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A Functionalist Framework for Identifying Business Clusters: Applications in Far North Queensland

by
Adee Athiyaman †
Celik Parkan §

Abstract:

The extant literature on industry-cluster identification recommends the use of both quantitative and qualitative data to uncover clusters. We argue for a functionalist approach to identifying clusters. The logic here is that since spatial proximity of firms is an observed fact, attempts to uncover business clusters should begin with a statistical test of the randomness of firm density in a region. Rejection of this hypothesis should lead to an inter-firm analysis that identifies the relationships among firms in the region. Data from a regional area in the state of Queensland, Australia, are employed to demonstrate the applicability of the proposed framework.

Keywords:

INDUSTRY CLUSTERS; COMPETITIVE ADVANTAGE; SPATIAL ANALYSIS; Q-METHODOLOGY; CAIRNS; AUSTRALIA

† Western Illinois University, Macomb, IL 61455, USA. Email: A-Athiyaman@wiu.edu
§ Long Island University, Brookville, NY 11548, USA. Email: cparkan@liu.edu

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1. Introduction

One of the empirical generalizations in the study of economic geography is that business firms tend to locate in close geographical proximity (Bennett, Graham & Bratton 1999; Ellison & Glaeser 1999). The reasons for spatial clustering of firms can be explained at a 'macro', geographical level utilizing 'urban versus rural' location theories such as the 'plant incubation hypothesis' (Nicholson, Brinkley & Evans 1981), or at a 'meso', industry level using conceptual schemes such as 'vertical linkages' (OhUallachain 1984) or, more narrowly, at a 'micro', firm level using the theory of production (Barff 1987). Whatever the explanation, the belief among regional planners is that industry clusters contribute to the economic development of regions (Bradshaw, King & Wahlstrom 1999).

On the other hand, the belief about the efficacy of industry clusters varies among academics. While some academics argue that in a clustered environment isolated companies suffer from a 'periphery discount,' which can amount to 40% lower returns (Morosini 2003; Steinle & Schiele 2002), others claim that 'Planners… are at risk from the official enthusiasm for clusters' (Perry 1999, p. 151). Specifically, Perry (1999) posits that definitional vagueness about clusters has helped cluster advocates to claim clusters at liberty. In other words, lack of theory about clusters has hampered the development of a single methodology to uncovering clusters.

This paper attempts to fill this gap in knowledge. In particular, the paper reviews the different theories or explanations about spatial clustering of firms, highlights the necessary conditions for business clusters to result in economic development, and suggests scientific methods to uncover business clusters in a region. We utilize spatial methods of physical geography to understand and model industry clusters. The logic here is that since spatial proximity of firms is an empirical reality, attempts to uncovering business clusters in a region should test the hypothesis of randomness of firm density in the region. Rejection of this hypothesis should lead to an inter-firm analysis that identifies the vertical/horizontal relationships among firms in the region.

Given that business research is often concerned with spatial and temporal representation of business performance, it could be said that spatial analysis should be part of the methods of business research (Kline 1995; Wilson & Burrough 1999). It is our expectation that readers will observe that the models introduced here, which are based on spatial concepts and use spatial methods, can serve as their 'tools and lenses.'

2. Theories of Spatial Clustering of Firms

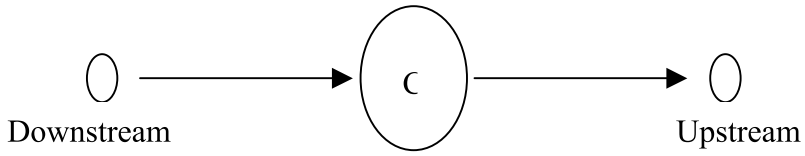
2.1 Macro-Level Geographical Explanations

In capitalist economies, the question of locating new business facilities is usually addressed on the basis of the 'least cost and maximum profit' principle (Lampard 1955). Plant incubation hypothesis conjectures that least cost and maximum profit points are found in or near large urban places. City locations attract new businesses because they house many support services and external economies that nurture immature firms (Nicholson, Brinkley & Evans 1981). These support services may range from financial, legal and educational services to air connections and other transport facilities. As new firms mature and grow, they depend less on the services offered by other firms at an incubation site. This reason, coupled with their requirements to expand, push them out of urban places to areas with lower site rents.

2.2 Meso-Level, Industry-Related Explanations

The plant incubation hypothesis explains agglomeration in a geographical area based on the presence of a diverse complex of economic and social institutions in that area (urbanization). The approach to explaining agglomeration presented in this section draws on vertical linkages among same-sector businesses (localization).

To illustrate, consider industries that are linked vertically as shown below



where C represents the plausible location for firms that must be on the chain.

The downstream industry forms the market for upstream industry. In line with Weber's conceptualisation of localization which suggests that firms locate closer to their markets (Weber 1909 cited in Krzyzanowski 1927, p. 281), market access considerations (technically, market demand considerations) will draw the upstream industry to locations where there are relatively many downstream firms (Phelps 1992). Similarly, firms in the downstream industry will locate where there are relatively many upstream firms in order to save trade costs on their inputs. The result of this combined 'demand pull' and 'cost-push' considerations is agglomeration of activity in a single location (the 'C' in the figure above) (OhUallachain 1984; Venables 1996).

Markusen (1996) classifies localization clusters into the following categories among others: Marshallian clusters and hub-and-spoke clusters. Marshallian clusters include locally owned, small- and medium-size businesses concentrated in craft-based, design-intensive industries, high technology industries, or advanced producer and financial services industries (e.g. Silicon Valley). There is substantial trade among these firms. Specialized services, labour markets, and institutions develop to serve the unique products of the cluster. On the other hand, 'hub and spoke clusters' are based on one or several large businesses surrounded by input suppliers and service providers such as automobile production in Detroit. These clusters frequently foster start-up businesses that buy from and sell to the anchor firm.

Yet another reason for agglomeration related to localization can be found in discussions concerned with the trade theory (see, Venables 1995). Briefly, trade theory relates agglomeration to location specific natural advantages such as topography. For instance, soybean-oil production is concentrated in soybean producing states (New England, North Dakota and South Dakota), and saw mills and wood processing sectors are mostly located in 'timber states' such as Arkansas, Montana, and Idaho. Research suggests that natural advantage accounts for about 20% of observed agglomerations (Ellison & Glaeser 1999, p. 315).

In summary, localization explanations of agglomeration focus on market demand, trade cost, and natural advantage considerations. Externalities such as financial and legal services do not play a prominent role in the theory.

2.3 Micro-Level, Firm-Specific Explanations

The theory of production (Barff 1987) argues that production processes, mainly labour process, determine spatial concentration of firms. The approach utilizes the interrelationships between capital and labour in production to theorize about agglomeration.

Briefly, a firm can be either intensive-intensive or capital-intensive. Firms that face varying demand for their products are most likely to use intensive-intensive production system (cf. Markusen's (1996) Marshallian clusters). In other words, changing demand hampers standardization and mechanization resulting in smaller production runs and thus higher production cost. This encourages small-scale, functionally disintegrated firms, which interact with one another to cluster in order to minimize costs. In contrast, highly capitalized firms internalise various aspects of the production process and thus depend less on proximity to other producers and cheap intensive markets.

A careful thought on the subject would reveal that the theory of production evolves into the localization theory of agglomeration: that is, functionally disintegrated firms in an industry banding together to achieve economies of scale in production. Therefore, in conclusion, it could be said that localization and urbanization concepts explain firm agglomeration activities (Isard 1960).

2.4 Synthesis of Various Explanations

In his attempt to address the question, 'Why do firms based in particular nations achieve international success in distinct segments and industries', Porter (1990) proposes the 'diamond' model of national competitive advantage. The diamond has four elements: (i) factor conditions; (ii) demand conditions; (iii) related and supporting industries; and, (iv) firm's strategy, structure and rivalry.

