# A Network Analytic Approach

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## Background and Objectives

The purpose of this contribution to the "car challenge" is to apply "network analysis" to make (some) sense of brand switching data. Briefly stated, "network analysis" is a "broad intellectual approach", that views social systems as networks of relations between social objects (e.g. groups, people and events) (Knoke and Kuklinski, 1982; Wellman, 1983). It is its contention that attitudes, strategies and behaviors of the members of a social system are affected by their relations to others, by the positions they hold within the whole system of relations as well as by its characteristics and structure.

Therefore, to describe or interpret attitudes and behaviors "network analysis" refers to concepts like centrality, cohesion, structural equivalence, brokerage, bridging, variously defining the position of individuals or organizations within the system they are embedded into.

In this contribution we take a descriptive approach, without attempting to explain or interpret data, as endogeneous or exogeneous variables, although this approach is somehow out of line with more recent and already well established trends in "network analysis" that is increasingly concerned with interpretations, beyond the descriptive stage.

To further define the objective of this analysis, we do not take into account the characteristics of the whole system as such and we focus upon the positions of individual actors, i.e. "subgroups within a network that are defined by the pattern of relations that connect the empirical actors to each other" (Knoke and Kuklinski, 1982). The relations in question may be those linking an actor to the others "directly" ("social cohesion") or "indirectly", by holding similar relations to third parties in the network ("structural equivalence") (Burt, 1982; Burt and Minor, 1983).

In the present context, we define a network $N = <S, S, X>$,where S is an algebraic structure $S = <P, R>$, with $P = \{p_i/p_i$ is a car make) and $R = \{<p_i, p_j>/$ there is a switch from $p_i$ to $p_j$ or vice versa}; S is a graph $S = <P, R>$, with $P = \{p_i/ p_i$ is a point} and $R = \{<p_i, p_j>/$ there is a line between $p_i$ and $p_j\}$; X is a matrix $X = [x_{ij}]$, s.t. $x_{ij} = 1$ if and only if $<p_i, p_j>$ E R, 0 otherwise, where $R = \{<p_i, p_j> ==> x_{ij}/ <p_i, p_j>$ E PxP and $x_{ij}$ is 0 or 1}.

The relation between car makes is therefore defined by the switch "from" and "to" a make, with positive entries in the contingency tables associated to a switch between makes and identifying the intensity or "strength" of the relationship, i.e. the number of individuals switching.

## Plan and Methodology of the Analysis

Only the French 198B, 198C and 198D data have been considered. Raw data have been analysed as such, but they have also been transformed and made binary, to make it easier to investigate the underlying structure of the system, because original matrices are very dense but have many entries with low values, due to diffuse, although at times very marginal, exchanges between makes. It is therefore useful to wipe out some of the weaker relations, by adopting "cutoff" points higher than 1 and by treating some of the lowest entries as a 0, but also to deal with the existence/absence of a relation, in binary terms, disregarding its strength, to make clear the underlying structure of the system. We end up with 3 original and 3 transformed matrices for the 3 years. The transformed matrices are such that $a_{ij}=1$ iff $a_{ij}>(a_i+a_j)/2*.01$, 0 otherwise.

In addition, two more matrices are considered (for 198D only) to investigate asymmetries in exchange flows: a "source" matrix where the flows "from" a make to other makes are considered by setting $a_{ij}=1$ iff $a_{ij}>a_i*.05$, 0 otherwise; and a "target" matrix where flows "to" a make are defined by setting $a_{ij}=1$ iff $a_{ij}>a_j*.05$, 0 otherwise.

Data have been treated with Structure, Version 4.2, developed by Raymond Burt and associates at the Center for Social Sciences, Columbia University. Maximum path length has been set to 1 for original data, to 14 for transformed data, with a frequency decay function. Cohesion is measured by the weakest relation; equivalence is given by the raw relation pattern. Clusters are derived by using the single-linkage or minimum method.

