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Article

Evaluating the Economic Sustainability of Two Selected Urban Centers—A Focus on Amherst and Braintree, MA, USA

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Abstract: The study is devoted to analyzing the economic sustainability of the town of Amherst, MA. The city's top employer and core enterprise is the University of Massachusetts Amherst, with over 32,000 students and almost 2,000 staff members. Based on a literature review, a hypothesis was put forward that a university city should have a high level of economic sustainability. To assess economic sustainability, the USCESI Index was developed. It evaluates sustainability in three groups of parameters: society, economy, and ecology. The first group includes the level of racial diversity, the level of education of the population, and the access to medical services. The second group consists of the Gini coefficient by income level, the median cost of housing, and the unemployment rate. The environmental situation is assessed according to the Air Quality Index developed by the US Environmental Protection Agency. For comparison, the town of Braintree, MA, was taken. The USCESI was calculated for both locations. The analysis showed that both Amherst and Braintree have a high degree of economic sustainability. However, it was revealed that proximity to a significant economic center has a more powerful positive impact on economic sustainability than the location of a large university.

Keywords: economic sustainability; university city; socio-economic inequality; index assessment

1. Introduction

For many years, the main conceptual framework for researching how cities and nations develop has been sustainable development. With the creation of the 17 Sustainable Development Goals (SDGs), the United Nations codified the unique status of that strategy. The sustainable development concept was studied from various perspectives including social, economic, environmental, political, and cultural considerations. While sustainable development is a clearly defined term, its variations are less definitive. Of particular interest for urban economics studies is the concept of economic sustainability. Most researchers who utilize it for empirical analysis or suggest their own vision share the opinion that this concept has no clear commonly accepted definition [1–5].

In the context of post-pandemic economic development, as well as growing geopolitical turbulence, sustainable development issues are becoming even more important. Cities, which concentrate the main part of added value production, may be both sustainable growth drivers and the most economically challenging places. In that regard, the goal is to form an assessment methodology for sustainable development, as well as to look for the factors that would impact it and assume a particular relevance.

Another important subject connected with sustainable development is the social and economic inequality within and among towns. In this regard, of interest are university towns, as they are a form of "monocities" oriented at the production and dissemination of knowledge and knowledge-intensive technologies instead of the industrial sector and natural resources.

Typical university towns, whose territories are mostly occupied by campuses, are common in the USA. Unlike many other countries, universities here are mostly located in specialized towns

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versus megalopolises (even though such universities exist as well). Apart from that, despite heightened attention to the issues of inequality, the USA remains a highly polarized country in terms of socio-economic indicators—income level, access to quality education, healthcare, and housing [6,7].

The objective of our study is to develop a quantitative assessment of economic sustainability based on the US Cities Economic Sustainability Index (USCESI) and proposed by the authors. The methodology has been tested on two selected US cities. One of them is the university town of Amherst, Massachusetts (USA), with a population of 39,000 people. Its main employer is the *University of Massachusetts Amherst (253rd place in the 2023 QS rankings), home to over 32,000 students and 2,000 faculty members. The second town is Braintree, Massachusetts, also with a population of 39,000 people. Braintree is part of* Greater Boston metropolitan area and is connected with this major megalopolis by a suburban railway line. The distance between Braintree and Boston is about 20 kilometers by car. The comparison of two cities of similar size and location is interesting because it reveals the specifics of a university city. This leads to a key research question: How does a university city in the US differ from a city without a major university in terms of the potential for economic sustainability? An obvious hypothesis is the assumption that the university, by creating an environment for the life of young, educated residents, as well as qualified teachers, also has a positive impact on the economic sustainability of the city. Therefore, we can assume that Amherst has the prerequisites for high performance in this area. To check if this is the case, it is essential to carry out a comparative analysis, and a city with similar geographical location and almost the same population is seen as a suiting option for this.

2. Economic Sustainability and Its Attributes

Before we proceed to the main subject of this paper, we need to clearly define the economic sustainability of a city. As our goal is the quantitative assessment of this phenomenon, the definition should include measurable attributes. Therefore, the institutional and cultural factors that do not easily lend themselves to quantification will not be accounted for.

The problem of economic sustainability was studied by authors as applied to different aspects of societal life. It has been noted that sustainability plans developed in many US cities tend to neglect the issues of inequality reduction, even though there is a trend to draw more attention to this problem [8].