Briefly, factor conditions include both inherited natural resources and created resources. Most important among the created factors are knowledge and human skills. Because they are susceptible to depreciation over time, they require continual upgrading to ensure that nation's continued economic growth.

Home-market customers are the second element in the Porter model. Sophisticated customers with high expectations demand that domestic industries produce excellent results to address consumer problems. These results are often transferable to other global markets thus enhancing the competitive advantage of the nation.

The third element of Porter's model is the development of related and supporting industries (in a 'localization' sense), which is an interrelated system of supplier and customer firms that encourage one another to innovate through communication. Put another way, regular contact and signalling between upstream/downstream firms helps them to identify and develop new methods, technologies and opportunities.

The final element in the model is firm strategy, structure, and more importantly, rivalry. Porter asserts that intense domestic rivalry produces a passion to win that makes all players leaner, meaner, and better equipped to cope with foreign competitors.

A careful review of the diamond model reveals that it is based on the concept of localization. Specifically, Porter discusses natural advantage (factor conditions), and vertical linkages (demanding customers, suppliers, and competitors) as a part of the explanation for firm or industry success which in turn leads to a nation's success. In a 1998 paper, Porter develops the diamond model further to include the 'urbanization' concept as well. Specifically, he defines clusters as:

> Geographic concentration of interconnected companies, specialist suppliers, service providers, firms in related industries and associated institutions (Porter 1998, p. 197).

Porter (1990, 1998) argues that clustered concentration which includes collection of firms in the same industry (localization) and support industries such as financial firms, legal firms, etc (urbanization) offers significant advantages for competing in global markets. His arguments have had a considerable impact on government policy decisions worldwide (Perry 1999; Clancy, O'Malley, O'Connell & Egeraat 2001; Lundequist & Power 2002).

3. Business Clusters and Economic Development

Porter's (1990, 1998) diamond conceptualisation of competitive advantage suggests that clusters help an area to compete and hence maintain or enhance its rate of economic growth. The implications of this model for governments and firms are to:

1. Create an atmosphere conducive to intense competition;
2. Steer clear of acquisitions and mergers that tend to dampen the competitive spirit and sap the drive to innovate;
3. Take a long-term view in business decisions; and,
4. Optimise factors of production, especially the human capital.

To these generic prescriptions, we add the following:

1. Check that the cluster is based on something unique: that is, a resource or infrastructure that is difficult to imitate (Perry 1999). As aptly stated by Kotval & Mullin (1998), a unique resource is essential to generate sustainable competitive advantage;
2. Develop trust and cooperation between businesses. A shared 'vision' concerning the future of the cluster has been demonstrated to be an important aspect for cluster success (Lundequist & Power 2002);
3. Authorize one or more persons to act as 'cluster drivers'. They can be from both public and the private sectors. Their role would be to act as network brokers between sectors and individual interests (Clancy et al. 2001);

4. Develop a cluster brand. Branding not only strengthens the attraction of cluster for investment, it also unites actors in a shared purpose and identity (Lundequist & Power 2002); and,
5. Provide competence support to clusters. Competence support includes support to individual firms for example, in customer management and marketing area, and more general academic programs targeted at all cluster members. Competence development in areas such as marketing would ensure long-term viability of clusters (Hallencreutz & Lundequist 2003).

There is still much to be learned about clusters and economic development. The above normative prescriptions are some of the lessons learned from clustering in Australia, Sweden, the United Kingdom, and the USA.

4. Uncovering Clusters: Methods and Measures

Thinking is tempered by the way ideas are organized in memory. Since academic discipline prescribes the repertoire of concepts, one is often 'constrained' by the mode of thought that it is specific to one's discipline (Rapoport 1958). However, as aptly observed by Kline (1995), solving real world problems often requires the combining of knowledge from two or more disciplines. As mentioned earlier, we utilize spatial methods of geography to understand and model industry clusters. The approach is based on a combination of spatial analysis methods (e.g. Strauss 1975) and Q-mode multivariate analyses (e.g. Cattell 1978).[1] Two assumptions guided the model construction here: (i) clustering interest or objective pertains to brick-and-mortar firms only; and that (ii) regional planners seek to encourage linkages among firms. Data from a regional area in the state of Queensland, Australia are used to demonstrate the applicability of the analytical framework.

4.1 Spatial Pattern Analysis

In this section, we formulate a model that explains how and when firm density is achieved in a region. To set the stage for discussion, consider a geographical region with $F(t)$ many firms at time t. The growth of these firms over time is assumed to be explained by the simple differential equation:

$$\frac{dF(t)}{dt} = \alpha F \tag{1}$$

where α is a change parameter that captures the determinants of firm growth in a region such as the efforts of local, state and federal governments to attract firms to the region. We assume that inter-firm linkages can be facilitated if there is adequate number of firms in close proximity, say, within a radius of 0.5 km. The logic is it is easier for cooperation to occur between firms that are located across the street to one another than across the state or national borders (Audretsch & Keilbach 2005).

1. More comprehensive discussion about methods of spatial science can be found in Haggett, Cliff, and Frey (1977), and Haining (2003).

To test for firm density within a given radius at time *t*, we employ distances between firms as a measure of density. The method entails centring a circle of radius *r* at each point *i* and counting the number of neighbouring firms within that circle. Assuming that the spatial distribution of the points in a geographical area of *A* units is governed by the Poisson process,[2] if *n* individual points are observed then
the ratio $\lambda = \frac{n}{A}$ provides an estimate of the mean number of points per unit area.
With this information the expected number of points within a circle of radius *r* would be $K(r) = \lambda\pi r^2$. Our intent is to obtain an estimate of the area that contains *n* points, which we represent by $\hat{A}(n)$, based on the observations of point patterns within a given radius and test this estimate against the null hypothesis of complete spatial randomness (Ripley 1981). If $\hat{A}(n)/A > 1$ we interpret the area to have high density of points.

For example, assume that in a circular area with a radius of 2 km one observes $n = 200$ points. The estimate of the mean number of points per unit area is $\lambda = 200/(2^2\pi) = 50/\pi$. The inverse of λ, $\pi/50$, is the mean area per point. Assume further that a circle of radius 0.5 km drawn at a point *i* covers 20 points. The estimate of the area that covers 20 points is

$$\hat{A}(20) = 20\,\frac{\pi}{50} = .4\,\pi = 1.2566 \text{ km}^2.$$

while the actual area *A* is $\pi(.5)^2 = 0.7854$ km^2. Since $\hat{A}(20)/A = 1.2566/0.7854 = 1.6 > 1$ we conclude that the 20 points represent a dense formation. In other words the observed 20 points are expected to occupy an area of 1.256 km^2 while the actual area they take up is 0.786 km^2. Another method of calculation is as follows: Since $\lambda = 50/\pi$ the expected number of points in a circle of $r = 0.5$ km radius is $\lambda\pi r^2 = (50/\pi)\pi(0.5)^2 = 12.5$. Thus 20 points in a circle of 0.5 km radius is 20/12.5 = 1.6 times as dense as 200 points in a circle of 2 km radius.

A formula that facilitates the computation of $\hat{A}(n)$ for *n* circles is given by the expression (Upton & Fingleton 1985):

$$\sum_{i}^{n}\sum_{j}^{n}\frac{I_{ij}(r)}{\lambda^2 A} \tag{2}$$

where $i \neq j$; $I_{ij}(r)$ is a counter variable which equals 1 when the distance between point i and $j \leq$ radius r; 0 otherwise; and A is the region's area.

