International Journal of Business and Economic Development
Vol. 1, No. 8; November, 2020. pp 1-15
ISSN 2692-5591 (print), 2692-5583 (online)

Published by International Center for Promoting Knowledge
www.icpknet.org

Utilizing Rasch Analysis to Establish the Psychometric Properties of an Economic Innovation Capacity Construct

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Abstract

In today's changing and highly competitive business environment, innovation and technology clusters are recognized as a powerful competitive tool. To be competitive, countries must improve their economic ecosystem to produce a highly skilled and educated workforce, enhance the quality of place to attract investments, provide services and infrastructure to support globally competitive firms, and develop more robust entrepreneurial and technological capacity among firms and industry. Measuring competitiveness is necessary to fully understand variables affecting countries' and regions' economic development. Yet, there is a lack of a psychometrically valid scale for innovation capacity construct for small island developing states. The purpose of this paper was to develop a reliable and valid scale of measurement for innovation capacity. The test comprised 25 items administered to 74 policymakers, business leaders, and economic development practitioners in the U.S. Virgin Islands. The data were analyzed using Rasch techniques to explore the instrument's dimensionality, the items' difficulty, the item's fit, reliability, and internal construct validity. The dimensions included specialized skills, infrastructure facilities, technology firms, venture capital, supporting institutions and network activities, competitors, and governance.

***Keywords**:* competitiveness, economic growth, clusters, Rasch analysis, psychometrics

1. Introduction

Technologies and economic globalization have shifted the basis of competition from the traditional mass-production industries based on factor endowments—land, labor, and capital—toward technology and knowledge-based industries (Porter, 1990, 1998; Rondinelli, Johnson, & Kasarda, 1998; U.S. Economic Development Administration [USEDA], 2015). The shift to knowledge-based industries has provided higher levels of growth and economic opportunities to firms and countries responsive to the competitive needs of business with local environments that have innovation assets to compete in the knowledge economy (Engel, 2014; Porter, 1990). Therefore, the most competitive regions and countries are those that innovate and drive technological change (Organisation for Economic Co-operation and Development [OECD], 2013).

Leaders of countries seeking to improve their economies are encouraged to adopt new innovative strategies that enable firms to participate and compete more successfully in the global economy. Academics and economic development practitioners have focused on high-technology innovation industrial clusters, which have played a catalytic role in countries' economic revitalization and growth, job generation, and wealth creation (Institute for Strategy & Competitiveness & Harvard Business School, n.d.; Martin & Sunley, 2011; USEDA, 2015). Due to strategic relationships and networks, industrial clusters are repositories of specialized skills, capital, research and development (R&D) capabilities, and creative talents (Florida, 2012; OECD, 2013; Porter, 1990), thus creating opportunities for new firms to form and new industries to develop. Therefore, industrial clusters can provide countries with opportunities to prosper but only to the extent that their firms and workers have the skills and knowledge, and the economic environment supports the creation of innovative industries more broadly across the economy (Duranton & Puga, 2004; Porter, 1990; Rondinelli et al., 1998).

For small-island developing economies (SDEs) in the Caribbean and similar regions worldwide, industry clusters provide an approach of organizing economic development efforts to strategically transform their economies to enhance competitiveness in the global markets, build resilience to external shocks, and deliver sustainable economic growth. Small island developing economies have several common handicaps and face similar challenges. They share characteristics of a small population and narrow economic base, high degree of openness, small domestic markets due to their size, and high dependence on few export products, making small island economies extremely vulnerable to global economic shocks (UN-DESA, 2014). In particular, for the Caribbean islands, high dependency on tourism and from a single source country, primarily the United States, make these economies excessively vulnerable to recessions and financial volatility in these markets.

Indeed, the economic aftershocks from the 2008 global financial and economic crisis and the COVID-19 pandemic exposed the fragility and vulnerabilities in these countries, which suffered disproportionately with devastating impacts on their economies compared to developed economies. The exogenous shocks compounded pre-existing financial and economic problems in many of these countries. Thus, SDEs must pursue policy re-orientation that would create new and alternative sectors capable of supporting economic growth and resiliency (World Bank, 2017). Addressing these constraints, industry clusters represent an opportunity for SDEs, their firms, and industries to develop broader markets that extend beyond local borders, address weaknesses and threats to their competitiveness, and encourage higher value-added industries.

Though the evidence suggests that clusters of innovation and entrepreneurship drive regional, national, and local growth (Agenor & Neanidis, 2015; Delgado, Porter & Stern, 2010; Galindo & Mendez, 2014; Pradhan, Mallik, & Bagchi, 2018; Ulku, 2004), it is less clear that SDEs have the capacity to generate those clusters. There is little empirical research in the literature that specifically focused on innovation clusters frameworks as a tactical tool for increasing fragile, small developing economies' economic health. The existing body of work draws mostly on the experience of highly industrial economies, where technology and knowledge infrastructure are present and robust. Economic growth is often encumbered by inadequate institutional structures, infrastructure, human capital, and global networks, which are constraints to competitiveness in many developing economies. Yet, cluster frameworks tend to overlook these unique factors. Feser (2002) pointed out that few studies identified the critical dimensions of clusters that might be applicable in other contexts; therefore, one should be cautious of cluster models that appear to fit all needs.

