Middle States Geographer, 1997, 30:88-96

A GEOGRAPHIC ANALYSIS OF SECONDARY EDUCATIONAL DISTANCE EDUCATION NETWORKS IN CENTRAL NEW YORK STATE

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***ABSTRACT**: There is great interest in using secondary and higher education distance education networks to offer more courses to a more diffuse and demographically diverse population. This paper presents an historical perspective on public school centralization and an analysis of the regionalization and spatial distribution of public school district distance education networks in Central New York State.The research in this paper indicates a negative correlation between the users of distance education and the student population of the district. It is also evident that the student population of a district is more significant in determining the need for distance education than the accessibility of the district relative to other districts in the network. A break-even analysis further shows that the distance education network studied is subsidized at 53%. School districts in the region will require some form of subsidy to participate in distance education until telecommunications costs decrease, networks are more fully utilized, and the installation charges are capitalized.*

INTRODUCTION

The concept of secondary public school distance education was introduced in New York State in 1967. The original model was broadcast courses on public television with limited voice interaction via a telephone connection between classrooms. Information technologies have expanded opportunities for distance education via synchronous, two-way video, voice and data communications at lowering cost. New York State public schools have a history of subsidized centralization to accommodate the need for educational specialization in the emerging post-industrial, information economy. The lowering of cost to the districts either through subsidies or less expensive technology has facilitated greater curriculum specialization using distance education. Districts wanting to offer courses that cannot normally be given due to lack of enrollment or funding typically employ distance education. The correlation of distance education users to geographic and instructional budget dispersion is observed, however, a paradox exists. There are two larger districts exhibiting higher than average dispersion that have not employed distance education.

The first section of the paper introduces a recent historical perspective on educational specialization and geographic centralization for New York State public education. Attention is given the need for subsidies to accomplish centralization. The next section describes the physical geography, demography, and the status of synchronous distance education network development for the region. Next, a break-even analysis is applied to determine the subsidy required for the network. Finally, an analysis is performed to identify the significant factors influencing the adoption of distance education and the need for distance education based on these factors. Asynchronous, internet-based, distance education is not explored in this study.

HISTORY OF SPATIAL DISTRIBUTION OF SCHOOL DISTRICTS – 1904 to PRESENT

New York State embarked on the centralization of 10,651 school districts with the Unification Act of 1904. The vast majority, 9,961, were common rural districts and most had only one building (Horner, 1954). The industrialization of the United States in the late 19th and early 20th century increased the need for specialized labor skills. Consequently, education institutions needed to provide more diverse curricula to prepare students for the evolving industrial economy. McCarty (1942) views the relationship between location and specialization as: "As the scope of the economy is broadened to include larger areas and larger numbers of people, opportunities for specialization becomes greater, and the number of factors influencing an individual's choice of location is

diminished". The centralization of public schools in New York State was a matter of increasing "economies of scale" to integrate more specialized curricula.

Lowe and Moryadas (1975) depict the postindustrial economy as "...characterized by high mass consumption and the increasing dominance of service economies, [in which] the division of labor and the resulting specialization reach extremes". Specialization results in agglomeration and scale economies (Lowe and Moryadas, 1975). School centralization achieves both agglomeration and scale economies. Increased specialization is found in expanded secondary school curricula facilitated by distance education.

New York State created Boards of Cooperative Educational Services (BOCES) in 1948 for cooperative purchasing of goods and services by more than one district. These purchases are subsidized at equalized rates among districts in the BOCES region. Successive legislation has increased the authority of BOCES to include administration of Vocational Education Programs, provision of telecommunications services, and a regional Superintendancy of member schools. Six hundred sixty nine districts in New York State are organized into 45 BOCES regional districts. There are also 11 BOCES Regional Information Centers (RIC) which have recently been given authority for purchasing data communications services for BOCES districts. The Otsego Northern Catskill (ONC) BOCES studied in this paper has nineteen member districts.