Another frequently addressed subject is sustainability and inequality in smart cities. The very concept of a smart city is extremely broad, with different scholars defining it differently. Yet, a common thread is the leading role of knowledge-intensive technologies and highly qualified workers in economic production [9,10]. Therefore, even though we cannot state that Amherst fully matches the notion of “a smart city”, it is logical to assume that a university city would be a likely candidate for that status.

In principle, smart cities often create conditions for greater inclusivity and inequality reduction [11]. That said, access to higher education in the US remains highly disproportionate, especially for various racial groups [12,13]. Thus, economic sustainability risks may include a gap in income, unemployment, and education attainment, as well as racial composition metrics.

The most telling racial indicator is the racial diversity level. Generally, its increase leads to the reduction of interracial inequality, which is even more visible in the higher education sector [14,15].

Apart from the above-mentioned factors, real estate and insurance are critically important for the American context of economic sustainability. According to Florida [16], the real estate market is the main cause of social and economic polarization in cities all over the world. With a clear connection between people' health and quality of life, it is especially fair for the United States [17].

Urban health has an impact on the sustainability level in the face of strong and sudden shocks: the healthier the city, the more efficient the city’s response to challenges, the less dangerous are risks, and the faster the city recovers from adverse ramifications. In a traditional vision, urban health reflects the outcomes of the environment (both physical and the social) that impact dwellers’ well-

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being and quality of life in urban areas [18]. A city with a good health level has higher sustainability and may thereby mitigate the impact of risks.

For the US, the main indicator of urban health is access to medical services. This domain is fraught with acute inequality, which in turn relates to an extremely uneven coverage of the population with medical insurance.

Without a doubt, economic sustainability may not be analyzed without being aware of the environmental issues. They may be conditionally divided into climatic and environmental. Climate change is one of the key challenges of economic sustainability [19]. Despite the importance of this subject, we will leave out climatic factors, as the scope of this paper is limited to two rather small towns located 130 km from one another and their climate conditions are very similar.

Economic sustainability is most often studied in a macroeconomic context [20]. However, according to the objectives of our study, it is necessary to reconceptualize this term for urban studies. The traditional definition of sustainable development proposed by the Brundtland Commission can be taken as a basis [21]. So, we define economic sustainability as such a state of a society, economy and environment that implies minimal risks for the long-term development of a city. Such assessment is to be trilateral: social, economic, and environmental. To be able to identify specific indicators that would help us assess these dimensions, let us address the experience of previous scholars.

To assess the environmental situation in the cities, it was decided to use a single indicator, albeit a complex one. It is the commonly accepted Air Quality Index (see below for details). Several scholars point out the powerful contribution of air quality differentiation to unequal conditions of achieving economic sustainability. In addition to that, as we differentiate economic sustainability from sustainable development, it was important not to give it too much importance in the index, which could lead to distortions not directly connected with the urban economy.

3. Developing City Economic Sustainability Index

Summing up the rationale behind the selection of economic sustainability indicators we can form their final composition (see Table 1).

Table 1. Primary indicators used to assess economic sustainability.

Indicator	Assessment Dimension	Source
Air Quality Index (AQI)	Environment	[22]
Gini Coefficient	Economy	[23]
Housing Value	Economy	[23]
Unemployment Level	Economy	[23]
Racial Diversity	Society	Calculated by the authors based on the data [23]
Educational Attainment	Society	[23]
Insurance Coverage	Society	[23]

Let us look closely at each of the indicators in terms of primary data collection and processing. An important goal was to narrow down divergent indicators to values that may be compared and put under a single index. Hence, most of the collected primary data were normalized, which will be further explained below.

4. Environment

AQI is a dimensionless evaluation of air quality calculated by the United States Environmental Protection Agency (EPA). This index factors in the emissions of five main pollutants:

a. ground-level ozone;
b. particle pollution (also known as particulate matter, including PM2.5 and PM10);
c. carbon monoxide;
d. sulfur dioxide;
e. nitrogen dioxide [24].