Importantly, smaller regions simply cannot rely on ideal-types or replicate cluster models of advanced industrialized countries (Feser, 2002; Porter, 1990). A cluster design should be congruent with local conditions and carefully targeted, given that the smaller developing countries do not have the excess resources available to spearhead multiple, simultaneous economic growth objectives. Leader of regions with limited economic resources must understand ways to develop localized clusters that are competitive and sustainable within the context of their economy.

Therefore, two critical questions for local innovation policy for small island developing economies are: What regional assets support innovation and technology industries to compete in this niche market? Are there limitations that hinder technology-innovation cluster growth? The measurement of the innovation capacity of the economic ecosystem is critical for both practitioners and academics. Yet, there is a lack of a psychometrically valid scale for evaluating SMEs' innovation capacity in the literature. Since many factors in a local and regional context may influence an innovation cluster implementation strategy, it is essential to conduct research using models that determine the direction and influences of such factors.

Thus, this study aimed to develop a reliable and valid scale for measuring innovation capacity based on an ensemble of economic factors and to assess the instrument's psychometric properties. The U.S. Virgin Islands was selected as the empirical object of this research due to its economic, financial, and competitive challenges, and the call for new and innovative approaches for economic growth. The assessment tool might lead to insights for an innovation and technology cluster policy intervention, which could be adapted for use in other regions and countries.

The remainder of this study is organized as follows. The methodology, sampling, and data collection and analysis are explained in Section 2. Empirical findings are described in Section 3. Section 4 provides a discussion of the empirical findings, followed by Section 5 with conclusions.

2. Research Methodology

The measure of innovation-technology capacity scale followed the scale development procedure described by Trochim (2006) which consists of (1) defining items to be measured, (2) generate a pool of items and the response format using an expert panel, (3) administer items to a sample of respondents, (4) select the items to retain for the final scale, and (5) administer the scale, reversing the ratings of some of the scale items. This technique can facilitate the development of instruments that provide data that can be used confidently for both descriptive and parametric statistics and provide outcome measures that offer meaningful guidance to researchers and practitioners (Trochim, 2006).

Survey Design

Much of the debate surrounding the value of innovation has been pursued in advanced economies, as noted earlier. Less well understood are the consequences of innovation for developing SMEs. This is particularly true for countries like the U.S. Virgin Islands that have staked their economic growth on sectors that are more vulnerable to the national and global environment vicissitudes. The USVI has a small, open economy, heavily integrated into the U.S. economy and the world market, making it vulnerable to shifts in these markets. Its economic vulnerability is heightened by its narrow export-base and the overwhelming dependence on tourism estimated to account for 60% of GDP (USVIBER, 2015). Tourism contributes one-third of total employment and the primary source of export revenue. Such a high concentration of economic activity in a single industry or sector exposes the economy to risks associated with the lack of diversification.

Technological innovation can be a purposeful strategy toward the solution of economic problems. But where the economic problems are many and have no common measure, it is not so easy to assess the innovatory trait of an economic ecosystem. To this end, a survey instrument was constructed with the primary aim of characterizing the USVI innovation assets along with a series of dimensions that define the nature of the innovation ecosystem. These assets included specialized skills, infrastructure facilities, technology firms, venture capital, supporting institutions and network activities, competitors, and governance. The underlying construct or "latent trait" that described the instrument was the *functional assessment of innovation assets*. This unidimensional construct comprised items that were directly related to the underlying theme of innovation capacity. The cluster's innovative capacity referred to the cluster's ability to generate the critical innovations in products, processes, services, and management relevant for competitive advantage in the industries in question (Enright, 2000). Enright (2003) noted that the characterization of assets along these dimensions allowed an understanding of challenges and potentials to inform policy and strategy.

The survey instrument often used to collect data of this kind is a scaled Likert-type instrument. The rating scales, commonly used in the social sciences and in educational testing (Croasmun & Ostrom, 2011), have been associated with classical test theory (CTT). As based on Likert-type scaling, CTT typically assigns a number to each polytomous response category, and then sums the scores to generate a single total (Gay, Mills, & Airasian, 2009). In CTT, these raw-score totals are summed to produce a total score for each item. Raw scores are labels and not metrics. These item totals are used to rank the items. This strategy does not conform to fundamental measurement; hence, these total raw scores, which represented ordinal data, can legitimately be used to rank items but cannot yield significant information about the distances between the items on the scales of Likert-type instruments (Busch & Turner, 1993). Retief, Potgieter, and Lutz (2013) observed the following about Likert-type instruments:

> This strategy does not constitute real measurement, because the total raw scores alone cannot generally yield meaningful information about the distance between respondents (or items) on the scale that CTT uses. Total raw scores merely represent ordinal data which can only be legitimately used for the ranking of persons. (p. 4)

Moreover, the total score provide no information on the relative strength of the items because it does not show the items that are easier to support, confirm, or reject. The inherent weakness of raw scores in functional assessment is that these are not true metrics, and therefore prohibit the use of parametric statistical tools. Bezruczko (2005) noted, "Raw scores have special conditions, restrictions, and assumptions which make them very treacherous to analyze and too ambiguous for the solution of contemporary measurement problems" (p. 13). Arithmetic computations on raw scores, such as means and standard deviations, can produce numbers with uncertain meanings. Hence, using these raw scores in addition, division, and computation of parametric statistics (e.g., difference-of-means test, ANOVA, and standard regression) was unjustified because the operations did not have mathematical meaning.