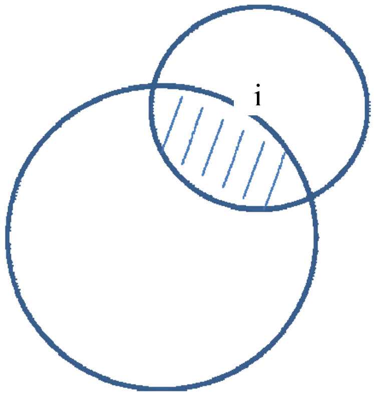
Diggle (1983) argues that an unbiased estimator of $K(r)$ should be corrected for 'bleeding' of sub-region circles beyond the edges of the study region. For instance, in figure 1, the circle centred on *i* would count only firms that are within the boundaries of the larger circle. This amounts to underestimating the geographical area of the smaller circle. What is needed is a procedure that would

2. Poisson distribution can be employed to describe the spatial distribution of *k* points in domain as varied as stars in space, raisins in a cake, flaws in materials, etc. (see, Feller 1957). When Poisson distribution is applicable the likelihood of finding a specific number of points in a domain is dependent only on the area, or volume, of the domain but not on its shape.

increase the unit count by an amount equal to the proportion of the circle that is unobservable because of the border, which is the shaded area in the figure.

Figure 1

Illustration of Density Assessment Methodology: Edge Correction Procedure



Diggle (1983) conjectures that a weighting factor based on the proportion of the circumference of the smaller circle that is embedded within the larger circle should be applied to Eq.(2) for the computation of $\hat{A}(n)$. For instance, in figure 1, the circumference of the smaller circle is $2r\pi$. Letting the part of the circumference of the smaller circle within the larger circle be C_{in}, the ratio $C_{in}/2\pi r = W_i$ is thought to represent 'weight.' The computational procedure for C_{in} is given in Haase (1995). Combining W_i with Eq. (2) results in (Gatrell, Bailey, Diggle & Rowlingson 1996)

$$\hat{A}(n) = \sum_{i}^{n}\sum_{j}^{n}\frac{I_{ij}(r)}{W_i\lambda^2 A}, \tag{3}$$

where $i \neq j$.

Finally, Ripley (1977) suggests scaling $\hat{A}(n)$ to recover the radius $\hat{r}$. Let us define

$$\hat{V}(r) = \sqrt{\frac{\hat{A}(n)}{\pi}} \tag{4}$$

In a situation involving dense concentration of points, $\hat{V}(r)$ would be greater than r. On the other hand, if $\hat{V}(r) < r$ then the tendency is toward an inhibited distribution of points.

Having explained how to assess firm density at time t, we now turn to explaining how firm density evolves in a region. Again, consider a simple growth model of the form

$$\frac{dL(t)}{dt} = \theta L \tag{5}$$

where $L(t)$ denotes the difference between the computed $\widehat{V}(r)$ and the given radius r at time t, and the parameter θ represents the variation of $L(t)$ over time. We utilize difference scores for $L(t)$ to highlight that dense concentration occurs when $L(t)$ is greater than zero. The difference score conceptualisation also reduces complexity in visual presentation of the density formation process (see Figure 2).

Integrating Eq. (5) results in

$$L(t) = L(0)e^{\theta(t)} \tag{6}$$

Eq. (5) is assumed to capture only the natural growth of a region; it is the result of the region's permeable boundaries and the parasitic or symbiotic relationship the region may have with other regions (Miller 1978). Eq. (7) adds to the natural growth by highlighting that regions engage in economic development activities to attract and retain businesses (see the macro and meso level explanations of spatial clustering of firms discussed in section 2).

When $L(t) > 0$, Eq. (5) takes the form:

$$\frac{dL(t)}{dt} = \theta L(t) + \beta Q_t \frac{S - L(t)}{S} \tag{7}$$

where Q_t, a time-specific constant, represents the attractiveness of the location at time t, β is the effect parameter, and S is the saturation level for $L(t)$. We assume that the saturation level is guided by the zoning regulations in the geographical region. The proportion $\frac{S-L(t)}{S}$ in Eq. (7) signifies the unutilised portion of industrial land available in the region. As shown in appendix 1 the solution to Eq. (7) can be expressed as:

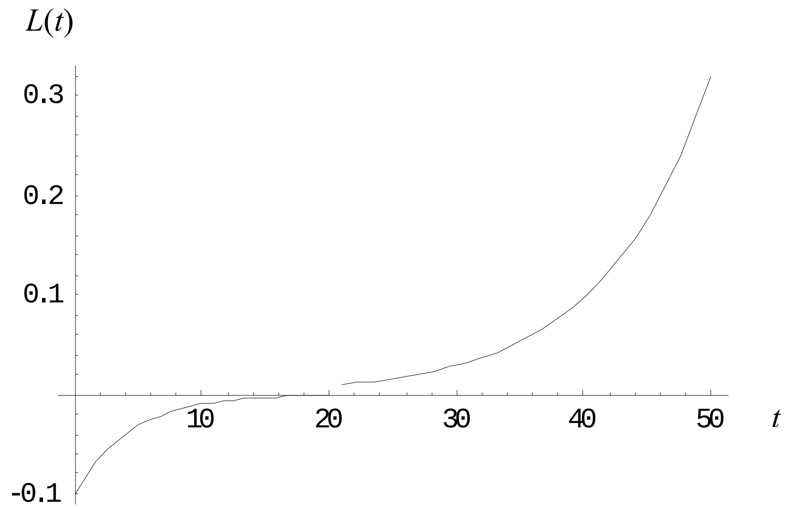
$$L(t) = \beta S\left[\frac{Q_t}{\beta Q_t - \theta S} - \frac{Q_R}{\beta Q_R - \theta S} e^{(\frac{\beta Q_R}{S} - \theta)R - (\frac{\beta Q_t}{S} - \theta)t}\right] \tag{8}$$

where Q_R is the attractiveness of the location at time R. Appendix 1 provides the derivations for equation 8.

Note that our definition of $L(t)$ suggests that $L(t) > 0$ indicates a dense region with many firms; $L(t) < 0$ denotes an inhibited distribution of firms. If information about $L(t)$, Q, and S are available, we can calibrate θ, and β in the model utilizing a criterion such as the minimum mean square error to assess model fit.

Figure 2 is a graphical demonstration of the evolution of $L(t)$ over time using equations 5 and 7. Mathematica 5.2 was used to plot the differential equations 5 and 7. Interested readers can obtain a copy of the program codes by writing to the first author.

Figure 2
A Dynamic Analysis of Firm Density ($L(t)$)



4.1.1 Measures for Spatial Pattern Analysis Data requirement to assess spatial density includes:

1. Names and addresses of firms in the geographical area of interest, and
2. Street directory maps of the geographical region.

The street directory maps should be scaled (abscissas and ordinates) and the location of firms in the area specified in terms of x,y coordinates for statistical analysis (see the Applications section). Note that our approach is simple and doesn't require one to use expensive spatial analysis softwares.

4.2 Q-Methodology

Once the presence of firm density is verified, the next stage in the analysis is to assess the nature of interrelationships among firms in the region. Q-methodology, specifically, Inverse Factor Analysis, can be employed to glean insights into common attributes among the groups (Miller 1978, p. 517). The computational procedures for Q factor analysis are similar to the 'R' factor analysis technique: that is, analysis based on an assessment of relationships among variables.

Cattell (1978) posits that Q and R techniques will produce the same factors if an un-rotated factor solution is obtained from the cross-products matrix derived from the original raw scores matrix. In other words, given a data matrix $A_{n,p}$, we should utilize $A'A$ as input for an R factor analysis. The resulting solution could then be employed to identify relationships among intra-cluster units or firms (Stewart 1981).