The EPA-collected data on the concentration of the five listed pollutants are combined into a single index in accordance with the following algorithm [24]. The AQI is the highest value calculated for each pollutant as follows:

1. Identify the highest concentration among all the monitors within each reporting area and truncate as follows:
   a. Ozone (ppm) – truncate to 3 decimal places.
   b. PM2.5 (µg/m3) – truncate to 1 decimal place.
   c. PM10 (µg/m3) – truncate to integer.
   d. CO (ppm) – truncate to 1 decimal place.
   e. SO2 (ppb) – truncate to integer NO2 (ppb) – truncate to integer.
2. Using the AQI Technical Assistance Document, find the two breakpoints that contain the concentration. The document can be read in [24, p. 9].
3. Calculate the AQI for each pollutant, using formula:

$$AQI_p = \frac{AQI_{high} - AQI_{low}}{BP_{high} - BP_{low}}\left(C_p - BP_{low}\right) + AQI_{low}$$

where AQI_p is the AQI index for pollutant p, C_p is the truncated concentration of pollutant p, BP_{high} is the concentration breakpoint that is greater than or equal to C_p, BPlow is the concentration breakpoint that is less than or equal to C_p, AQI_{high} is the AQI value corresponding to BP_{high}, AQI_{low} is the AQI value corresponding to BP_{low}.

4. The final value of the AQI index is the maximum value among all AQI_p.

The results of the index calculation are the dimensionless indicators ranging from 0 to 500. The interpretation of values is recorded in the analytical materials provided by AQI. The distribution of values by residents' health hazards may be found in Table 2.

Table 2. AQI Basics for Ozone and Particle Pollution.

Levels of Concern	Values of AQI	Description of Air Quality
Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Note. Derived from [25].

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EPA provides AQI data open access [22]. However, the index is calculated not only at the county level but also at the level of individual towns. In this regard, we had to assume that air quality in the analyzed towns matches the average level for counties. Amherst is in Hampshire County, while Braintree is in Norfolk County.

For a better understanding of the context as well as the specificity of the territories under study, let us do a retrospective analysis of the AQI values dynamics for the two counties (which include Amherst and Braintree), the state of Massachusetts, and the United States of America overall. To that end, we built a graph presented in Figure 1.

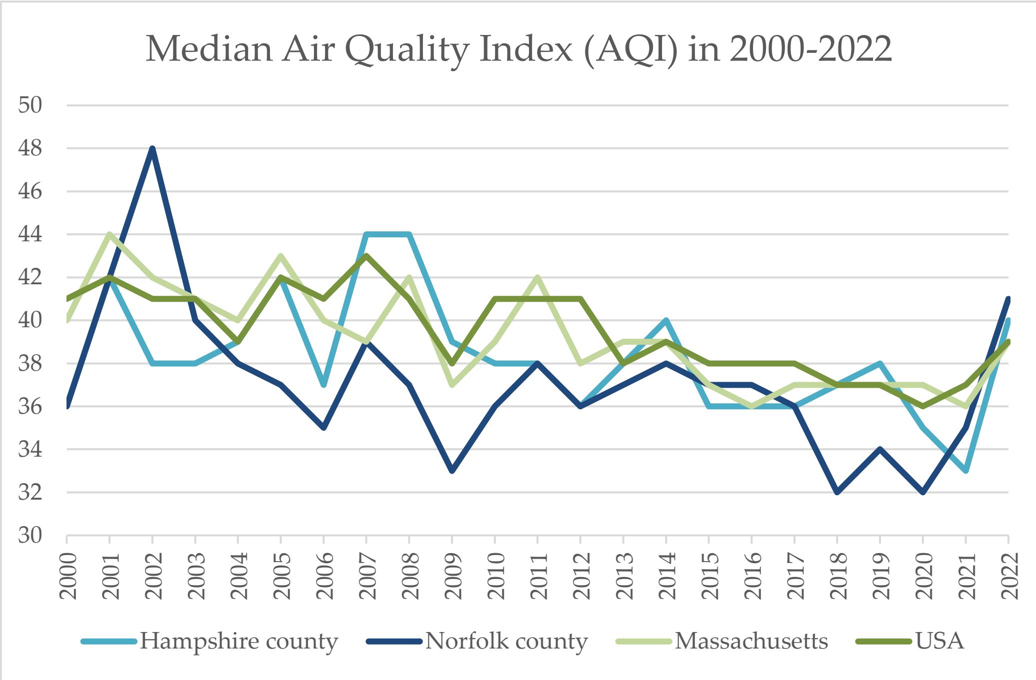

Figure 1. Dynamics of median AQI for Hampshire County (Amherst), Norfolk County (Braintree), the state of Massachusetts, and the USA in 2000–2022.