However, the shortcomings of CTT in functional assessment are overcome by the Rasch rating scale model (RSM), which aimed to support true measurements considered methodologically superior to the CTT method. Researchers stated, "The Rasch measurement is aligned with the idea of 'objective measurement'—no matter what construct is being measured, or what measurement instrument is being used, a common metric is used to express results" (Boone & Noltemeyer, 2017, p. 2). In Rasch model analysis, raw scores were elevated for both respondents and items, and these were transformed to log-linear (or logit) measures, which described differences between asset items in measurement terms. The measures included true linear, equal-interval, additive units that not only could establish rank order of innovation assets, but these also could possess the property of magnitude. The concept of magnitude was fundamental in this study as it not only enhanced the detection of differences between economic innovation assets but also signaled the magnitude of change that occurred between the assets. The assessment of magnitude is crucial for innovation policy considerations.

The Rasch model has been increasingly touted as a powerful tool for the analysis and refinement of survey instruments for the following reasons. First, one of its outstanding features is its ability to establish the construct validity of an instrument and to convert each item of the scale into hierarchical properties or into order of item difficulty. Second, construct validity provides the evidence that the survey instrument accurately measures the construct under consideration, but more directly, that the instrument measures what it intends to measure. Third, reliability measures inform whether the instrument is measuring the trait consistently. Fourth, the linear measures that are initially produced by the model are in log-odd units—or *logits*—that may be conveniently rescaled to the more conventional form of 0 to 100, while still retaining the feature of *conjoint additivity*—in which conjoint refers to the measurement of persons and items on the same scale, and additivity is the equal-interval property of the scale. Fifth, the model transforms ordinal scores into interval measures and these latter are accompanied by standard errors for more substantive parametric statistical analyses. Sixth, when Rasch measures are developed from an appropriate sample, the internal measures are independent of the sample from which these are derived (i.e., the findings for the sample extend to the population from which it was derived). Seventh, an important consideration in the selection of the model for the analysis is that the latter does not depend on the assumption of a normal distribution of scores (Retief et al., 2013).

The rating-scale measurement model is given in the equation as the following:

$$\ln(P_{nik} \,/\, P_{ni(k-1)}) = B_n - D_i - F_k$$

where

ln is the natural log
P_{nik} = the probability that person *n* chooses any given category on any item
$P_{ni(k-1)}$ = the probability that the observation would be in category *k-1*
B_n = the agreeability of person *n*
D_i = the difficulty of endorsement of item *i*
F_k = the difficulty of the rating step up from *k-1* category to *k*

VALIDITY AND RELIABILITY

The construct was subjected to standard psychometric tests of validity and reliability. Validity provides evidence that the instrument is being applied appropriately, and that it measured what it was intended to measure. Item measures were generated for construct validity as well. Mean square values were also computed for each item, which determined whether each item fits the model within acceptable ranges. Reliability is the degree to which a measure remains unchanged upon test and retest (i.e., when repeated measurements of the same thing produce highly similar results). Reliability indices were also generated for both person measures and item calibration measures. These indicated whether the instrument was measuring the respondents or the items consistently. Bradley and Sampson (2006) observed, "The Rasch model provides a sound and preferable alternative to traditional method for determining the reliability of an assessment and examining the validity of its results" (p. 24). The linear measures that were produced were all accompanied by standard errors—reliability—and model fit values—validity.

Sampling

A nonprobability sample design was utilized to select 74 individuals from the government, business, academia, and support organizations (see Lavrakas, 2008). The target respondents for conducting the survey included decision-makers from the executive and legislative branches of government, directors of economic development and workforce agencies, business executives, education and workforce administrators, and executives from broadband and technology companies. A key consideration in selecting these respondents was their positions as decision-makers and their knowledge and professional experiences (see Amsden, Capriot & Robinson, 2012). Furthermore, they had knowledge of present and future economic development and technology trends.

