Capability-Market Matrix Analysis for Economic Development Policy

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Abstract:
Over the past decade, there has been significant interest in regions and communities worldwide to attract and incubate growth oriented high technology companies as an approach to economic development. In this paper, we introduce a simple method (CM Matrix) for analyzing the strengths of a community to grow high technology companies. The method can be applied to distinguish the relative strengths of a region based on the available talent pool in that region. The model is illustrated using data collected in the Champaign-Urbana region in Illinois, USA. Several hypotheses for future research are also suggested.

INTRODUCTION
One of the commonly observed features of workforce demographics is that businesses with similar interests tend to cluster together. The notion of geographical proximity is an important factor in the emergence and sustainability of professional talent in a region or community [1,2]. Industries agglomerate in a region rather than remaining dispersed because of advantages partly attributed to the presence of 'localized technological spillovers' that reduce the cost of transmitting ideas and innovations [3]. Soubeyran agrees that informational spillovers are caused by the accumulation of human capital and the subsequent face-to-face communication [1]. Saxenian studied the development of two well-known high technology industrial regions (Silicon Valley and Massachusetts' Route 128) over the last two decades and found similar clustering trends [2].

Although many qualitative studies exist, in the literature, about analyzing the occurrence of human capital clustering and its consequences, there is a lack of quantitative tools that can be used for such analysis. This study introduces a simple quantitative method for analyzing the potential of a community to grow high technology companies. The proposed method can distinguish the relative strengths of a region based on the available talent pool in that region. Most of the qualitative work on the clustering of human capital, study the clustering of professionals based on a single criteria such as technical skill. In this paper we quantitatively study the clustering of professionals based on both the markets they serve as well as their specialization (i.e. capability). With this data, we can make inferences about the relative strengths of the region based on the talent pool of skills and relationships already existing in that region.

Our rationale to use both criteria is based on Ansor's work. Ansor describes three risk-mitigating strategies for growing a particular company with a given product (or technology) and selling into a given market [4]. He suggests that keeping the product or market constant while changing the other is a less risky way to strategically adapt and target growth. Specifically, a company desiring intensive growth has options, which include: 1) market penetration (same product and market), 2) product development (same market, new product), or 3) market development (new market, same product).[1] Product diversification in this case is the unnamed option of developing a new product for a new market. In the realm of a technology company, we broaden the definition of product to include the "capability" of what can be produced by that company. In this work, we extend these business foundations with quantitative analysis techniques, which are tractable for larger groups of businesses as opposed to a single business for which the foundations were originally applied.

The rest of the paper proceeds as follows, in section 2 we present a literature review of scholarly work relevant to this paper. This is followed by an explanation of the capability-market matrix model in section 3. The model is illustrated using real data in section 4. Finally section 5 contains a summary and our final conclusions.

LITERATURE REVIEW
Cities and regions that look for technology based economic growth speculate on which companies or industries are likely to grow and do well in their respective environments. Alaedini and Marcotullio show that for developed countries, the centers of advanced business services and high-tech industries have benefited, while cities dominated

[1] Besides intensive growth, other well-known growth techniques are 1) to diversify or 2) to change business landscape through horizontal and vertical acquisitions.

by traditional blue-collar employment have stagnated [5]. Soubeyran and Weber demonstrate that a dispersed equilibrium can emerge only if firms' and districts' characteristics possess a sufficient degree of heterogeneity [1]. Both these papers give valuable information on the effects of change in the talent pool of a region, but provided only qualitative.

Many studies have attempted to correlate either the human resource characteristics or the regional characteristics with the creation of new businesses [6,7]. D'Cruz, for example, identifies 10 regional policy ingredients, which are important for successful venture creation [7]. These factors include suitable financing, availability of a competent workforce, access to helpful suppliers, government support (or at least absence of obstacles), proximity to Universities to assist in research, availability of land and facilities, access to transportation, support of local population, available support services (secretarial, telecom, etc), and low barriers to entry. While Cruz was effective at identifying high level policy considerations for a geographic region, he does not examine synergies between companies, the company capabilities in that region or the resulting policy issues that may arise.

Both theoretical and empirical models exist for analyzing local or regional clustering of workers [8,1,2]. Peri finds that skills can be transferred from one person to another in young companies due to technological factors resulting in urban areas becoming learning grounds for educated workers, which is a more recent argument for clustering [8].

Business growth can also be analyzed from a perspective of business strategy. From this orientation, it is common to evaluate a business as an individual entity or as portfolio of sub components. For example, SWOT (strengths, weaknesses, opportunities, and threats) analysis is a method of evaluating the potential of an individual business [9]. The SWOT method was developed after the more fundamental analysis of how businesses grow by Ansor. As stated earlier, Ansor argued that companies take unnecessary risks when they develop new products that don't match the firms existing capabilities [4].