As the AQI data may have a considerable variation (from 0 to 500), they are traditionally analyzed in relation to the median value rather than mean. On the graph we may see that the amplitude of yearly median values is not very high, from 32 to 48, which corresponds to good air quality. Incidentally, both extremes have been registered in Norfolk County. Quite visible is the downward trend, which took place in all the four territories before 2020, but in the last two years (2021–2022) it has changed to growth. It is more pronounced in Norfolk and Hampshire counties (that said, the 2020 values were lower there). This is indicative of a rather substantial aggravation of the environmental component of sustainability within common values.

AQI data are available for 2022, but the main part of the statistics collected by the US Census Bureau is restricted to the year 2021, as of this writing, hence AQI for 2021 will be used in further analysis.

As AQI assumes values from 0 to 500, these values should be normalized in the composite index for usability purposes. At the same time, one more methodological detail connected with the use of AQI needs to be considered. Some assessed pollutants may be the result of human activity, while their concentration depends on physical and geographical conditions. Therefore, it is not correct to normalize values for all the United States—the climate, relief, soil, and vegetation of New England, where the towns under study are located, have nothing to do with, say, the Sonoran Desert. In this regard, the median AQI values for the two counties were normalized from 0 to 1 by a multitude of values of 13 Massachusetts counties (there is a total of 14 counties in this state, but there are no data for the Nantucket County due to its small territory and low population density).

As a result, the counties got the values in the format of 0 to 1. They were then subtracted from 1 so that the higher value corresponded to better air quality.

5. Economy

The goal of assessing the economic dimension within the index was to factor in the indicators that have not only an economic but also a high social value. That is, in lieu of the indicators characterizing the volume of economy or its industrial structure, we used those indicators that are directly related to the effects on people.

The most important factor of this kind, particularly in the context of a strong social and economic inequality in the USA, is the income polarization. The traditional method of assessing inequality is the Gini coefficient, calculated in accordance with the formula:

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|y_i - y_j|}{2n^2\bar{y}},$$

where n is the number of households, y_i is the share of the household i income in the total income, y_j is the share of the household j income in total income, while $\bar{y}$ is the arithmetic mean (value) of income shares of the households.

The Gini coefficient reflects the degree of social stratification by a certain attribute under study, in our case by median per capita income. The result of the calculation assumes values from 0 to 1; the closer it is to 1, the higher the level of inequality. As the range of values for Gini coefficient is 0 to 1, this indicator does not require being normalized.

The American statistics published by the US Census Bureau does not require the calculation of the Gini coefficient, as its values are published in the ready-for-analysis format (based on the aforementioned parameter). Notably, this indicator, just like all the other ones derived from the statistical databases, was collected on the NHGIS project website (NHGIS Data Finder). This is a usable database of official statistics from 1790 to date compiled by the researchers from the University of Minnesota.

The two other economic indicators used also reflect the economic conditions of society. They are the median cost of real estate and the unemployment level. Just like the polarization of income level, these are major factors determining the possibilities of the city to develop sustainably. Also, they are closely connected with both economic activity and the overall volume of economy.

For these two indicators it was decided, just like for AQI, to linearly normalize values from 0 to 1 for the set of values for the state of Massachusetts. This was done to mitigate the discrepancies connected with emissions as well as to avoid too high results, as Massachusetts is one of the most economically thriving US states and its comparison to states with a completely different economic specialization and other population composition would be incorrect.

6. Society

The bloc of "society" indicators implies the assessment of those social and economic indicators that represent to a larger extent the condition of the residents rather than the economy of the city. They were selected in the logic of assessing social capital as an important factor of economic sustainability [26,27]. Given the US context (the importance of interracial inequality as well as a disproportion in terms of the access to education and medical services), it was decided to select three indicators: Racial Diversity, Education Attainment, and Insurance Coverage. All these determinants to a large extent define the level of social capital in US cities [28–30].

The racial diversity level was estimated based on the Herfindahl-Hirschman index in accordance with the formula:

$$HHI = S_1^2 + S_2^2 + \cdots + S_n^2,$$

where S_1^2, S_2^2 are shares (percentages) of racial groups in the total population.

After the calculation, the results (from 0 to 10,000) are converted into a non-percentage format (from 0 to 1) for the convenience of further analysis: 100 = 0,01; 10,000 = 1. As the index interpretation

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implies the logic of "the lower the index value, the higher the diversity," the results in the format of 0 to 1 were subtracted from 1 for the convenience of integration.

Education attainment and medical insurance coverage were estimated based on the statistics about people aged 25 and over with the education attainment level of bachelor degree and higher as well as on the share of people of any age that have at least one medical insurance. The values vary from 0 to 1; the higher they are, the better the situation in the town.