The respondents were USVI residents who were reasonably knowledgeable about the USVI economy; therefore, they did not comprise a probability sample. However, Forster and Ingebo (1978) supported the efficacy for this approach of not requiring the use of random observations. After a study of student testing, they concluded that random samples were not needed to calibrate item levels in reading and mathematics. Ingebo (1997) later reported, "Rasch technology does not require random sampling for accurate results" (p. 36). In a study of the calibration of test items among students, Ingebo (1997) affirmed, "Volunteer groups can be used to establish a curriculum scale for use with a population. This is a preferred substitute for random sampling of a total population" (p. 76). Therefore, the selection of the respondents was not bound by the standard requirement of probability sampling once the psychometric properties of reliability and validity were met, and the Rasch model fit the data (see Bond & Fox, 2015; Smith & Smith, 2004). Once the model holds, the principle of invariance minimized the need for randomness in the selection of people, as the same scaling of the items in the survey basically held from one sample to the next (see Ingebo, 1997). Curtin (2007) observed, "When data fit the Rasch model, it is mathematically proven that the item difficulty estimates are independent of the sample of respondents" p. v).

Data Collection

The primary data were collected using a self-administered structured survey questionnaire adopted from the Cluster Mapping framework (Ketels, 2017; Council on Competitiveness, 2018) adapted to the USVI conditions. This instrument was developed by Harvard Business School's Institute for Strategy and Competitiveness and the Council on Competitiveness (2018) to assess a region's cluster business and innovation environment. The survey instrument was established and widely used by states and regions to assess innovation business environments. The questionnaire was distributed among participants through an email, which contained the questionnaire as a web-based link. The data were collected electronically via the SurveyMonkey platform.

Data Analysis

The analysis of primary data via the survey was reduced to produce descriptions and establish relationships. Interval level measures were necessary to conduct specific comparisons. The raw scores, which were generated from the responses, were nonlinear and deficient in the measurement of precise estimates. Therefore, the approach was to apply the Rasch rating scale method (RSM; Bond & Fox, 2015; Smith & Smith, 2004) to the Likert-type data to transform the raw-score to linear measures that could be analyzed using parametric statistics. The software WINSTEPS was utilized to conduct the Rasch analysis.

One additional valuable outcome from Rasch analysis was the "item map" or "variable map." A symbol for each respondent on the left, and the name of each item on the right are aligned along a shared measurement continuum of innovation assets. True interval measurement units are also given on the left. A higher item measure indicated an innovation asset perceived of high importance by innovative thinkers, and a higher item measure identified assets that were selected by respondents who observed asset items that were low on the pole of being an innovation asset.

Data collected through a survey instrument were analyzed to assess the perception of USVI residents of the state of economic innovation and technology in the territory in recent years. The outcome of this Rasch analysis was intended to be the identification of a set of specific characteristics of the USVI economy that could be hierarchically ranked in terms of what the respondents perceived as the order of importance that decision makers should address regarding the development of the USVI. Besides the ranking of the calibrated items, the procedure permitted the identification of the precise measurement between any pair of items that comprised the latent trait.

There were two specified requirements for the use of data in the Rasch measurement model: unidimensionality and local independence. First, in this study, unidimensionality referred to the contribution of all items to a single "latent trait." A single construct underlined all of the items, with all items collectively defining unidimensionality in such a way that the items comprised a hierarchical continuum with easily endorsed items at one end (near the bottom) and items with limited support at the other (near the top). The author expected that the easily endorsable innovation-technology items would be those agreed to by most respondents, while those who disagreed with the current state of innovation-technology would express disapproval of stated items. Second, local independence related to the probability of a respondent's endorsement of an item that does not depend on the order in which the other items appeared (i.e., the items are required to be independent of each other). This term meant that there should not be any correlation between two items or the correlation of residuals should be 0. The two requirements of unidimensionality and local dependence were met when the data fit the Rasch model, and a number of beneficial conditions followed. The estimates of the parameters were reported in a common metric on the same interval scale.

3. *Empirical Findings*

One of the first steps taken in the analysis of the data was to assess the meaning of the psychometric statistics in Table 1. The metrics were derived from the RSM, which was applied to a 25-item instrument that was rated by 74 respondents. The person reliability index of .75—which was conceptually equivalent to a Coefficient alpha—was considered acceptable, as it was above the generally acceptable .70 for exploratory research. Rasch analysis also produced a separation index *G*, which could be used to indicate the number of distinct strata of persons among the respondents. The larger the index, the larger the number of distinct levels of respondents that might be identified. A person separation index *G* of 1.73 was equivalent to 2.3, or two distinct strata of respondents that could be identified (see Duncan, Bode, Min Lai, & Perera, 2003). With a *G* value of 4.37 among the items (Table 1), 4 distinct levels of functioning might be discernible among the 25 items.

Table 1. *Psychometric Statistics of the Innovation Technology Construct*

	Logits		On 0-to-100 Scale	
Properties	Respondents	Items	Respondents	Items
Mean	-1.25	.00	42.00	51.02
SD	.71	.89	5.11	6.45
Separation index *G*	1.73	4.37	1.73	4.37
Separability (reliability)	.75	.95	.75	.95
Outfit Mean Square	1.00	1.00	1.00	1.00
SD of Outfit Mean Square	.45	1.88	.45	.30
Mean Outfit z	-.16	-.13	-.16	-.13
SD of Outfit z	1.75	1.88	1.75	1.88
No. of items	74	25	74	74

The items in the scale measured the latent variable of innovation technology (IT). The item reliability index indicated that the construct acceptably measured the variable of interest, and thus discriminated between the survey respondents well. The item separation reliability of the items of .95 signified that the items that comprised the IT construct created a well-defined variable.