Centralization also required better, more reliable transportation systems to extend public school markets. Improved methods of transportation enhanced the opportunities to centralize school districts. In fact, most centralizations prior to 1924 in New York were between two rural, one building districts and not necessarily influenced by a change in transportation methods (Horner, 1954). In 1924, the State Legislature understood that to further enhance "economies of scale" in public education, centralization would require infrastructure subsidies. A new larger district generally required large investments in buildings and transportation. New York State continues to subsidize building, transportation, and shared services with "equalized" state aid and BOCES aid. (New York State Executive Budget).

Travel distance to school is constrained by the limit of acceptable transport time to school. Thus, the quality and quantity of transport options enhances the opportunity for district expansion. Rural districts tend to have lower student population densities than suburban and urban districts. Lower density results in higher per student transportation costs (RTA Report 1993 DATA). There is decreasing marginal utility in the physical movement of people as evidenced by the slowing of gains in travel time over the last two centuries (Lowe and Moryadas, 1975). Distance education networks, however, provide opportunities for increasing utility without moving people. The trade off is between the total cost of moving people versus the total cost of distance education infrastructure.

Maurice Yeates (1968) examines several cases of the relationship of economic development to network connectivity). "It is generally considered that specialization has been the key to the economic development of mankind and that, without the development of transportation systems to facilitate trade, the intense degree of specialization found in different parts of the world could not be supported"(Yeates, 1968). Yeates goes on to define the extent of network development as connectivity, ß=E/V. Where ß is the connectivity, E is number of edges in the network and V is the number of nodes. Typical planar transportation networks have ß values from zero to three with higher betas indicating a more evolved, specialized network. The ONC BOCES distance education network, which is defined as a fully connected network because an edge exists between every node, has a ß of four. Following is a chart depicting ß values for fully connected networks for a range of nodes.

Nodes	Edges	ß
5	10	2
10	45	4.5
15	105	7
20	190	9.5

As the ß value increases there is greater opportunity for economic specialization. This is especially true for distance education networks and other information technology intensive industries where physical transport is not required.

Economic activity on information networks introduces a whole new set of parameters to the traditional problems of location for service and manufacturing businesses and educational institutions. The selling or distribution of knowledge has little weight and fixed capital investment associated with the production of the product, thus Weber's theory of the location of industries based on weight, distance, and minimizing transportation cost must be modified to account for economic activity without mass and low

capital intensity. Current examples of these phenomena include distance education and telecommuting. New York State's subsidies for school consolidation coupled with the new Regents requirements for graduation from high school will continue to promote the need for increasing specialization and centralization.

PHYSICAL GEOGRAPHY, DEMOGRAPHY AND NETWORK CHARACTERISTICS

The physical geography of the ONC BOCES district is characterized by rolling hills with southwest to northeast oriented valleys in the northern half of the region. The southern half extends into the Catskill Mountains with river valleys oriented more east to west. The topography encouraged the development of major transportation routes in the valley areas where nearly all of the communities with more 500 residents evolved. The region has one community with a population greater than 10,000, two between 1,000 and 2,500, and 21 between 200 and 1,000. The communities are evenly distributed and the diameter of the ONC BOCES district is 53 miles. Per capita incomes range from $10,365 to $16,010 versus the state average of $16,501 (U.S. Census, 1990). The region is rural in character.

Central school districts needed to reach a "threshold" population of students to provide a mandated curriculum. Logically, central districts would tend to locate in larger central places (Yeates, 1968). Occasionally, schools may locate between communities to decrease overall transportation distance for students. For example, in Otsego County there are 12 central school districts. Nine districts have high schools located in the largest central community. The three remaining are centralized from previously centralized districts. Therefore, high school location is between each central community. Districts are compelled to be spatially efficient by minimizing transport costs for students (Yeates, 1968). Centralizations continue in the rural areas of Central New York today. In the study region the most recent consolidation was between Cherry Valley Central and Springfield Central Schools in 1990.