7. Economic Sustainability Index (USCESI)

All the collected data was converted into the format from 0 to 1, the logic being that "the higher the value, the higher is the economic sustainability level." The "environmental" dimension is represented by one indicator while "society" and "economy" are represented by three. For the two latter ones mean values were used for the formula. Thus, the formula looks as follows:

$$USCESI = \sqrt[3]{AQI \times Soc \times Eco}$$

where AQI is a normalized median value of the Air Quality Index, Soc is the mean of three normalized indicators of the "society" dimension, and Eco is the mean of three normalized indicators of the "economy" dimension.

This formula matches the calculation of geometric mean. This method proved to be efficient when calculating the Human Development Index developed by the UN [31].

8. Results

Let us consider the index calculation results. Firstly, we need to draw our attention to individual USCESI indicators to identify the specificity of the cities in question/studies (see Figure 2).

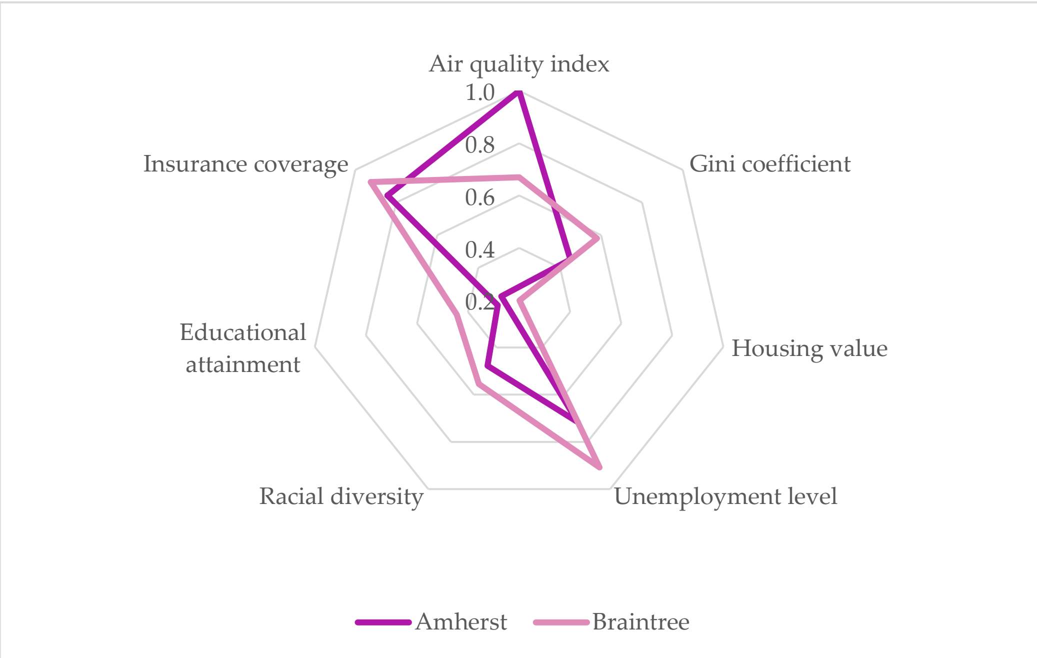

Figure 2. The USCESI indicators scores (the higher the value, the better the situation in the city).

Perhaps the most unexpected result of the calculation was that by almost every parameter the economic sustainability of Amherst, a university town, is lower than that of Braintree. Particularly surprising is the value of education attainment—a mere 0.28. Let us recall that the values of this indicator were normalized for many other towns in Massachusetts, which has a high concentration of university towns. For Braintree, this indicator was 0.44.

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A possible explanation could be that many jobs are generated within and around the university; these jobs relate to furnishing the needs of students and faculty: security, grounds maintenance, shops and public catering facilities inside and near the campus. It also bears reminding that most bachelor students were not included in the assessment, as the US statistics only factors in persons aged 25 and older (implying that most students are younger than that). At the same time, Braintree is quite a prosperous suburb of Boston, and it is highly possible that the main stratum of its population are white collar workers, i.e. educated, qualified, and privileged employees of various corporations.

Insurance coverage varies insignificantly and both towns have a high value of it (0.84 in Amherst and 0.92 in Braintree). The difference in some other indicators in favor of Braintree has a trivial explanation: Amherst has a lower racial diversity, as the accessibility of education is uneven for white and non-white population groups (with a noticeable exception of Asian Americans), while the real estate oriented toward students should logically be cheaper that in the suburbs.

