeeze on profits, which translated into a squeeze on rents, hence on relative wages. Industries that saw the erosion of margins due to government price controls would also suffer losses in their wages share at this time, and the Italian system of wage indexation, the famous *Scala Mobile*, did not fully offset this effect.[8]

Japan:

The wage patterns of Japanese industry cluster into four, very distinct and highly homogeneous, sectors (Figure 3a). One group is composed of key manufacturing and export industries, including motor vehicles, iron and steel, and computers. A second group contains the labor-intensive, import-sensitive industries: textiles, wearing apparel, footwear and leather. A third group contains all of the oil and chemical industries. The last group is a mixture of construction industries and such specialty, craft and luxury items as china, jewelry and musical instruments.

[8] Erikson and Ichino (1994) point out that during the 1970s indexation programs and labor policies were wage compressing. Both indexation and labor policies saw a shift against egalitarianism during the period between 1983 and 1986. Our industry group wages are convergent throughout the 1970s and start diverging in the mid 1980s and are therefore consistent with these findings.

Japan's manufactured exports sector paid consistently high earnings throughout our period of observation (Figure 3b). In the early 1980s, however, this sector was equaled, and later slightly overtaken, by the sector in which construction work predominates (perhaps, a wage consequence of the Japanese property boom?) Chemicals and petrochemicals emerge comparatively as losers: they start at the high end of the wage scale, but lose relative ground through the 1970s, 1980s and 1990s; average earnings in the chemical industries in Japan are now below the averages for manufacturing as a whole. Meanwhile, the traditional labor intensive sectors remain as always at the low end of the wage scale. Indeed relative wages in this sector declined during our study period.

The first two roots of a discriminant function for Japan account for 80 and 15 percent of the between-group wage variations, which in turn account for the overwhelming share of total cross-industry variations. Though the first root strongly separates the export leaders from the import followers, we did not find a close association between any trade or exchange rate variable and this root. Inflation, lagged one year, is strongly correlated with this root (0.63), suggesting a difference in the effectiveness of wage indexation across industries as a strong factor. However, this variable only successfully distinguishes the lowest-wage sector from the other three; the correlation disappears when the most labor-intensive industries are removed from the analysis.

Clearly, Japan's import-sensitive traditional industries lost wage ground most severely in the inflationary periods. The reason seems plain: these sectors enjoy the least market power in the Japanese economy. This simple insight leads us to look away from trade-related explanations of the first root, and to consider instead a variable related mainly to the internal strength of Japanese

domestic demand. Change of consumption spending per capita is such a variable, and it does the job: the correlation of scores on this variable with our first canonical root is a highly significant 0.81, falling only to 0.67 when the import-sensitive sector is excluded. Figure 3c illustrates. We believe this provides evidence for the simple Keynesian idea that the strength of consumer demand, interacting with the degree of monopoly power across different sectors of industry, is the critical factor underlying changes in the Japanese wage and earnings structure.

Conclusions

This paper illustrates a technique for exploring the macro-determinants of changing patterns of income distribution, particularly with respect to the distribution of wages and salaries in industrial sectors. We have shown, we believe, that in an eclectic subset of developed countries, there exist comparatively simple patterns of between-group variation, which account for a very large share of the total change in inter-industry relative wages through time. Arriving at a firm judgment as to the nature of the forces behind industrial change is a more difficult task, and one whose completion will await the energies of additional researchers armed with more detailed national data sets and more knowledge of individual national economies than we claim to possess. But, we believe, these methods will prove useful to researchers who would like to go beyond the conventional micro-analyses of wage change and attempt to arrive at explanations that can be supported by close reference to the historical record.