The next step was to examine the location of the respondents relative to the items on the instrument. The mean of the items' logit measure was arbitrarily set at 0, but when converted to a 0-to-100 scale, the mean had a value of 51.02. The mean respondent logit measure was -1.25 or equivalent to 42.0 on the 0-to-100 scale (Table 1). This location of the respondents' mean being lower than the items' mean indicated that the items were relatively difficult for the respondents to assign them high scores (Figure 2). Thus, the high items' scores were indicative of low endorsement of or agreement with many of the items. For 25 items, respondents were asked to utilize a Likert-type scale to rate the innovation technology environment in the USVI. The rating scale ranged from 1 = *Strongly Disagree* to 4 = *Strongly Agree*. The Rasch-Andrich thresholds for Category Values 1, 2, 3, and 4 with l0-to-100 values were *none* (because the bottom category has no prior transition), -15.06, 0.4, and 15.02 (Figure 1). These thresholds were the intersections of the curves for adjacent categories. The points of intersection of the adjacent categories might be used to examine the functioning of the response options in the survey instrument. Figure 1 shows that each of the four ordered categories is used in the data collected from the respondents to the survey, and the probability of the selection of each category increases as the person measure (on the horizontal axis) increases along the length of the fundamental latent trait.

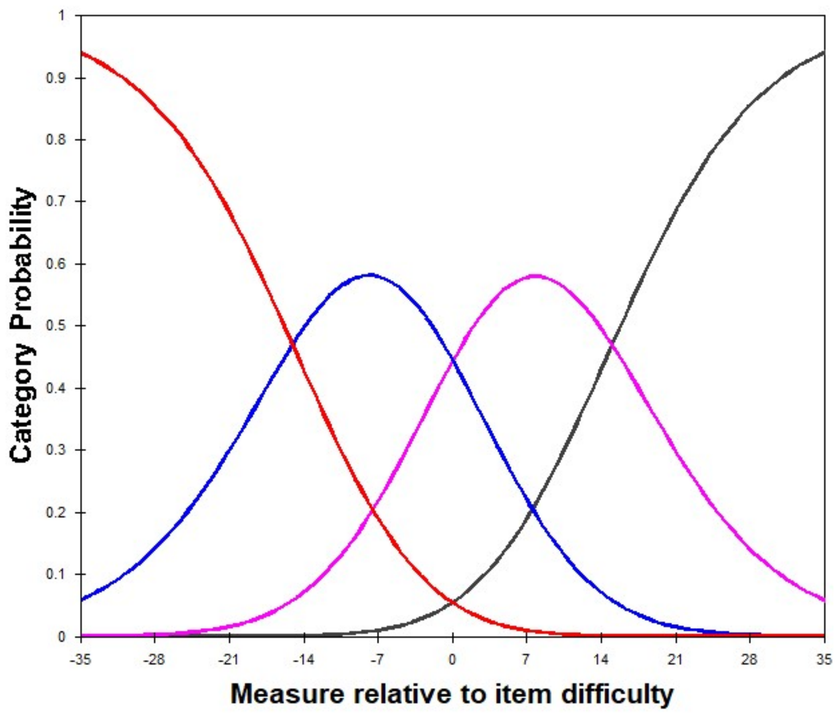

Figure 1. **Category probability curves.**

The peaking of the response categories indicated the usage of that particular response category. From the probability curves in Figure 1, the respondents utilized each response category provided on the instrument. Each of the categories was observed, and none of the thresholds were disordered.

One of the primary reasons for the application of the RSM was its ideal capacity to test the reliability and validity of a new instrument, as well as to measure the items—economic assets—and respondents along a shared continuum of "less" to "more" endorsement. The Wright map in Figure 2 visually shows the hierarchical structure of the 25 innovation assets based on informed knowledge of the USVI economic environment. The assets were arranged in a hierarchy from those that were easily identifiable and endorsable as being part of the USVI economy to assets that were recipients of extremely low endorsement. The map indicated that the average respondents' measure—*M* on the left side of the vertical line—was below the average item measure—*M* on the right side of the vertical line—which thus imparted that the overall tendency was for respondents to rate the assets with low endorsement.