From a strategy point of view, portfolio analysis techniques such as Boston Consulting Groups Model [10] and the GE and McKenzie approach [11] offer methods to compare a set of business units (within a single corporate umbrella) using two primary determinants: 1) market attractiveness and 2) uniqueness of position. Historically, these models have been extensively been used, as well as criticized, for corporate strategy. Recently, the authors have observed local geographic regions with multiple companies using these same techniques for analyzing their portfolio of companies. However, it is not clear that the models have any relevance in this context since no decision can be made to divest or transfer resource from one business to another when examined from a public policy point of view. For this reason, we are proposing in this paper the Capability-Market matrix, which is a more suitable analysis tool for companies within a geographic region.

Portfolio models are also well known for not considering the synergy between the holdings in the portfolio. In successful geographic regions, synergistic companies do tend to cluster with each other [12,13,14]. Molotch studies the relationship between industries and geographic areas [14]. He investigates why one city prevails over another to produce a particular product – Why Detroit, say, beat Toledo, Ohio, to become the center of US car production. Sorenson, for example, has pointed out that a clustering of companies shows a positive correlation with industry sector success [12]. This study is augmented with anecdotal evidence from Silicon Valley and Chicago. Jacobs furthers these ideas in her paper on 'Co-development webs' [13]. Rivero discusses some of the reasons for this clustering phenomenon and provides an empirical discussion on the birth and growth of a technology cluster [15]. In this paper, we accept and build on clustering as a phenomenon. However, by introducing the Capability-Market matrix, we establish a tool, which can be used for predicting potential growth areas in a region based on observable clusters of synergistic activities.

CAPABILITY-MARKET MATRIX

From an economic development policy viewpoint, Ansor's method is not sufficient because it was intended to be a thought process for a single company. In this paper, we suggest that it is possible to extend this process for a geographic region or portfolio of relatively unrelated companies using a more general formulation called the Capability-Market (CM) matrix. The matrix is defined by rows representing a set of "Capabilities" that completely partition the space of capability to develop products and services. Examples of some capabilities are software, hardware, consulting, etc., which are applicable to all industries or markets. The matrix is also defined by a set of columns, which represent potential markets or industries where existing products are being sold and where existing distribution channel relationships have already been established. In particular, we also show that it is quite tractable to translate a list of ventures into a CM matrix.

For a given element in a CM matrix, within a row (say designated by the software capability) and a column (say designated by the government market sector), the element would represent the probability (calculated from data collected as will be explained later) that a person taken at random would work in a business, which creates software that is sold to the government. Multiplying each element of the matrix by the number of people in the workforce (say x, i.e. each element in the modified x*CM matrix) gives the corresponding number of people in the local economy working on a capability for a given market.

An illustration of a CM matrix is shown in Figure 1. The columns represent the different markets segments serving the employee pool of a region. The rows represent categories of the capabilities. In the illustration the value in

cell (2,2) represents the strength of the cluster of people with similar capability (i.e., capability 2) in a particular market type (i.e. market 2).

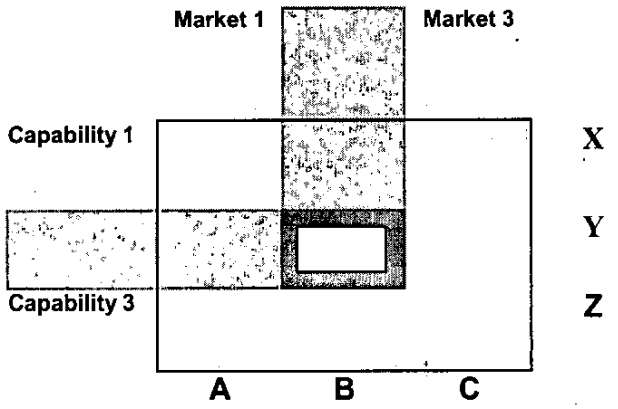

Figure 1: Capability-Market Matrix Illustration

The formulation of the CM matrix is as shown below. Assume a set of companies in a target area where economic development is desired. There are n companies in the target area (i.e., *company 1, company 2,..., company n*) each of size x_i employees, where $1 \le i \le n$. The vector c_{ij} represents the n_c potential capabilities of company i, where $1 \le j \le n_c$. The vector m_{ij} represents the n_m potential markets which they may serve, where $1 \le k \le n_m$.