4.2.1 Measures for Factor Analysis Data requirements for factor analysis could be classified as pertaining to localization factors and urbanization factors. We operationally define localization factors to include the degree of emphasis firms place on activities related to suppliers, customers and competitors. For example, demanding customers, as defined by Porter (1990, 1998), require firms to monitor changing customer requirements. We could measure this aspect of a firm's activity by asking one or more senior managers of the firm to state the degree of emphasis the firm places on predicting customer requirements. The degree or variation in response can be captured on a 1 to 5 scale where 1 relates to 'Never' and 5 to the response category 'Always'.

For urbanization measures, a perceptual measure such as the following can be used: 'How do you expect local (for example, within 5 miles) financing sources to meet your needs for business financing?' Responses can be obtained on a 5-point scale anchored with 'Very Well' to 'Very Poorly' responses. Table 1 lists the measures related to vertical and horizontal relationships that could be used for an inter-firm factor analysis. Note that these are only plausible indicators of the concepts. Domain sampling theory must be employed to construct the most reliable and valid measures (Nunnally 1967).

5. Applications: Uncovering Business Clusters in Cairns, Australia

Clustering approaches for local economic development in Australia is based on the concept of 'facilitated or induced clusters' (Roberts & Enright 2004, p. 100). Specifically, local businesses are provided with public policy support to collaborate and innovate thus resulting in a cluster of collaborating firms.

The northern region of the state of Queensland is one of Australia's most popular tourism destinations. The economic development agency in the Cairns region (Cairns Region Economic Development Corporation (CREDC)) aims to position the region as an innovative and desirable business and lifestyle location. The cluster initiative is one of the ways to achieve this goal.

5.1 Spatial Analysis of Cairns Businesses

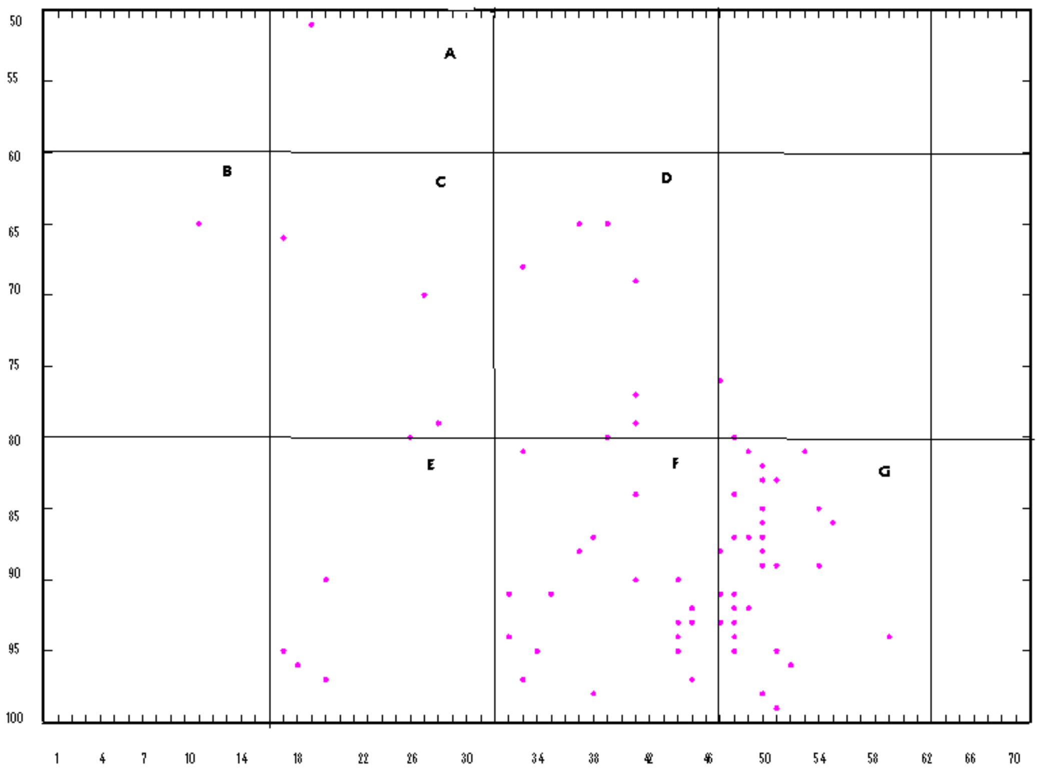
CREDC's cluster initiatives focus on firms that are in the stable or growth stages of business life cycle (Perry 2005). To identify such firms in the region, a database maintained by the Centre for Business & Economic Research at James Cook University was used. Specifically, the database contained information about 113 firms in the Cairns region that matched the 'life cycle' criterion required for 'cluster' analysis: that is, growing and mature firms. Again, readers should note that it is not our intention to scientifically identify clusters in the North Queensland region. Rather, the objective is to demonstrate the applicability of a hierarchical analytical approach to uncovering clusters.

Table 1
Measures to Assess Inter-Firm Relationships: Vertical and Horizontal Relationships

Concept	Definition	Operational Definition
Interrelated supplier and customer factors	Dealings with supplier firms and customers that encourage one another to upgrade and innovate (Porter 1998).	The extent to which the firm: (i) depends on a single supplier for purchases; (ii) predicts customer requirements (for product innovations); (iii) improves existing products (upgrade products to meet customer expectations); Measured on a 5-point 'Never' to 'Always' scale. *Justification*: Dependence on a single source for purchases often requires a complete understanding of market requirements. A consequence of this is product development and innovation.
Rivalry	Firms that operate within the same system of factor endowments (Porter 1990).	The extent to which the firm: (i) prices products lower than competitors; (ii) advertises to build goodwill/reputation; (iii) explores new methods for marketing products. Measured on a 5-point 'Never' to 'Always' scale. *Justification*: All of the above activities are often done after taking into account competitors' actions/reactions. In other words, the pressure of rivalry determines these actions.
Cultural similarity	Firms with the same mind set. For example, similar managerial traits such as leadership and experience (Farjoun 1998, p. 616). The theory is that firms with similar values and beliefs tend to cluster to gain competitive advantage (Morosini 2003).	(i) The extent to which the firm participates in activities related to trade/industry associations. (Measured on a 5-point 'Never' to 'Always' scale.), and (ii) Senior manger's self rating of herself on the following attributes: leadership, creativity, risk-taking, independence, self-confidence, ambition and persistence. Measured on a 5-point 'Well Below Average' and 'Well Above Average' scale.

To spatially analyse these 113 firms, 14 street directory maps of the Cairns region published in the *Telstra White Pages and Yellow Pages Directory* (2005/2006) were utilized. Specifically, the 14 maps were partitioned into 70 x 50 x,y coordinates, the locations of each of the 113 firms were ascertained on the x,y coordinates and the results plotted as a scatter diagram as shown in figure 3.