### Cohesion and Equivalence in French Car Industry

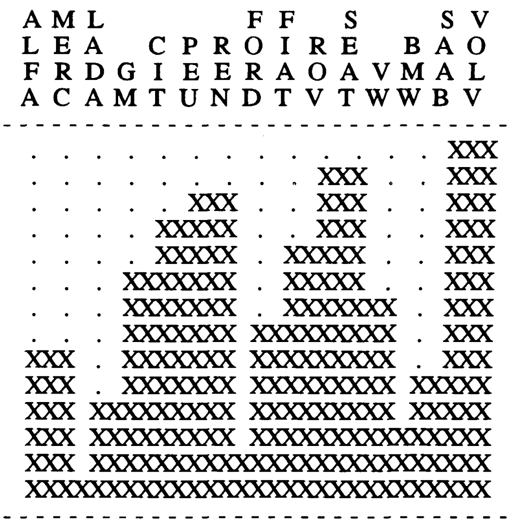
National makes (Peugeot, Renault and Citroen) show strong cohesion in the original matrices and their interchanges are strong and stable over the period (only figures for France 198D are shown). They are frequently joined by Fiat, Ford, VW, GM and few among the major competitors, although those linkages are much weaker and unstable and small yearly differences emerge. At times smaller and lesser cohesive groups are found, involving Seat, Saab, BMW, Mercedes, competitors with lesser market shares and restricted and specialized product lines. The same makes - Seat and Saab, along with Volvo, Lada, Alfa, Rover - are almost structurally equivalent, while Citroen, Peugeot and Renault, on the contrary, have low structural equivalence, with a consistent pattern over the whole period, although at times slightly modified by small yearly changes.

Cohesion and structural equivalence follows therefore a very different - indeed an opposite - pattern, although at times individual positions along those two dimensions may overlap. By disregarding the strength of relations, the "bare" structure of the system comes out, giving a different picture.

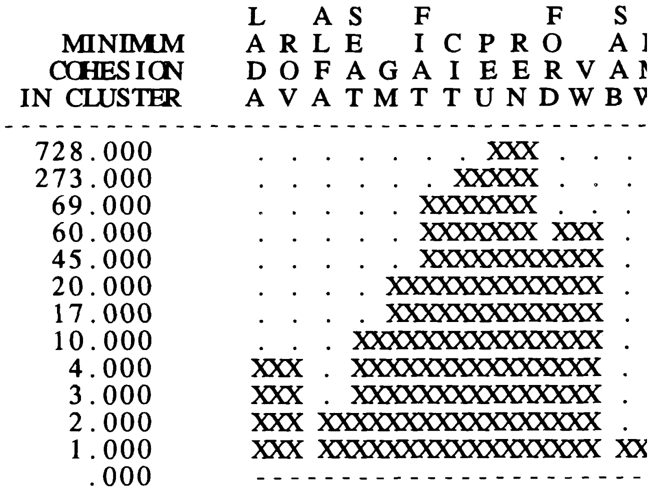
Lada and Seat (in 198B), Mercedes and BMW (in 1988), Saab and Volvo (in 198D) are the highest in cohesion, but very cohesive are also Fiat and Rover; BMW and Mercedes (in 198B); Alfa and Seat; BMW, Mercedes and Volvo; Renault and Rover (in 1988); Seat and Rover; Peugeot, Renault and Citroen (in 198D). No pattern is readily evident, if it isn't for one of general instability, because the structure of the system varies widely, and one of persistence over time of high cohesion among a small number of makes, that change or exchange partners among themselves. The instability of relations is therefore coupled to a (relative) stability of actors.

An unusual feature of the system lies in the coherence between cohesion and structural equivalence, because the makes that are strongly connected tend to be also structurally equivalent, as it is the case for Lada and Seat, with the addition of Fiat and Ford; BMW and Mercedes, in 198B; BMW and Mercedes, Renault and Fiat, Lada and GM, in 198C; Peugeot and Citroen, Lada and Renault, Fiat, Seat, GM, Volvo and Saab, in 198D. "Source" and "target" matrices share a similar feature, because cohesion and equivalence positions are congruent, although patterns across matrices vary, as a result of asymmetries between makes as a source or as a target of switches. Among the "sources" the highest cohesion and structural equivalence is found between Citroen, Peugeot and Renault, and Ford and GM, with the addition of BMW and Mercedes, as far as equivalence only is concerned; among the "targets", the highest values are found between BMW and Mercedes, and between Citroen, Peugeot and Renault, with the addition of Saab and Volvo, when equivalence only is taken into account.