The calibrated item at the extreme bottom was I19, which stated, "The USVI is in a strategic location for a telecommunications hub." This item had more support than any other of the 25 items. About 88% of the respondents either *Agreed* or *Strongly Agreed* with the statement. Thus, this item was at the top of the hierarchical scale regarding endorsements of all the items. The item with the second highest overall endorsement was I09, "Good communication infrastructure exists (internet access and broadband services) and are readily accessible." Its visual distance from I19 indicated how much easier it was for respondents to endorse I19 than it was to approve item I09. Among the respondents, 55% either *Agreed* or *Strongly Agreed* (7%) with the statement, while 27% *Disagreed* and 11% *Strongly Disagreed*.

```
RESPONDENTS            ITEMS
High Agreement        <Low endorsement of items>
                     |
                     |  I01 Power cost reasonable
60                   |  I05 Public infrastructure adequate
                     |
                     |S I12 Licensing & development  I25 Location cost
                     |  I15 Regulation simple
                     |  I03 Accessible capital       I16 Qualified personnel
                     |  I04 Transport reasonable     I06 Skilled personnel
                     |  I21 ITC Training available
                     |  I22 Innovation ecosystem
                XX T |  I11 Entrepreneurship support I18 UVI funding adequate
                     |  I24 Strategic collaboration
                XX   |M I10 Strategic partnership    I13 Broad industry range
                     |  I14 Quality k12 Education    I20 Government support
                     |  I23 Advanced Education
50              XX   |
               XXX   |
          XXXXXXXX S |  I07 Research facilities      I17 Competitive environ
          XXXXXXXX   |
                     |S
               XXX   |  I02 High-quality UVI
             XXXXX   |
               XXX M |  I08 Development incentives
40 XXXXXXXXXXXX      |  I09 Communication access
            XXXXXX   |
        XXXXXXXXXX   |T
                 X S |
                XX   |
                XX   |
                     |
                XX   |
                XX T |
30               X   |  I19 Strategic location
Low agreement        |   >|<High endorsement of items>
```

Figure 2. Hierarchical perception of innovation technology assets in the USVI. *Note*: Person-Item map of respondents' agreement and Innovation Technology items are expressed on a 0-to-100 measures scale from low to high. A total of 74 policy makers, educators, business sector personnel and others are aligned along a shared measurement continuum of the perception of innovation technology. True equal-interval measurement units are given on the left. Items are listed from bottom to top in order of increasing difficulty of endorsement in the items' section. A higher item measure means lower endorsement for that item, and a higher person measure means higher agreement with the items. "X" = 1 respondent, "M", "S" and "T" symbols indicate mean, 1 standard deviation and 2 standard deviation of the measures recorded in respondents and items, respectively.

The third item in the hierarchical structure was I08, which stated, "Tax incentives for business development are adequate." About 55% of all responses were supportive of the item, while 45% *Disagreed* or *Strongly Disagreed* with the item. At the top of the map, item I01 was ranked last or 25th in respect of agreement with the statements. I01 stated, "Cost of electricity is reasonable." Every respondent rated this item to the effect that 91% of the total did not endorse the statement of reasonable cost of electricity. Approximately two-thirds or 65% of the respondents *Strongly Disagreed* with the item, and 25% *Disagreed*. Only 8% of the respondents approved this statement. The second lowest-ranked item was I05, which was the following: "There has been adequate investment in public infrastructure." This very low ranking is certified by 56% of those responding in the *Strongly Disagree* category and 36% in the *Disagree* category. Only 8% overall gave positive endorsement to this statement. The third lowest-ranked item in position along this hierarchical construct was Item I12. The statement read, "The Government's licensing process encourages development." Ninety-six (96%) of all respondents did not approve the statement: 45% *Strongly Disagreed* and 51% *Disagreed*.

Table 2 presents additional information on the IT construct. The first column presents the ranking of the items from the lowest approved item to the most highly endorsed item (i.e., from Rank 25 to Rank 1). The second column of the list of abbreviated items contains shortened versions of the statements on the survey instrument with accompanying item numbers. The third column presents the measures for all the items, with the accompanying mean and standard deviation. These measures are provided as true equal-interval units, derived from logits that ranged from -2.9 to 1.4. The rescaled interval-level measures range from 0 to 100. The item reliability measure of .95 indicates a well-defined variable. The fourth column lists the standard error for each item. This list is a measure of precision of every item and is used to describe the range or confidence interval within which each item's true endorsement falls. The last column addresses the matter of how well the data conform to the Rasch model—the characteristic of fit. *Infit* and *outfit* help to determine how well the data fit the Rasch model. Following the guidance of experts in this field, only the outfit values need be presented.

Table 2. *The USVI Innovation Technology Construct*

Rank	Abbreviated Items	Measure	SE	Outfit MnSq
25	I01 Cost of electricity is reasonable	60.88	1.56	1.29
24	I05 Adequate Investment in infrastructure	59.27	1.49	1.14
23	I12 Government's licensing encourages development	57.68	1.44	.69
22	I25 USVI as average-cost location for business	57.22	1.42	1.39
21	I15 Regulatory process is reasonably brief	56.44	1.42	1.11
20	I03 Financial capital for bus. is easily accessible	55.10	1.41	.90
19	I16 USVI produces qualified scientists it needs	54.91	1.37	.95
18	I21 Graduates in STEM are readily at hand	54.31	1.35	.76
17	I06 Availability of skilled workers currently exists	53.56	1.34	1.01
16	I04 Cost of transport (land, air, sea) is reasonable	53.49	1.34	1.07
15	I22 Existing policies encourage innovation	52.63	1.36	.70
14	I24 Evidence of strategic collaboration in R&D	52.20	1.35	.61
13	I18 Funding for university research is adequate	51.76	1.35	.82
12	I11 Support for entrepreneurship is apparent	51.47	1.34	.78
11	I23 Advanced training & skills development available	51.17	1.30	1.08
10	I10 Strategic partnership in speed tech transfer	50.88	1.32	.43
9	I13 Broad range of industries in the USVI	50.71	1.30	.74
8	I20 Government's policies supportive of business creation	50.28	1.33	.89
7	I14 High-quality K12 education exists in the USVI	50.25	1.28	1.49
6	I17 Industries are in competitive environment in USVI	47.53	1.29	1.11
5	I07 Specialized research facilities exist in USVI	47.32	1.27	.78
4	I02 UVI is a high-quality scientific research university	43.66	1.28	1.10
3	I08 Tax incentives for business development adequate	41.77	1.26	1.41
2	I09 Good communication infrastructure exists	40.72	1.25	1.30
1	I19 USVI is in strategic location re telecommunication	30.29	1.35	1.49
M		51.02	1.35	1.00
SD		6.45	.07	.28
Item reliability		.95		