High bandwidth communications networks are also oriented in the valleys with central switching offices typically located in the larger central communities. Line charges are determined by the distance from the central switching location of the network to each network node. The ONC BOCES network has central switching located in Oneonta. Thus, the distance education network telecommunications line charges are determined by the distance from Oneonta to each participating school district.

Districts in ONC BOCES use the distance education network to offer and receive courses that normally would not be offered due to low local enrollment. The network creates an opportunity for shared enrollment for up to three districts. ONC distance education is used for AP (advanced placement), SUNY college credit, Syracuse University Project Advance Freshman courses, Accounting, English, Film, Foreign Language, Nutrition, Calculus, Meteorology, Paleontology, Civil War, Geography, and Criminal Justice courses. All courses given are not part of the core curricula for a high school diploma. For example, a district may have three students requesting German. By combining with two other districts with five students each, a total of 13 students are available to take the course. BOCES currently limits total class size to 24 and number of simultaneous locations to three. Educational specialization is gained by increasing class offerings to students. Student classroom interaction now extends beyond traditional district boundaries into the local BOCES region. As BOCES districts begin to develop inter-BOCES communications networks, interactions will extend to the entire state. Naturally, this expansion leads to more opportunity for educational specialization.

Distance is also a factor in resource sharing. Small, rural, dispersed districts cannot share personnel resources as efficiently as less dispersed and or larger districts. It is common in the ONC region for districts to share or hire part time personnel for low enrollments. District dispersion and the demand for more specialized courses reduces the opportunity to effectively share personnel. Distance education removes the factor of distance from human resource sharing. Distance education effectively lowers direct transportation costs and the opportunity cost of transport time.

Sassen (1996) views economic globalization as "both a dynamic of dispersal and a dynamic of centralization". "The massive trends towards the spatial dispersal of economic activities at the metropolitan, national, and global level, which we associate with globalization, have contributed to a demand for new forms of territorial centralization of top-level management and control operations" (Sassen. 1996).

Table 1. Tariff Rates for 1985, 1990 and 1997 for Various Telecommunications Lines.

	1985	1985	1990	1990	1997	1997
Line*	Fixed	Per Mile	Fixed	Per Mile	Fixed	Per Mile
56 KBPS	$179.86	$3.87	$76.93	$1.65	$30.12	$1.98
T1 – 1 MBPS	$36.78	$48.95	$206.26	$36.43	$66.00	$20.00
MCV – 45 MBPS	NA	NA	NA	NA	$26.00	$165.00

*KBPS – 1,000 Bits per Second
MBPS – 1,000,000 Bits per Second
Multi Channel Video - 45MBPS (Not Available Until 1994)

Table 2. Total Monthly Cost for ONC BOCES 120 Mile Distance Education Network with Nine Sites.

Line	1985	1990	1997
56 KBPS	$2,083	$ 890	$ 509
T1 – 1 MBPS	$6,205	$6,228	$2,994
MCV – 45MBPS	NA	NA	$20,034

Table 3. Cost per Bit for ONC BOCES 120 Mile Network for Different Bandwidths.

Line	1985	1990	1997
56 KBPS	$.01150	$.00491	$.00478
T1 – 1 MBPS	$.00591	$.00458	$.00247
MCV – 45 MBPS	NA	NA	$.00044

Source: Nynex Tariff Rates for 1997.

As distance education networks expand, the dispersal of classroom activities will increase, as will the needs for more centralized network management. This is already observed in the regional consolidation of BOCES networks and the trend towards consolidating these services to the RICs.

BREAK EVEN ANALYSIS

High capacity (bandwidth) telecommunication infrastructure is required for synchronous, two-way video, voice and data distance education. The ONC BOCES network uses a 45 million bit, multi-channel video, telecommunications line between the distance education sites. Significant funding is required to build distance education classrooms, lease telecommunications lines, train faculty and manage systems. The explosive growth of data communications and telecommunication deregulation contributes to lowering tariffs on telecommunications lines and associated bandwidth.