Figure 3
Scatter Plots of 113 Firms in the Cairns Region

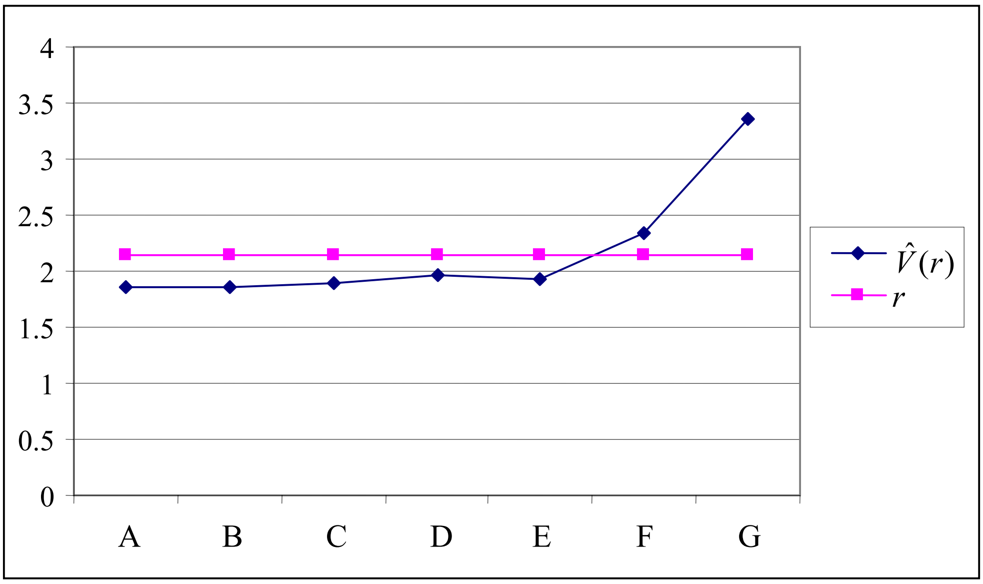


Note: Labels A to G denote suburbs as follows:
A = Barron, Smithfield and Yorkeys Knob (1 firm);
B = Caravonica and Kamerunga (2 firms);
C and D = Aeroglen, Brinsmead, Edge Hill, Freshwater, and Stratford (10 firms);
E = Redlynch (6 firms);
F = Bungalow, Kanimbla, Manoora, Manunda, Mooroobool and Woree (35 firms), and,
G = Cairns city, Cairns North, Paramatta Park and Portsmith (59 firms).

A visual inspection of figure 3 suggests that regions F and G have high density of firms whereas the other regions have only a few firms scattered around their geographical boundaries. To statistically test this assertion, we computed $\hat{V}(r)$ using r = 214 meters (the per unit measurement of figure 3). Note that the value of r determines the geographical boundaries relevant for counting the number of neighbouring firms. Put another way, $r^2 = (0.214)^2$ is weighted by a factor of (22/7) to result in 0.14 kilometers^2 which is the area of the circle or the geographical area that is relevant for counting neighbouring firms. The results (figure 4) confirm our predictions that only regions F and G possess dense distribution of firms. Note that the firms in these regions are predominantly in the construction and the business services industries (table 2).

Figure 4

Test for Firm Density ($\hat{V}(r) > r$)



5.3 Inter-Firm Factor Analysis

The focus was on the 59 firms in the ‘G’ region and the 35 firms in the ‘F’ region (figures 3 and 4). Although these two groups were analysed separately, the methodology of the analyses was the same: that is, factor analyse 9 variables that represented both vertical/horizontal and urbanization facets of firm linkages.

Table 2

Industry Sectors of Firms in Regions F and G

Industry	No. of Firms in Region F	No. of Firms in Region G
Retail	6	9
Wholesale	2	8
Durable Manufacturing	2	5
Business Services	8	14
Personal Services	3	–
Construction	8	23
Other	6	–
Total	35	59

Data for the analyses came from an earlier mail survey of firms in the North Queensland region. Briefly, a total of 959 firms in the North Queensland region were mailed a questionnaire in late 2003, early 2004. Information requested included personal characteristics and work experience of the management, sources of financing, number of employees, problems encountered in running the business, the importance of selected community characteristics such as availability of financial support, and other considerations. Completed questionnaires were received from 181 firms (a 21% response rate for the survey corrected for coverage error). Of these, 62% (n = 113) were located in the Cairns region and these firms constitute the unit of analysis for this research.

The descriptive statistics for the 9 variables employed in the factor analyses are shown in table 3. Both of the factor analyses resulted in one factor explaining approximately 90% of the variability in the data. In other words, all facets of localization and urbanization were captured by the first principal component.

To understand existing linkages among firms in the regions, component coordinate scores were computed for each firm, the distance between firms assessed and based on that assessment, similarity between firms established. Appendix 2 highlights the computational procedures involved in this exercise. Briefly, the procedures involved constructing a 95% confidence interval around the mean value of the component scores, determining firms within the 95% confidence interval and examining their relationships on variables x1 to x9 (table 3). Note that all individual component variables rather than components/factors are used in this exercise to glean insights into relationships among firms.

Table 3

Descriptions of Variables Used in the Factor Analyses

Variable	Definition	Perceptual Measure
x_1	Single supplier	The question read, 'Please show the extent to which the following practices are being used in your business.' Measured on a 5-point 'Never' to 'Always' scale.
x_2	Predict customer requirements	
x_3	Improve products	
x_4	Price ‹ Competitors' price	
x_5	Advertising	
x_6	New marketing methods	
x_7	Participate in trade associations	
x_8	Personal attributes	'How would you rate yourself on each of the following attributes: leadership, creativity, risk-taking, independence, self-confidence, ambition and persistence'. The attributes were measured on a 5-point 'Well Below Average' and 'Well Above Average' scale and the ratings summed to arrive at an average composite score.
x_9	Adequacy of local financing sources (urbanization indicator)	'How do you expect local financing sources to meet your needs for business financing?' Responses were obtained on a 5-point scale anchored with 'Very Well' to 'Very Poorly' responses.

Table 3 Cont.

	r_{i1}	r_{i2}	r_{i3}	r_{i4}	r_{i5}	r_{i6}	r_{i7}	r_{i8}	r_{i9}	Mean	SD
(i) Region G = Cairns city, Cairns North, Paramatta Park and Portsmith (59 firms)											
x_1	1									4.2	0.83
x_2	0.44	1								3.5	0.77
x_3	0.09	–0.02	1							3.6	1.3
x_4	0.19	0.05	0.12	1						4.1	1.9
x_5	–0.27	–0.22	0.13	–0.17	1					3.5	1.3
x_6	–0.12	–0.21	0.22	0.39	0.23	1				3.3	1.6
x_7	0.47	0.22	–0.21	–0.14	0.13	–0.54	1			3.5	1.5
x_8	0.12	–0.37	–0.41	0.25	–0.27	0.31	0.1	1		3.7	0.51
x_9	–0.34	–0.3	–0.23	0.13	0.17	0.53	0.02	0.72	1	4.0	1.2
(ii) Region F = Bungalow, Kanimbla, Manoora, Manunda, Mooroobool and Woree (35 firms)											
x_1	1									3.4	1.4
x_2	0.41	1								3.8	0.9
x_3	–0.08	0.16	1							3.6	1.0
x_4	0.37	0.41	–0.09	1						3.5	0.9
x_5	0.16	0.53	–0.1	0.42	1					3.7	0.9
x_6	–0.21	0.41	0.39	0.24	0.35	1				3.8	2.3
x_7	0.08	0.27	0.12	0.42	0.53	0.37	1			3.7	1.1
x_8	–0.3	–0.14	–0.13	–0.21	0.32	0.23	0.18	1		3.6	0.6
x_9	0.15	0.05	–0.02	–0.27	0.01	0.36	–0.02	–0.19	1	3.5	2.4

Note: Theoretical justification for the variables are summarised in table 1.