An item with unfavorable responses, when there is good reason to believe that it is highly endorsable, is said to be a "misfitting" item. Similarly, this is the case with an item that is expected to receive a high level of agreement but receives many negative responses instead. The outfit statistic is one that is sensitive to outliers, labelled in Table 2 as *OutFit Mean Square*. The ideal value was 1.0. Values less than 1.0 would indicate possible redundancies in the responses to the items, and values greater than 1.0 indicated an irregular or unexpected response pattern that might be causing noise or the lack of unidimensionality. A range in *OutFit Mean Square* between 0.5 and 1.5 would be suggestive of a reasonable fit and productive for measurement.

By focusing on the last column in Table 2, one observed that of the 25 items in the IT construct, all *OutFit MnSq* values—with the exception of I10—were within the productive range for measurement, thus contributing further to the strength of the psychometric properties of the scale. The only item that fell below 0.5 was one in which there might have been miscoding because of the joint subject that was being questioned. In a further development of the instrument, this item would be modified to reflect a single subject that was being questioned.

In the third column, the items were lined up according to their rank—those at the bottom of the table received the highest endorsement or level of agreement, and those at the top of the table received the least support. The third column presented interval-level calibrated measures, as presented graphically in Figure 2. The overall mean of the items was 51.0, which reaffirmed the unbalanced nature of the distribution of items—15 items were above the mean and 10 below it. This imbalance was also evident from the position of the mean of the items compared with that of the respondents. The location of 15 items above the mean of the items once more emphasized the difficulty that respondents experienced in endorsing most of the items. A revisit to Figure 2 would remind the reader of the variation in gaps between items along the latent continuum of IT.

The data in Figure 2 and Table 2 provide decision makers and policy analysts with empirical evidence for planning and development across the USVI. An additional value of these data was that for rational decision making and development planning, these data could serve as the anchor values against which future results could be measured to determine the level of progress, if any, between the anchor year and some meaningful later year. Further, the interval nature of the measures with standard errors allowed the application of parametric statistical tests that would lend robust arguments to take further actions.

4. Discussion of Findings

Like the sparse literature on cluster strategies for small-island states discussed previously, this author found no valid measure in the empirical literature that produced the USVI innovation trait or identified a set of specific characteristics of the local business environment that could be hierarchically ranked regarding what practitioners perceived as necessary for decision-makers to address. Therefore, a primary goal of the study was to create an instrument that could help to determine the regional assets that support innovation, entrepreneurship, and cluster growth and what barriers may hinder successful cluster development. Discussed here is a comprehensive set of competitive factors or items that defined the USVI's latent innovation trait.

The quality of a region's business environment is embodied in four broad factors, which influence the innovation capacity: the presence of factor conditions, demand conditions, the context for firm strategy and rivalry, and related and supporting industries (Porter, 1990). These four attributes in a region's marketplace are self-reinforcing and act as a system (Porter, 1990). Therefore, the *functional assessment of innovation assets* construct was developed to validate the range of factors or items that economic development stakeholders appointed as crucial for innovation in industries. This construct constituted the competitive factors (Figure 2), which formed the latent trait of innovation. The factors were placed into four focused areas of one or more different items, which described the capacity of the local economy for innovation: infrastructure, workforce and education, and private-public collaboration, and the enabling business environment. Each factor group is subsequently discussed.

A Strategic Telecommunication Hub. Regarding the potentiality of the USVI to be a telecommunication hub, economic development stakeholders highly endorsed the location as a venue for high-technology activities. This finding was consistent with other studies, which indicated that the USVI's proximity to a cluster of undersea cables that transmitted data between South America, Central America, and the Caribbean to North America and Europe positions was a strong location for IT and telecommunications industries (TIP Strategies, 2014; USVIBER, 2015). The USVI was also deemed to have a strong communication (broadband and Internet) infrastructure. Businesses and residents could access a fully interconnected broadband infrastructure network, the only fully interconnected jurisdiction of all U.S. states and territories (TIP Strategies, 2014). This first group of factors was considered strengths or assets. Hence, these were at the top of the hierarchical scale of innovation traits.