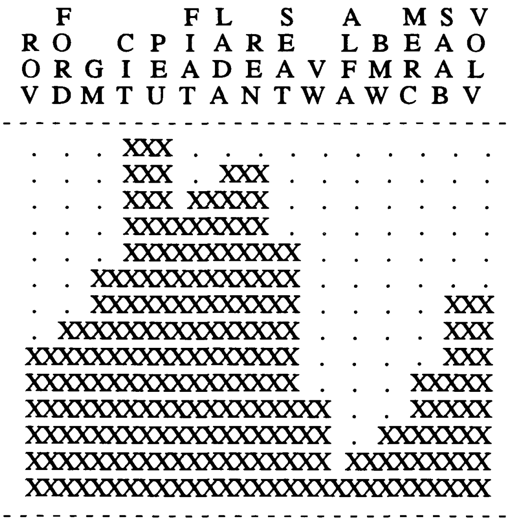
ANSFORMED MATRIX) - COHESION



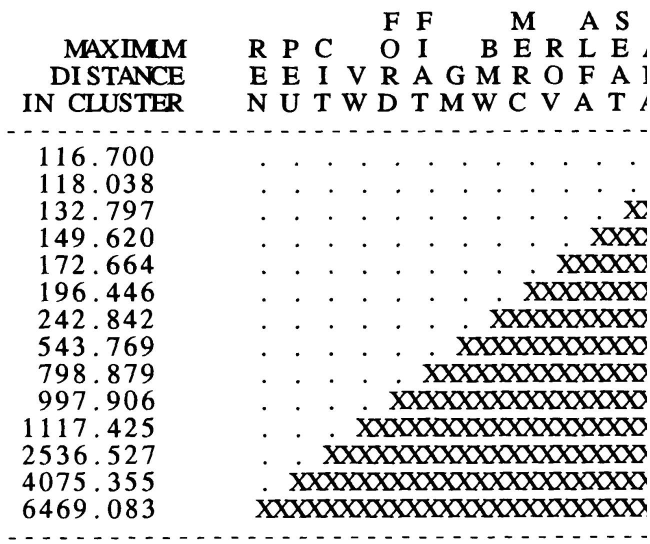
FRANCE 1989 (ORIGINAL MATRIX) - COHESION




ANSFORMED MATRIX) - STRUCTURAL EQUIVALENCE



FRANCE 1989 (ORIGINAL MATRIX) - STRUCTURAL



SOURCE) - COHESION

```
  A F F   L   M           S S   V
  L I O   A B E C P R R A E   O
  F A R G D M R I E E O A A V L
  A T D M A W C T U N V B T W V
---------------------------------
  . . . . . . . . . XXX . . . . .
  . . . . . . . . XXXXX . . . . .
  . . XXX . . . . XXXXX . . . . .
  . . XXX . XXX XXXXX . . . . .
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FRANCE 1989 (TARGET) - COHESION

```
                A F F   L   M
  MINIMUM       L I O   A B E C P R
  COHESION      F A R G D M R I E E
  IN CLUSTER    A T D M A W C T U N
-------------------------------------
     .333       . . . . . XXX . . .
     .067       . . . . . XXX . XXX
     .067       . . . . . XXX XXXXX
     .000       -------------------
```

FRANCE 1989 (TARGET) - STRUCTURAL EQU

SOURCE) - STRUCTURAL EQUIVALENCE

```
  S   M S L A F   F               V
  A B E E A L I R O   C P R       O
  A M R A D F A O R G I E E V L
  B W C T A A T V D M T U N W V
---------------------------------
  . . . . . . . . . . . XXX . .
  . . . . . . . . XXX . XXX . .
  . XXX . . . . . XXX . XXX . .
  . XXX . . . . . XXX XXXXX . .
  . XXX . . . . . XXX XXXXXXX .
  . XXX . . . XXX XXX XXXXXXX .
  . XXX . . XXXXX XXX XXXXXXX .
  . XXX . . XXXXX XXXXXXXXXXX .
  . XXX . XXXXXXX XXXXXXXXXXX .
  . XXX . XXXXXXXXXXXXXXXXXXX .
  . XXX XXXXXXXXXXXXXXXXXXXXX .
  . XXX XXXXXXXXXXXXXXXXXXXXXXX
  . XXXXXXXXXXXXXXXXXXXXXXXXXXX
  XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
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                      A F L   F   S
  MAXIMUM       P C R L I A   O R E
  DISTANCE      E I E F A D G R O A
  IN CLUSTER    U T N A T A M D V T
-------------------------------------
    1.082       . . . . . . . . . .
    1.662       . . . . . . . . . .
    1.794       . XXX . . . . . . .
    1.794       XXXXX . . . . . . .
    1.814       XXXXX . . . . XXX .
    1.825       XXXXX . . . . XXX .
    1.825       XXXXX . . . XXXXX .
    1.833       XXXXX . . . XXXXX .
    1.836       XXXXX . . . XXXXXXX
    1.844       XXXXX . XXX XXXXXXX
    1.852       XXXXX . XXX XXXXXXXX
    1.855       XXXXX XXXXX XXXXXXXX
    1.861       XXXXX XXXXXXXXXXXXXX
    1.894       XXXXXXXXXXXXXXXXXXXX
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