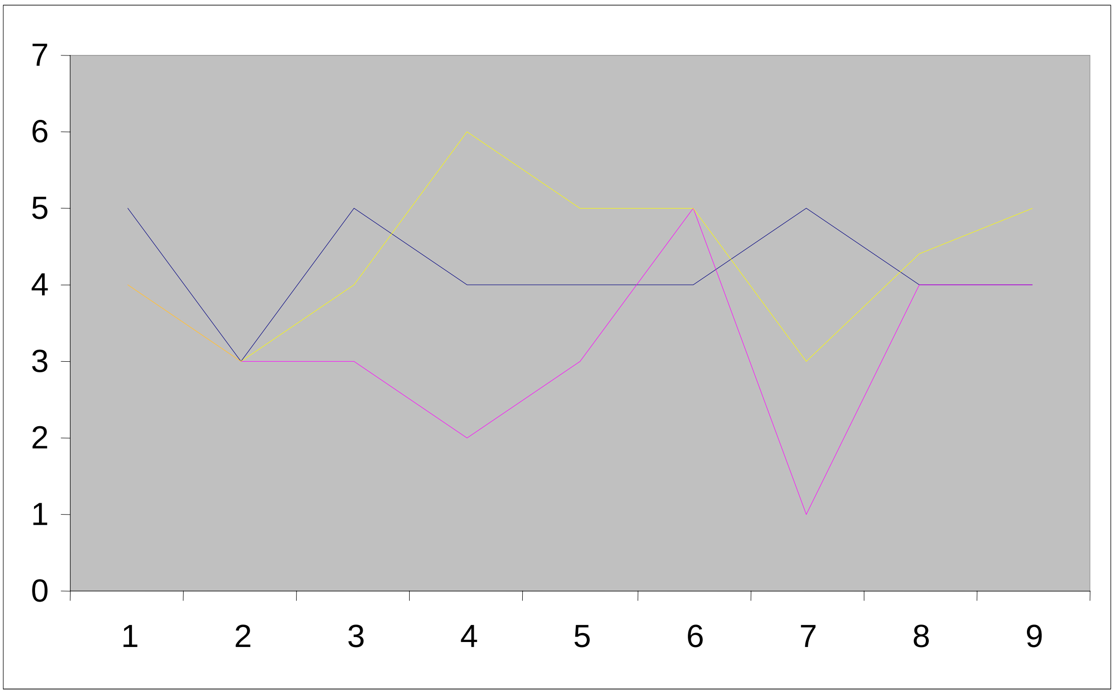
The findings highlight that construction and business services sectors in Cairns could be targeted for cluster development purposes. Specifically, opportunities exist to develop both intra-industry and inter-industry collaboration. To elaborate, note that the Snake Plot given in figure 5 demonstrates that construction firms want to explore new marketing methods for their products. Intra-industry collaboration in this area should result in setting aside resources for researching this aspect of the market. Business services firms in the region, especially management consulting firms, could join this initiative by implementing 'house of quality' research to discovering innovative and unique methods to marketing the construction industry products. Ideas for conducting such research can be gleaned from Griffin and Hauser (1993, pp. 8–16).

The empirical findings can be justified using Porter's theory of competitive advantage. For instance, the Porter model highlights that competitive advantage is a result of value creation in the marketplace. The study of strategy offers 'value chain analysis' as a method to capture the value creation processes of firms (Davis & Devinney 1997). Specifically, value-chain analysis examines processes within a firm to determine value-creating activities.

An approach similar to value-chain analysis that is applied at the industry-level is 'value-system analysis' (Grundy 1998). This technique enables one to examine how the various value chains in an industry are arranged vertically among companies in the industry.

Figure 5

Snake Plot Highlighting Similarities among Firms: A Sample of Construction Firms



Note: X axis pertains to the 9 variables given in table 3. Y axis relates to the measurement scales. Consult appendix 2 for further details about linkages among firms.

We theorise about linkages between construction industry and business service sectors using a variation of the value-chain and the value-system approaches. The components of the conceptual framework include:

1. A business model: Value-added activities of firms in the industry. These would be a collection of activities that firms in the industry perform to be in business;
2. An assessment of ‘value adding’ activities that are internal to industry in the study region (indigenous value adding activities); and,
3. An analysis of gaps between the business model and the indigenous value adding activities.

We begin with a discussion about business model for an industry. A business model describes the major activities that firms in an industry perform to be in business. We contend that a business model could be constructed by linking all the value adding activities of firms in the industry (value system analysis). These activities would be the industry’s core value-adding activities. To this structure, we add the value adding activities of the domestic industry in the region (indigenous value adding activities). These are major activities that the domestic industry performs in the course of its business. Note that activities that are required but are not internal must be filled by network relationships. Network relationships highlight both horizontal and vertical linkages of an industry. Specifically, it includes customers, suppliers, competitors, allies, regulatory agencies, etc.

Consider figure 6a. It highlights the business model for the construction industry. Specifically, there are eight core activities for the construction industry: project definition, evaluation, design management, cost management, project evaluation, procurement, construction management, and facilities management (Jamieson, Thorpe & Tyler 2002). In Cairns, the construction industry is dominated by firms that provide building construction services such as bricklaying and roofing, plumbing and electrical, plastering, carpentry, and landscaping (table 4). Building consultants, and quantity surveyors were also present but in limited numbers (table 4). In line with our conceptualisation, the value adding activities of indigenous firms in the region can be categorized into three categories: Designing the building (architects and consultants), costing the project (quantity surveyor), and constructing the building (building contractors) (figure 6b).

Figure 6

Analyses for Cluster Development Purposes

(a) Business Model for the Construction Industry

Project Definition → Evaluation → Design Management → Cost Management → Project Evaluation → Procurement → Construction Management → Facilities Management

(b) Indigenous Value Adding Activities

Design Management → Cost Management → Construction Management

(c) Overall Analyses for Cluster Development Purposes

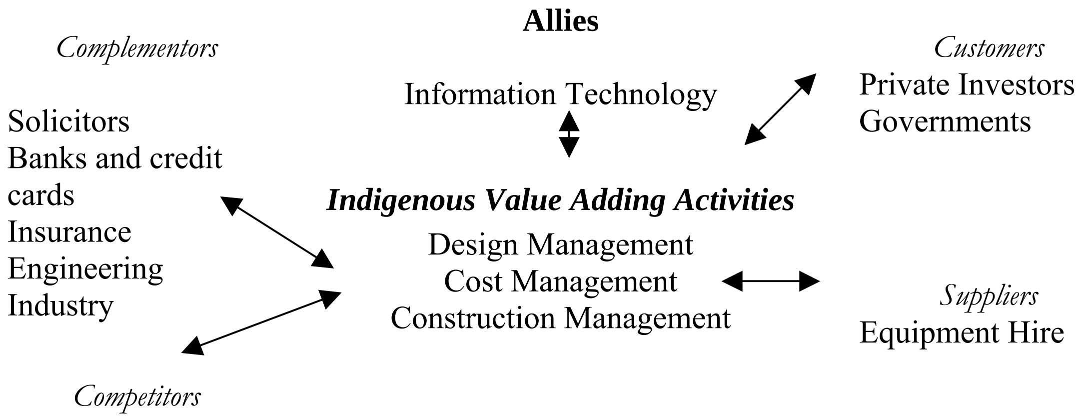


Table 4

Yellow Pages Search Results for Construction Industry in Cairns, Queensland

Type of Business	Number of Firms
Building consultants	22
Building contractors	27
Building surveyors	4
Roof construction	13
Equipment hire	12
Solicitors—construction related	8
Insurance—construction products	3
Paving—brick	16
Concrete contractors	1
Landscape architects	5
Building renovations	6
Surveyors	5
Irrigation or reticulation systems	2
Garage builders / prefabricators	5
Drainers	10
Carpenters	8
Concrete products	3
Kitchens	4
Fencing	3
Kit homes	1
Drafting services	2
Spas and equipment	2
Rubbish removers	3
Pest control	1
Painters and decorators	2

Note: Source: 'http://www.yellowpages.com. au'. Accessed March 29, 2007.

The gap between the business model and the indigenous value-adding activities suggest opportunities for networking. For instance, the project definition and evaluation phases require an understanding of clients' requirements. Recent research conducted by Microsoft and SevenThree highlight that as much as 60% of firms in the construction industry fail to understand customer requirements (Pearman 2007). Hope (2006) posits that networking with marketing firms can reinvigorate the marketing processes in construction firms. El-Higzi (2002) argues that marketing is required to address the industry's cyclical nature of demand; specifically, to synchronize supply and demand. Hence it is logical that the industry develops network relationships with business services in the region.