Company (i)	Size	Capability Vector (j)	Market Vector (k)
Company 1	x_1	$c_{1j}=(c_{11},....c_{1n_c})$	$m_{1k}=(m_{11},....m_{1n_m})$
...	...	.....	.....
Company i	x_i	$c_{ij}=(c_{i1},....c_{in_c})$	$m_{ik}=(m_{i1},....m_{in_m})$
...	...	.....	.....
Company n	x_n	$c_{nj}=(c_{n1},....c_{nn_c})$	$m_{nk}=(m_{n1},....m_{nn_m})$

The capability vector c_{ij} for company i has elements representing the fraction of the company's capability across the set of technology capabilities, where j is an index for capability. Similarly, for company i, a market vector indexed by k, partitions the space of market relationship types ($1 \le i \le n_c$; $1 \le j \le n_m$). Completely partitioned sets of capabilities and markets must satisfy Equations (1) and (2), respectively.

$$\sum_{j=1}^{n_c} c_{ij} = 1; \forall i \quad \text{---------- (Eqn. 1)}$$

$$\sum_{k=1}^{n_m} c_{ik} = 1; \forall i \quad \text{----------(Eqn. 2)}$$

Let the total population of workers in the area be x, which is the sum of x_i over all companies.

$$x = \sum_{i=1}^{n} x_i \quad \text{---------- (Eqn. 3)}$$

The capability vector for the entire target area is $C=(C_1, C_2 ... C_{n_c})$ indexed by j within the range $1 \le j \le n_c$ of which the elements are:

$$C_j = \frac{\sum_{i=1}^{n} x_i c_{ij}}{x} \quad \text{----------(Eqn. 4)}$$

Consequently the market vector for the entire target area is $M = (M_1, M_2 ... M_{n_m})$ indexed by k within the range $1 \le k \le n_m$ of which the elements are:

$$M_k = \frac{\sum_{i=1}^{n} x_i m_{ik}}{x} \quad \text{----------(Eqn. 5)}$$

Using the capability vector C and the market vector M the Capability-Market matrix for the target area considered can be derived as shown in Equation (5), below. The next section will illustrate the use of the CM matrix method with a real case study form the Urbana-Champaign, Illinois, geographical region.

$$CM = \begin{bmatrix} C_1M_1 & C_1M_2 & ... & C_1M_{n_m} \\ C_2M_1 & C_2M_2 & ... & C_2M_{n_m} \\ ... & ... & C_jM_k & ... \\ C_{n_c}M_1 & C_{n_c}M_2 & ... & C_{n_c}M_{n_m} \end{bmatrix} \quad \text{(Eqn. 6)}$$

CASE STUDY: CHAMPAIGN-URBANA CASE

The utility of the CM matrix is demonstrated in this section by considering 75 technology companies that either originated or are headquartered in the Champaign-Urbana, Illinois region. The original list of companies was taken from year 2001-2002 Advanced Technology Directory of Champaign County Economic Development Corporation (www.cupartnership.org) and then supplemented with phone interviews and web based research.

The sample being studied comprises of 2595 people working in the technology sector comprised of a list of 75 technology companies in Champaign-Urbana (see appendix). In Table 1, we show the Capability-Market matrix multiplied by (x =2595). From the CM formulation, we can estimate, for example, that there are approximately 334 people in the regional economy that work in businesses that develop software for government markets.

This sample set of capabilities (Software, Hardware...) and markets/industries (consumer, transportations,

	Retail Trade	Transportation	Health Care	IT & Telecom	Gov/Milt	Educational Services	Agricultural Group	Finance & Insurance	Sum
Software	123.42	94.42	83.30	111.69	333.66	245.27	14.50	35.94	1042.2
Hardware/Device	39.66	30.34	26.77	35.89	107.22	78.81	4.66	11.55	334.9
Chemical/Biomedical	6.21	4.75	4.19	5.62	16.78	12.33	0.73	1.81	52.4
Civil/Construction	47.37	36.24	31.97	42.87	128.06	94.13	5.56	13.80	400
Industrial/Systems	21.66	16.57	14.62	19.60	58.56	43.04	2.54	6.31	182.9
Consulting/System Inte	52.34	40.04	35.33	47.37	141.51	104.02	6.15	15.24	442
Data & Technical Serv.	12.85	9.83	8.67	11.63	34.74	25.53	1.51	3.74	108.5
Agricultural/Food Sci.	1.01	0.77	0.68	0.91	2.72	2.00	0.12	0.29	8.5
Materials & Other	2.79	2.14	1.89	2.53	7.56	5.55	0.33	0.81	23.6
Number of Employees	307.3	235.1	207.4	278.1	830.8	610.7	36.1	89.5	2595