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Figure 1a

Germany

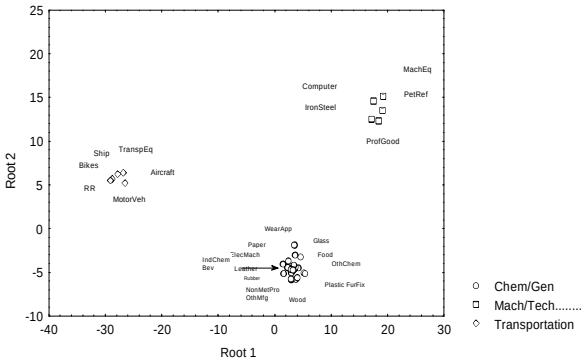


Figure 1b
Germany

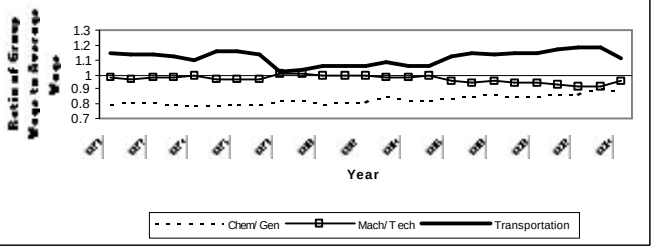


Figure 1c

Germany

Correlation: r = .74630

INDUSTRY ROOT2 SCORE = -1.048 + .03111 * EXCH/WAGE INDEX

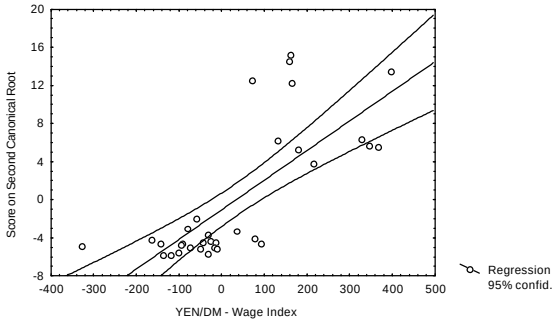


Figure 2a
Italy

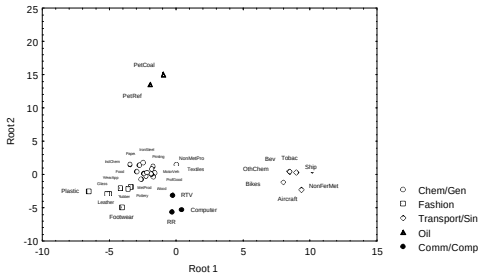


Figure 2b
Italy

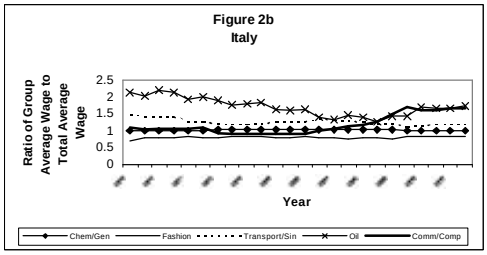


Figure 2c
Italy
Correlation: r = -.7026
INDUSTRY ROOT2 SCORE= 34.342 - .0080 * INF/WAGE INDEX

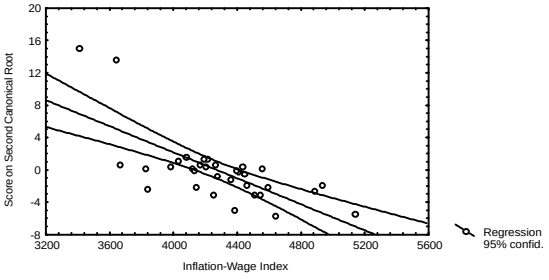
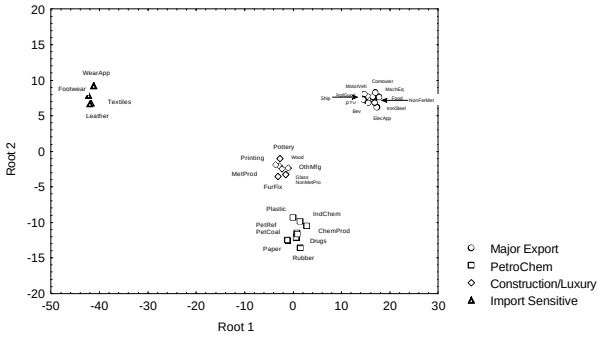