The tables show costs are decreasing for 56K, T1, and MVC telecommunication lines. It is interesting to note that mileage (network edge) charges for the 56K line have actually increased while fixed (nodal) charges have decreased. The total cost for the nine node ONC BOCES network has declined in all cases. As mileage charges continue to decline, the opportunities for network expansion will increase. ONC BOCES estimates a fixed charge of $50,000 to build and equip a distance education classroom. Approximately $35,000 of this charge is for equipment with the balance for room modifications, furniture, and fixtures. ONC BOCES has created a payment structure for senders and receivers of distance education. A school providing a class receives $6,000 for the class from up to three subscribers of the class. If you send a course you automatically are a receiver of that course. For example, a school sends a course on meteorology to two other districts. The tuition for each district is $2,000. Thus the host district nets $4,000 ($6,000 - $2,000) for sending the course. If there is only one host and one receiver than the host district nets $3,000. The payment plan creates an arbitrage situation that encourages districts to trade courses. College courses are offered for a charge of $1,000 per course. All

costs associated with the ONC BOCES distance education network are subsidized with BOCES aid. Each district has a different aid ratio based on demographic data. Following is a cost benefit analysis for the ONC BOCES network from 1996 to 1997. A break-even aid percentage shows the required subsidy for the network to break even.

ANALYSIS OF DISPERSION FOR ONC BOCES DISTANCE EDUCATION NETWORK

Constructing a contour plot to depict district need for distance education in the ONC BOCES region requires measurement of the factors of production in public education that create economies of scale. The factors chosen for this study are district pupil population and total district instructional expenditure. Districts with higher enrollments and instructional budgets typically offer more specialized opportunity for their pupils. Because distance is a factor in terms of telecommunications costs, opportunity costs, and transportation costs, the dispersion (accessibility) of the district relative to other districts is also a factor in determining the need for distance education. One would expect that small, more dispersed districts would tend to be users of distance education while larger, less dispersed districts would tend to either not use distance education or be providers of courses.

Table 5. shows district student populations and instructional budgets compiled from the 1995 New York State Department of Education data for the 19 districts in the ONC BOCES region. In addition, an accessibility "reachability" index was calculated for each district using the formula: $A = \sum d_{ij}$ (Moryadas p. 84) where d_{ij} is the distance between any two districts. Ratios were then computed for (1.) District Student Population/A and (2.) District Instructional Expenditure /A. Table 5 shows the data.

Using the ratio data and Surfer software, two contour plots were drawn to show the effect of accessibility on instructional expenditure (Figure 1) and student population (Figure 2). Data was interpolated using the Kriging method. Distance education users are identified by the number of courses in parentheses. Inspection of the plots leads to the following observations: (1) The users distance education are primarily small districts close to Oneonta with the exception of Cherry Valley and Oneonta. (2) Oneonta, by far the largest district, does not offer any distance education courses despite being connected to the network. Cooperstown, the next largest, is not connected to the network.

Table 4. Break-even Analysis for ONC BOCES Distance Education Network

Yearly Expenses	Per District	
Line	$ 29,333	
Operation/Maintenance	$ 13,820	
Room Installation Charge	$ 12,195	50,000 Amortized Over Five Years @ 7%
Class Aide	$ 1,870	
Total For One Year	$ 57,217	
Total for All Districts	$ 514,957	
Teachers Replaced	6.00	
Total Cost of Replaced Teache Teachers	$ 239,736	
Net Cost	$ (275,221)	
Subsidy Required to Break Even	53%	
Districts: 9 Host Classes:	17	Received Classes: 36

Source: ONC BOCES Distance Learning Network Budget for Fiscal Year 1996-1997 and ONC BOCES 1996-1997 Salary Survey Data.