Table 1 : CM Matrix For Champaign-Urbana Case

healthcare...) represent only one possible set of partitions.[2] Our choice of market segmentation was chosen to closely correspond with that of Gross National Product (GNP) classification from the U.S. census bureau.[3]

The Capability Market matrix is also a unique way of representing the economic clustering in a region. Because worker salaries are generally the larger portion of operating budgets for technology companies, these elements represent relative magnitudes of the regional economy by business capability and market. The sums of the rows represent skill resources, which exist in the regional area. Any row with a large sum represents a relative strength in capability. Weaker columns in any such row represent an area, which is conducive for growth. The sums of the columns represent strength of distribution channels and relationships with certain customer categories. A column with large sum indicates that many people with different specializations are serving that market. The larger numbers in the matrix represent hot spots for the regional economy.

From the CM matrix we may infer, on a relative basis, that Software is the largest capability strength. Hardware, civil/construction, and system integration are running a distant but relatively equal second place in magnitude. We may also infer that the government and educational markets represent the largest category of customers for the products of the local economy.

We suggest that this matrix is more suitable intermediate tool for estimating the capabilities potential growth patterns of a regional economy than portfolio management tools.

Table 2 actually shows two tables. The table on the left provides the sums of the capability rows in the CM matrix, but listed in decreasing order of employees. The second column is the number of employees in each capability normalized so that the sum of all employees is 1. The third column is the cumulative distribution. The table on the right is the same but derived from the sums of the columns on the CM matrix and represents market strengths.

In examining the CM matrix in this case study, we were able to quickly note the following recommendations. First, in terms of critical mass of regional capabilities, we note software and system integration makes up 57.2% of the high tech community's capability. Civil/construction, hardware, and industrial manufacturing make up 15.4%, 12.9%, and 7% percent respectively. Companies with these skills make up over 96% of the high tech workforce. Conversely, chemical, biomedical, agricultural, materials, and food science are not significant in the current job marketplace.

Second, from a market point of view 55.5% of the technology economy sells to government and educational markets. An additional 11.8%, 10.9%, and 7% are attributed to retail, transportation, and healthcare respectively for technology companies. Again less than 4% of the technology company economy sells to healthcare, finance, and agriculture combined.

Third, there is a difference between industry leadership and academic leadership. In university settings for example, these distinctions are not always clear. Suggestions of leadership in areas like biosciences or nanotechnology can be tested against actual economic metrics to understand how much economic activity already exists in areas known for thought leadership.

LIMITATIONS AND CONCLUSIONS

This paper quantitatively analyzes the clustering of professionals in a region based on their specialization and the markets they serve using the capability-market matrix method. The capability-market matrix method is easily tractable. We acknowledge certain limitations of this method.

First, the Capability-market matrix does not consider the external world changes that might affect the growth of specific markets within a region. This method

[2] In future study, we intend to investigate other alternative capability and market sets.

[3] This classification is commonly referred to as NAIC.

Capabilities	Number of Employees	Normalized Employees	Cumulative
Software	1042.2	0.402	0.402
Consulting/System Integ.	442	0.17	0.572
Civil/Construction	400	0.154	0.726
Hardware/Device	334.9	0.129	0.855
Industrial/Systems	182.9	0.07	0.926
Technical Serv.	108.5	0.042	0.967
Chemical/Biomedical	52.4	0.02	0.988
Materials & Other	23.6	0.009	0.997
Agricultural/Food Sci.	8.5	0.003	1
	2595	1	

Industries	Number of Employees	Normalized Employees	Cumulative
Gov/Milt	830.80	0.32	0.32
Educational Services	610.70	0.24	0.56
Retail Trade	307.30	0.12	0.67
IT & Telecom	278.10	0.11	0.78
Transportation	235.10	0.09	0.87
Health Care	207.40	0.08	0.95
Finance & Insurance	89.50	0.03	0.99
Agricultural Group	36.10	0.01	1.00
	2595	1	

Table 2 : Regional Capability and Market Strength listed in order of decreasing size

can however be used in combination with other techniques such as SWOT analysis or market attractiveness evaluations to provide a greater degree of precision in the evaluations. Second, future work could elaborate on the temporal analysis of this matrix and track the changes in the Capability-Market Matrix of a region over time. Third, clustering of professionals within a region is only one component for the relative strength an industry within that region, although it is by far the dominant measure in the literature. Finally, the current level of research does not probe into the sensitivity of the Capability-Market matrix to factors such as the choice of data set and the level of aggregation.

In spite of the above limitations, we have shown in this paper that this simple tool is effective for policymakers to understand the capabilities and market relationships in a particular region. The tool serves as a visual aid and communication tool, which can be used between policy makers to supplement and refine their intuition about regional economic trends

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