Figure 3a
Japan



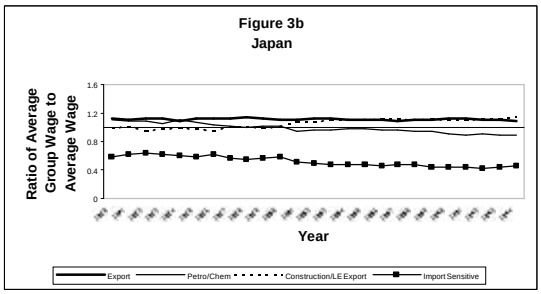
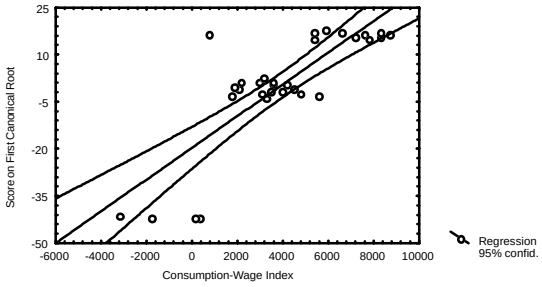


Figure 3c
Japan
Correlation: r = .81304
ROOT1 = -19.69 + .00505 * CONSUMPTION-WAGE INDEX



Appendix 1

Table One
Summary Properties of the First and Second Canonical Roots
Wage Change Between Industrial Groups, Six OECD Countries

CANADA
Discriminant Analysis: Wilks' Lambda = .000098, Approx. F (72,15) = 4.598063, p< .0007

Root	Eigenvalue	Prop.*	p-level
1	116.5530	.8747	.000000
2	9.1086	.06837	.003659

GERMANY
Discriminant Analysis: Wilks' Lambda = .0000864, Approx. F (48,14) = 31.07956, p< .0000

Root	Eigenvalue	Prop.	p-level
1	216.5649	.8059	.000000
2	52.1727	.1941	.000000

ITALY
Discriminant Analysis: Wilks' Lambda = .0000500, Approx. F (92,30) = 3.679267, p<.00007

Root	Eigenvalue	Prop	p-level
1	27.16082	.46137	.000000
2	18.47832	.31388	.000018

JAPAN
Discriminant Analysis: Wilks' Lambda = .0000018, Approx F (72,12) = 14.70896, p< .00000

Root	Eigenvalue	Prop.	p-level
1	367.5749	.8018	.000000
2	70.8889	.15461	.000000

NEW ZEALAND
Discriminant Analysis: Wilks' Lambda = .0000042, Approx. F (69, 9) = 8.859464, p< .00037

Root	Eigenvalue	Prop.	p-level
1	1530.977	.984	.000000
2	17.814	.01128	.003664

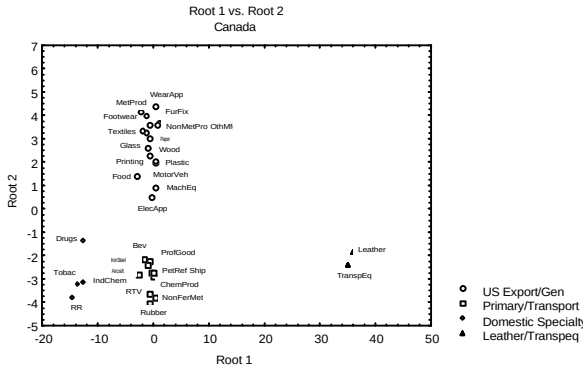
NORWAY
Discriminant Analysis: Wilks' Lambda = .0048912, Approx. F (69,9) = 4.432875, p<.00105

Root	Eigenvalue	Prop.	P-level
1	31.97910	.86015	.000006
2	5.19940	.13985	.045626

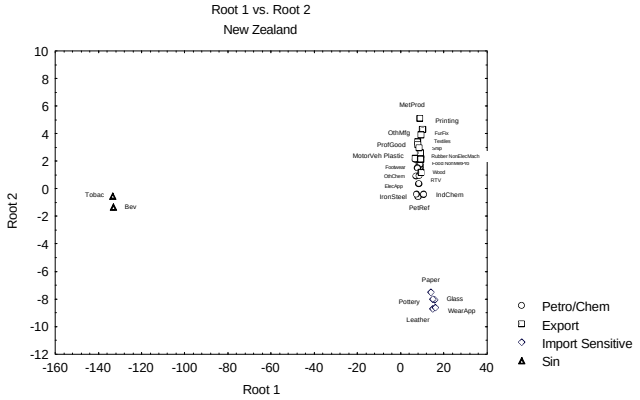
* Denotes proportion of between group variations explained by the root.

Appendix 2

Canada: Discriminant Plots



New Zealand: Discriminant Plots



Norway: Discriminant Plots