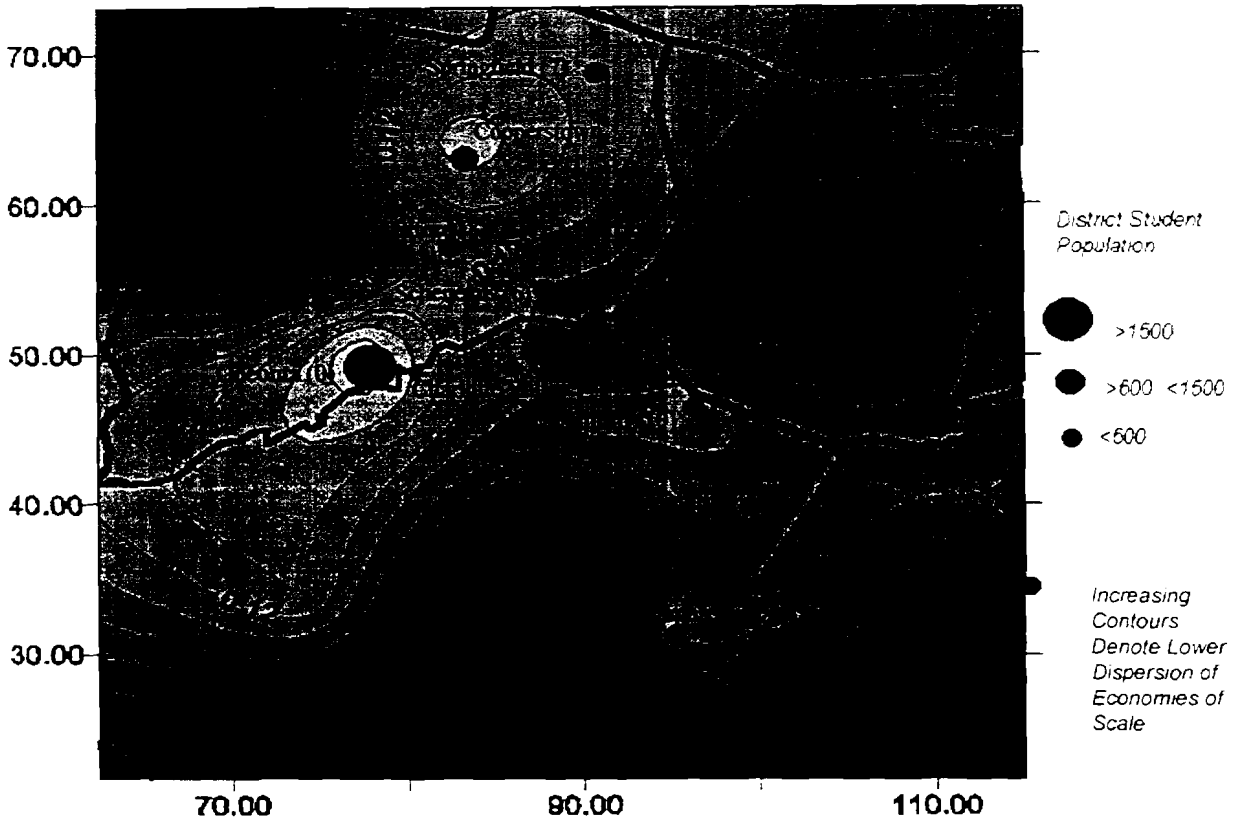

Figure 1 Contour Plot of Ratio of Instructional Budget to Dispersion Index

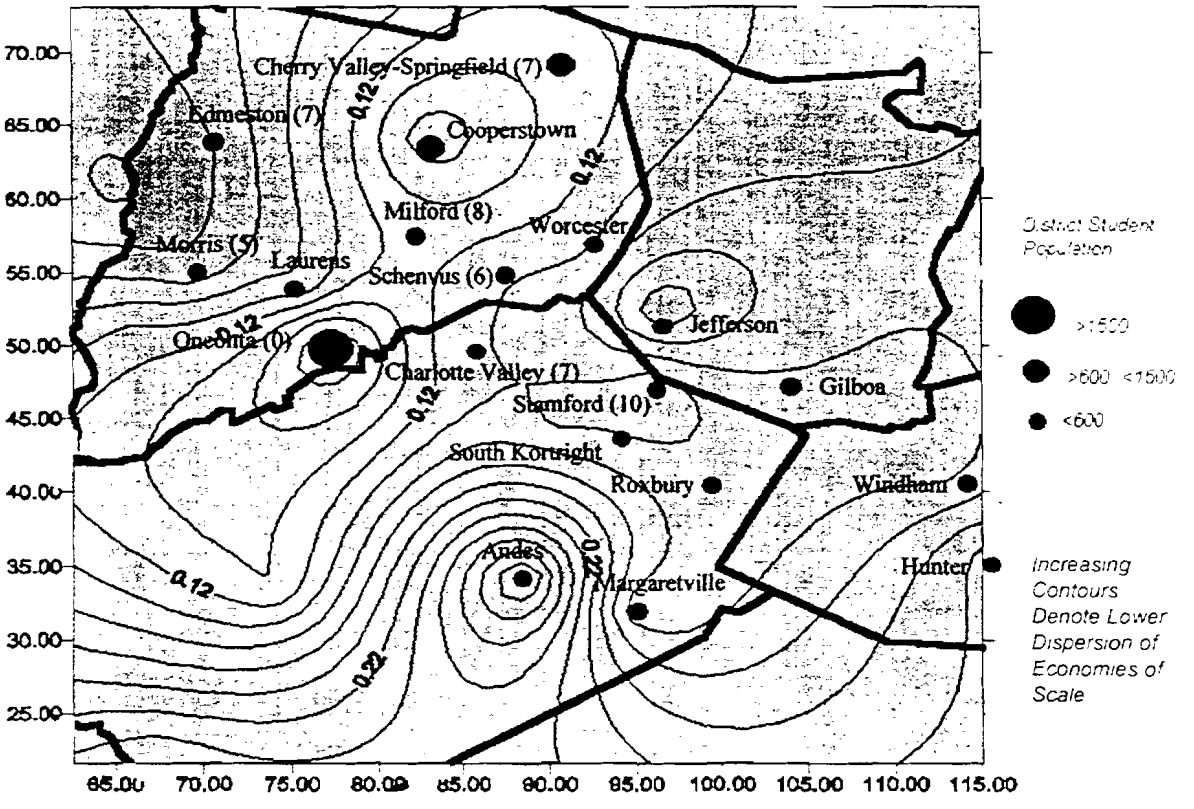

Figure 2 Contour Plot of Ratio of Students to Dispersion Index

Table 5. Student Populations and Instructional Budgets

District	A	Students	Ratio I. A/Students	Instructional Spending per	Total District Instructional Spending	Ratio II. A/Total District Instructional
Cherry Valley	523.0	848	0.62	$5,748	$4,874,304	0.11
Cooperstown	443.2	1341	0.33	$5,081	$6,813,6210.07	0.07
Edmeston	580.0	582	1.00	$4,876	$2,837,832	0.20
Laurens	419.5	487	0.86	$5,629	$2,741,323	0.15
Milford	373.8	493	0.76	$6,754	$3,329,722	0.11
Morris	526.0	482	1.09	$5,623	$2,710,286	0.19
Oneonta	404.1	2170	0.19	$5,983	$12,983,110	0.03
Schenevus	335.2	381	0.88	$6,399	$2,438,0190.14	0.14
Worcester	355.0	488	0.73	$5,463	$2,665,944	0.13
Andes	473.4	177	2.67	$7,591	$1,343,607	0.35
Charlotte Valley	337.6	470	0.72	$5,330	$2,505,100	0.13
Margretville	507.7	559	0.91	$6,199	$3,465,241	0.15
Roxbury	409.4	419	0.98	$6,580	$2,757,020	0.15
South Kortright	347.9	449	0.77	$5,660	$2,541,340	0.14
Stamford	351.9	549	0.64	$5,126	$2,814,174	0.13
Hunter	604.0	536	1.13	$7,542	$4,042,512	0.15
Windham	689.3	509	1.35	$5,981	$3,044,329	0.23
Jefferson	356.8	302	1.18	$5,376	$1,623,552	0.22
Gilboa	437.4	445	0.98	$6,181	$2,750,545	0.16

(3) Because distance from the Oneonta central office determines telecommunications line costs, only the largest more dispersed districts, Edmeston and Cherry Valley, are connected to the network. Thus, economies of scale may also determine a district's ability to fund the installation of the network.