6. Conclusion

The major contribution of this paper is the methodology to uncovering clusters in a region. We argue for a functionalist approach to identifying clusters. Since spatial clustering of firms is an empirical reality, attempts at uncovering business clusters should begin with a 'point-pattern analysis' of firms in a region to test the hypothesis of randomness of the spatial agglomeration process. Rejection of this hypothesis should lead to an inter-firm, Q-method analysis that identifies the vertical/horizontal relationships among firms in the region.

This approach to identifying industry clusters is built on the assumption that spatially agglomerated firms with a similar mind set could cooperate on critical activities that are of common interest to all. The methodology outlined in this paper can help regional planners facilitate economic and social linkages among firms.

The paper offers guidelines for networking among existing clusters in North Queensland. For instance, the Cairns Region Engineering Network (CREN)[3] aims to increase the market opportunities of its members. Given that engineering firms such as metal fabrication firms are complementors for the construction industry (figure 6c), opportunities exist to secure joint venture projects between engineering and construction firms. Furthermore, business service firms in the region could help networking and information sharing between these clusters and clients in international markets. Specifically, market research firms in Cairns can help construction industry recognize gaps for goods and services in the market place. Similarly, financial services firms in the region can help construction managers to assemble necessary resources to 'complete' the inputs needed in the production processes, and optimise the production process. An example of such an initiative involving engineering, construction, and business service firms can be found in Edmonton, Canada.[4]

Finally, we recognise that a questionnaire survey of firms in the region is required to implement the approach but believe that it will gain the necessary information to 'link' intra and inter industry firms.

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3. http://www.credc.com.au/cluster_cren.html
4. See http://www.edmonton.com/business

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Appendix 1

Derivations Related to Equation 8

From Eq. (7)

$$\frac{dL(t)}{dt} = \theta L(t) + \beta Q_t \frac{S - L(t)}{S}$$

$$= \theta L(t) + \beta Q_t - \frac{\beta Q_t L(t)}{S}$$

$$= \beta Q_t + L(t)(\theta - \frac{\beta Q_t}{S})$$

which can be rewritten as

$$\frac{dL(t)}{dt} - L(t)(\theta - \frac{\beta Q_t}{S}) = \beta Q_t$$

or

$$\frac{dL(t)}{dt} + (\frac{\beta Q_t}{S} - \theta)L(t) = \beta Q_t$$

Applying an integrating factor $e^{\int \frac{\beta Q_t}{S} - \theta} dt$ to the last equation above results in:

$$e^{\int (\frac{\beta Q_t}{S} - \theta) dt} [\frac{dL(t)}{dt} + (\frac{\beta Q_t}{S} - \theta)L(t)] = e^{\int (\frac{\beta Q_t}{S} - \theta) dt} \beta Q_t ,$$

$$e^{(\frac{\beta Q_t}{S} - \theta)t} \frac{dL(t)}{dt} + (\frac{\beta Q_t}{S} - \theta)L(t)\, e^{(\frac{\beta Q_t}{S} - \theta)t} = e^{(\frac{\beta Q_t}{S} - \theta)t} \beta Q_t ,$$

or equivalently, $D_t[e^{(\frac{\beta Q_t}{S} - \theta)t} L(t)] = e^{(\frac{\beta Q_t}{S} - \theta)t} \beta Q_t$.

Integrating both sides with respect to *t* yields:

$$e^{(\frac{\beta Q_t}{S} - \theta)t} L(t) = \int e^{(\frac{\beta Q_t}{S} - \theta)t} \beta Q_t\, dt ,$$

$$e^{(\frac{\beta Q_t}{S} - \theta)t} L(t) = \beta Q_t \int e^{(\frac{\beta Q_t}{S} - \theta)t} dt ,$$

$$e^{(\frac{\beta Q_t}{S} - \theta)t} L(t) = \frac{\beta Q_t e^{(\frac{\beta Q_t}{S} - \theta)t}}{\frac{\beta Q_t}{S} - \theta} + C \text{, and}$$

$$L(t) = [\ \frac{\beta Q_t e^{(\frac{\beta Q_t}{S} - \theta)t}}{\frac{\beta Q_t}{S} - \theta} + C\ ]\ e^{-(\frac{\beta Q_t}{S} - \theta)t}$$

or

$$L(t) = \frac{\beta Q_t}{\frac{\beta Q_t}{S} - \theta} + Ce^{-(\frac{\beta Qt}{s} - \theta)t}$$

Set *L(R)* = 0. This results in:

$$L(R) = \frac{\beta Q_R}{\frac{\beta Q_R}{S} - \theta} + Ce^{-(\frac{\beta Q_R}{s} - \theta)R} = 0$$

and

$$C = -\frac{\beta Q_R}{\frac{\beta Q_R}{S} - \theta} e^{(\frac{\beta Q_R}{S} - \theta)R}$$

Therefore,

$$L(t) = \frac{\beta Q_t}{\frac{\beta Q_t}{S} - \theta} - \frac{\beta Q_R}{\frac{\beta Q_R}{S} - \theta} e^{(\frac{\beta Q_R}{S} - \theta)R} e^{-(\frac{\beta Q_t}{S} - \theta)t}$$

$$L(t) = \frac{\beta Q_t}{\frac{\beta Q_t}{S} - \theta} - \frac{\beta Q_R}{\frac{\beta Q_R}{S} - \theta} e^{(\frac{\beta Q_R}{S} - \theta)R - (\frac{\beta Q_t}{S} - \theta)t}$$

$$L(t) = \beta S \left[\frac{Q_t}{\beta Q_t - \theta S} - \frac{Q_R}{\beta Q_R - \theta S} e^{(\frac{\beta Q_R}{S} - \theta)R - (\frac{\beta Q_t}{S} - \theta)t} \right]$$

Appendix 2

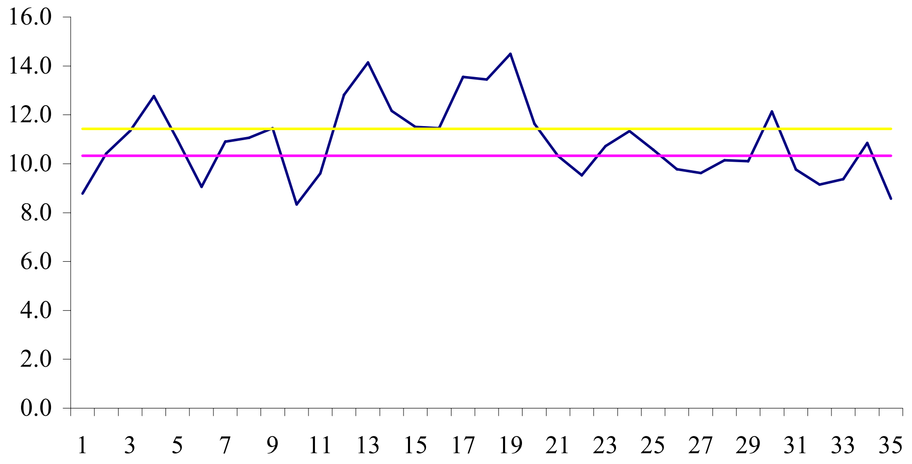
Note on Uncovering Clusters Utilizing Q-Methodology and Agreement Measures

To explore the similarity of firms in the regions, firms were first classified according to their component scores (figure 1). Next, based on an examination of intra-industry scores, firms that are closer to each other were chosen (table 1). Finally, a probability model was fitted to each of the nine 'relationships' variables given in table 3 to glean insights into relationships that can be nurtured for cluster development purposes (figure 2).