The Cost of Energy Power and Physical Capital Stock. Among the factors essential for innovation and entrepreneurship, the cost of power and physical stock stand out among the second group as having received a low endorsement, indicating these as weak areas in the local business environment. First, the cost of electrical power was the item that garnered the most forceful response from the respondents. The USVI had among the highest energy costs of $.43 per kilowatt hour compared to about $.10 in the United States (TIP Strategies, 2014).

The quality of the infrastructure are vital factors for industrial development and essential for economic growth (Doms, Lewis, & Robb, 2010; Glaeser, Kallal, Scheinkman, & Shleifer, 1992). Therefore, the quality of place undergirds the argument put forth in Porter (1990) that a region's factors conditions determine its innovation capacity and competitiveness. These factors were unsupportive of business development and innovation.

Workforce and Education. The third group of factors often found important in business location is the presence of an educated and skilled workforce (Engel, 2014). The low endorsement of both factors indicated that the USVI faced significant challenges in these two areas. The USVI's educational attainment was far below national averages, with nearly 25.8% of the adult population 25 years and over having less than a high school diploma (UVIECC, 2015). Similarly, the USVI faced a shortage of highly educated adults, as only 18.1% of the adult population had a bachelor's degree or higher, compared to the national rate of 30.1% (U.S. Census Bureau, 2017; UVIECC, 2015).

In the knowledge-driven economy, competitiveness requires a highly skilled labor force and a strong educational infrastructure. This connection is part of a more significant finding in the literature that competent human-capital is essential for the growth and development of regions (Gennaioli, La Porta, López-de-Silanes, & Shleifer, 2013; Glaeser & Saiz, 2004; Simon & Nardinelli, 2002).

Collaboration and Networking. Public-private institutional partnership facilitates the flow of information and technology transfer and creates opportunities for products commercialization. This collaboration and sharing of resources and knowledge are the primary conduits that lead to the competitiveness of a cluster (OECD, 2013). The findings from the fourth group of factors, which related to collaboration and resources, indicated that there was not strong university-business collaboration. Moreover, there were not sufficient qualified scientists and engineers and STEM graduates to develop competitive innovation clusters, nor adequate funding for university research.

The relative importance of educational attainment and skills as a positive influence on industrial development and economic performance points to the need for workforce development in cluster-based strategies. Industry–university collaborations have a long tradition in cluster development with universities playing a crucial role in achieving economic growth outcomes (Engel, 2014; OECD, 2013; USEDA, 2015). Given the ambition of local policymakers and university officials to facilitate R&D and commercialize academic knowledge through technology parks and business incubators, intensify the necessity of collaborations (Perkmann & Walsh, 2007).

Business Support and Enabling Business Environment. Perhaps, the most unsurprising finding was the low endorsement of the fifth group of competitive factors related to the support for entrepreneurs and the enabling environment for business development. Several researchers have documented that common areas of concern are financial and technical support for entrepreneurs, government efficiency, and effectiveness (TIP Strategies, 2014; USVIBER, 2015). The government processes for obtaining licenses and permitting are impediments to business development. This finding indicates that policy efforts to encourage entrepreneurship and enable business development are imperatives.

Synthesizing the findings, the USVI business environment has competitive firms and related supporting industries. There is a reliable communication infrastructure, a high-quality university, and robust tax incentives for the attraction of new industries. However, its economic structure is characterized by low wage industries, and the economic environment does not now sufficiently support innovation in industries. The high cost of electricity and inadequate physical infrastructure are factors that put the USVI at a disadvantage where innovation clusters are concerned. Although it appears that the USVI may become a telecommunications hub, there is a need to improve its human capital, physical capital stock, public-private partnerships, and the business environment. One strategic approach to position the USVI's industries for success in the knowledge era is to leverage the regional technology assets and networks to increase activities in industries and exploit the potential that technology and innovation clusters present.

5. Conclusions

The empirical evidence indicated that higher innovation rates resulted from the local economic conditions favoring the production and assimilation of innovation and entrepreneurship. Furthermore, technology and innovation are imperative for economic development in today's knowledge-based economy, implying that what a region does to leverage the potential of innovation in industries matters more for its growth than continuingly chasings industries with diminishing economic returns.

This research provided the first valid testing of an innovative measure based on Rasch's model for assessing economic innovation capacity in the USVI. The validity and reliability test results provide supportive evidence that the construct can be used as a robust evaluative tool for understanding the latent trait of innovation and prioritizing economic development strategies to improve the innovation ecosystem. The innovation construct can also help determine infrastructure investment priorities, education and skills development, and training support. Thus, developing an innovation capacity instrument has laid the foundation for assessing possible innovation and technology capability predictors in other contexts. Future cluster research can validate the instrument's applicability in different countries and regions and give psychometric data on the assessment tool regarding industrial SMEs' economic innovation capacity. The suggested areas for further study can expand knowledge in understanding the drivers of economic growth and the central role technological innovation can play in industrial small-island developing states that can lead to their success.

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