Next a correlation coefficient was calculated to find the correlation of student population to instructional budgets. New York State aid is on an equalized basis, thus instructional budgets should be highly correlated to student population. A low correlation may indicate that either variable may not fully explain district economies. The correlation of the student population and the district instructional expenditure resulted in a coefficient of .9872. This is significant because it verifies that instructional budgets are highly equalized based on the number of students, therefore, neither variable can be eliminated.

As expected the coefficients of classes to instructional budgets (-0.83) and number of students (-0.82) denote an inverse relationship. As the number of students or instructional budgets increase, the number of distance education classes offered decrease. The relationship of total classes to the accessibility index yields a coefficient of .48. While not highly correlated, a trend toward distance education being used by more dispersed districts is apparent. The coefficients for classes hosted and received are less conclusive in all cases although it does appear that smaller districts have a tendency to receive more classes. The limited number of data points makes this a preliminary glance at best. The study region must be expanded to have more conclusive statistical data.

Table 6*. Distance Education Usage

District	A	Number of Students	Instructional Budget	Total Distance Education Classes	Classes Sent	Classes Received
Cherry Valley	523.0	848	$4,874,304	7	6	1
Edmeston	580.0	582	$2,837,832	7	2	5
Milford	373.8	493	$3,329,722	8	3	5
Morris	526.0	482	$2,710,286	5	3	2
Oneonta	404.1	2170	$12,983,110	0	0	0
Schenevus	335.2	381	$2,438,019	6	1	5
Charlotte Valley	337.6	470	$2,505,100	7	4	3
Stamford	351.9	549	$2,814,174	10	3	7

*contains college courses which were not included in the break-even analysis.

Table 7 Correlation Coefficients for Distance Education Usage and the Accessibility Index (A), Instructional Budgets, and the Number of Students.

	Correlation Coefficient
Total Distance Education (DE)Classes to A	0.48
DE Classes Hosted to A	0.21
DE Classes Received to A	0.42
Total DE Classes to Instructional Budget	-0.83
DE Classes Hosted to Instructional Budget	-0.45
DE Classes Received to Instructional Budget	-0.67
Total DE Classes to Number of Students	-0.82
DE Classes Hosted to Number of Students	-0.44
DE Classes Received to Number of Students	-0.66

CONCLUSION

The increased specialization of the post-industrial economy requires secondary public education to offer increasingly more diverse curricula. New York State has a history of centralizing school districts to gain scale economies and the prospect of a global economy reinforces the need for more specialization. Distance education provides curricula specialization opportunities for schools lacking economies of scale.

The high correlation of the instructional spending and student population indicate economies of scale exist in public school districts. The contour plots show less need for distance education in the larger districts despite their relative dispersion to other districts in the network. A trend is also apparent that smaller districts connected to the distance education network are offering more distance education courses to their students. The size of the district is certainly more significant in being a user of distance education than the location of the district. This point is further verified by Oneonta and Cooperstown not using distance education and Cherry Valley indicating in an interview that they are using the arbitrage payment scenario to be a net offerer of courses to make money. In addition, subsidies will be required for distance education networks until the cost per bit of transmission decreases. Subsidies are paid to the district in the form of BOCES aid. As long as the weighted average aid ratio of the participating districts exceeds 53% the network will break even. In the study region, the aid ratios range from 25% to 75%. As curriculum demands exceed the resources of small districts, distance education provides a viable solution to increase specialization as long as subsidies exist to support the network. In fact, the subsidy can be viewed as a transfer payment to allow more educational specialization for the districts participating in the ONC BOCES distance education network.

More data related to the use of synchronous distance education versus the size of the district needs to be compiled for a more conclusive argument. This study does give preliminary guidance concerning the trends in secondary distance education for the ONC BOCES district in Central New York State.

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