Figure 1

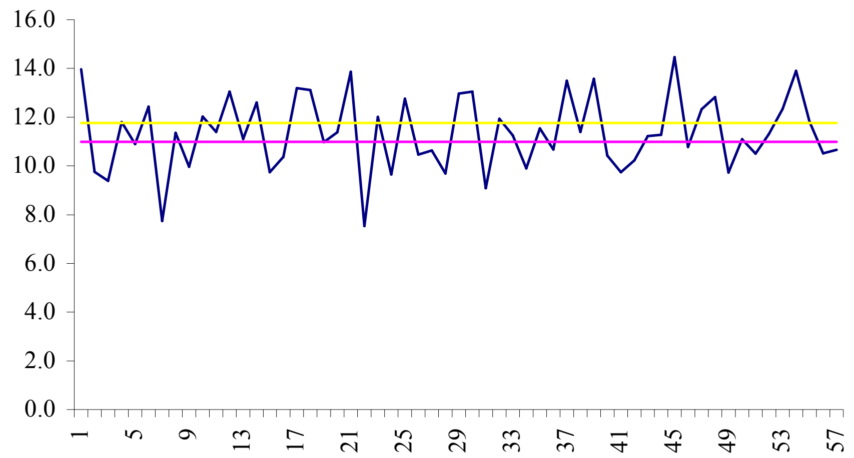
Principal Component Scores for Clustered Concentration in the Cairns Region

(i) The 35 firms in the F Region



Note: $\text{Mean}_{\text{component scores}} = 10.90$; $S^2 = 2.47$; LCI = 10.33; UCI = 11.43

(ii) The 59 firms in the G Region



Note: $\text{Mean}_{\text{component scores}} = 11.37$; $S^2 = 2.30$; LCI = 10.98; UCI = 11.76. The 'band' in the figure shows the areas that include the 95% confidence interval for the mean.

To explore associations or linkages among firms, we chose a set of firms that are closer to each other on the component scores. Specifically, the 95% confidence interval measure was used to reduce the original N firms to a smaller set of n firms. As shown in table 1 a subset of 10 firms were chosen from the original 35 firms in region F and a subset of 11 firms were chosen from the original set of 59 firms in region G.

Table 1

Firms Chosen for Further Analysis: Implementation of Confidence Interval Criterion

(i) The 35 Firms in the F Region

Firm No	PCA Coordinate	Industry
1	8.3	Construction
2	9.8	Retail
3	9.6	Construction
4	9.5	Personal Services
5	8.8	Business Services
6	9.6	Retail
7	10.1	Retail
8	10.4	Business Services
9	11.3	Business Services
10	12.8	Business Services
11	10.7	Personal Services
12	9.4	Wholesale
13	13.5	Other
14	10.1	Retail
15	11.4	Durable Mfg
16	12.8	Construction
17	13.4	Other
18	14.5	Other
19	14.1	Construction
20	11.6	Other
21	11.0	Business Services
22	8.6	Construction
23	12.2	Construction
24	12.1	Retail
25	11.5	Construction
26	11.3	Personal Services
27	9.1	Business Services
28	9.8	Retail
29	9.2	Retail
30	10.9	Business Services
31	11.1	Business Services
32	11.5	Business Services
33	10.6	Personal Services
34	10.8	Wholesale
35	10.3	Other

(ii) The 59 Firms in the G Region

Firm No	PCA Coordinate	Industry	Firm No	PCA Coordinate	Industry
1	13.6	Business Services	31	9.7	Construction
2	10.4	Retail	32	12.4	Business Services
3	9.7	Wholesale	33	12.8	Construction
4	11.1	Construction	34	14.5	Retail
5	12.6	Construction	35	11.4	Durable Mfg
6	10.7	Business Services	36	13.9	Wholesale
7	9.7	Construction	37	10.5	Construction
8	9.7	Retail	38	7.7	Business Services
9	10.7	Durable Mfg	39	10.6	Construction
10	11.1	Wholesale	40	11.4	Business Services
11	10.4	Construction	41	10.8	Retail
12	14.0	Business Services	42	11.8	Wholesale
13	13.2	Construction	43	9.7	Construction
14	9.8	Business Services	44	13.0	Construction
15	10.2	Retail	45	10.0	Business Services
16	10.5	Wholesale	46	13.0	Construction
17	13.1	Construction	47	12.3	Retail
18	11.0	Construction	48	13.6	Durable Mfg
19	9.4	Business Services	49	10.5	Wholesale
20	11.4	Construction	50	9.1	Construction
21	11.2	Retail	51	12.0	Business Services
22	13.5	Durable Mfg	52	11.9	Construction
23	11.3	Wholesale	53	11.4	Business Services
24	13.9	Construction	54	12.8	Retail
25	11.8	Business Services	55	10.7	Wholesale
26	7.5	Construction	56	11.2	Construction
27	10.9	Business Services	57	9.9	Construction
28	11.3	Retail	58	13.1	Business Services
29	12.3	Wholesale	59	11.5	Construction
30	12.0	Construction			

Note: Highlighted firms have component scores within the 95% Confidence Interval range. These firms were chosen for further analyses to uncover relationships involving x_1 to x_9 variables.

Where are the Commonalities?

We employed the concept of 'agreement' to glean insights into firm relationships. In line with measurement theory (Nunnally 1967) we defined agreement as identical, paired values. For example, agreement between Firm1 and Firm2 on x_1 variable requires that $F1_{x_1} = F2_{x_1}$. To ensure validity of findings, a statistical test of agreements based on the χ^2 distribution was conducted (figure 2.).

As shown in figure 2, commonalities exist among firms in both goods producing and service sectors. For instance, the managers of construction firms have a common mindset or personality (x_8). They also advertise their products (x_5). Service business managers not only have personal attributes (x_8) similar to that of construction companies, but also rely on single supplier for purchases (x_1), and price their products less than that of competitors' (x_5).

Note that information from figure 2 can be used as inputs to cluster mustering activities. For instance, regional planners can make use of the common interest among firms on 'supply factors' to organize a workshop on the topic and thus bring firms in the region together for discussions and plausible collaboration.

Figure 2

Uncovering Relationships Among Firms Using Agreement Measures

(i) The 35 Firms in the F Region

Relationships that are above chance (Observed $\chi^2 \geq \alpha \sim .10$, $\nu = 9$)

x_1: Single supplier

(5)
|
(10)
|
(1) – (2) – (3) – (7) – (8) – (9)
|
(4) – (6)

x_2: Predict customer requirements

(6) – (9)
|
(1) – (2) – (3) – (4)
|
(5) – (7) – (8) – (9) – (10)

x_4: Price < Competitors'

(10)
|
(3) – (8) – (9)
|
(1) – (2) – (4) – (5) – (6) – (7)

x_8: Personal Attributes

(1) – (2) – (5) – (6) – (10)
|
(3) – (7) – (8) – (9)
|
(4)

Note: Firms 1, 2, 5, 7 and 8 are business services; firms 3, 6 and 9 are personal services; firm 4 is a manufacturing enterprise, and firm 10 is in wholesale business.

(ii) The 59 Firms in the G Region

Relationships that are above chance (Observed $\chi^2 \geq \alpha \sim .10$, $\nu = 10$)

x_1: Single supplier

(1)
|
(3)
|
(5) – (6) – (7) – (9) – (10) – (11)
|
(2) – (4) – (8)

x_5: Advertising

(2)
|
(10)
|
(3) – (4) – (5) – (6) – (7) – (8) – (9)
|
(1) – (11)

x_8: Personal Attributes

(1) – (3) – (4) – (8) – (9)
|
(2) – (6) – (7) – (10) – (11)
|
(5)

Note: Firms 1, 3, 4 and 11 are in construction business; firms 2 and 6 are in wholesale; 5 and 7 in retail; 9 and 10 in business services, and firm 8 is a manufacturing enterprise.