The only dimension where Amherst proved to be far more successful that Braintree is the environment. Hampshire County, where the university town is located, boasts the best air quality in Massachusetts as of 2021, therefore Amherst got the maximum score (1) by that measure. The indicator of Norfolk County where Braintree is located is also high (0.67).

A lower indicator may be explained by the fact that Norfolk in general and Braintree in particular have larger industrial enterprises than Hampshire, where the main employers are universities and colleges. Thus, Braintree is home to a major transmission production (brakes, motors for elevators) under the Altra Industrial Motion brand, which employs 10,000 people. Other large Braintree-based companies relate to media industry and knowledge-intensive developments in medicine (in particular, a branch of Haemonetics company, one of the leaders in blood and plasm donorship equipment). This also partially explains Braintree's higher education attainment level.

Let us proceed to the result of the USCESI calculation and its components (sub-indices). The calculation results are presented in Figure 3.

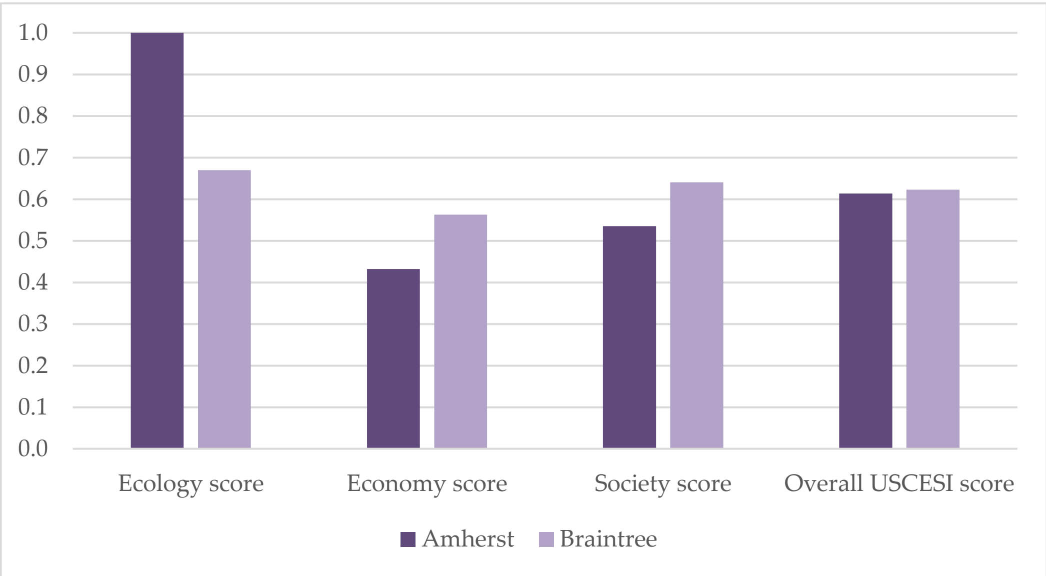

Figure 3. The USCESI components score and overall USCESI score.

It is apparent that Amherst is quite substantially lagging as compared to Braintree in terms of "economy" and "society" dimensions. The reasons for that were examined above, but it is important to emphasize Braintree's main advantage, which is its proximity to Boston. So, our analysis showed that the proximity of a large economic center has a more powerful positive impact on economic sustainability than the presence of a university campus within the boundaries of the city, which, to a large degree, shapes the economic specialization of the city.

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However, a high economic activity has a flip side to it: a large volume of emissions into the air. That said, since the productions concentrated in Braintree and Norfolk County on the whole are oriented toward knowledge-intensive technologies, the quality of air is quite favorable.

Despite a considerable environmental advantage, the total USCESI value is slightly lower than in Braintree: 0.61 against 0.62. At first glance, these indicators may seem very close, yet the analysis of the individual components of the index shows that there is a better situation with economic sustainability in the Boston suburb rather than in a university town.

This allows for the conclusion that a university town is a victim of its own status, a monotown in a sense. The economy of Amherst does not lend itself to diversification like that of Braintree, where innovative and knowledge-intensive productions were set up. Even though the US's technology parks are almost invariably associated with the concentration of universities (e.g. Silicon Valley in California, the Silicon Prairie in Texas, and the Research Triangle in North Carolina), they still form autonomous territories. Employees of such regions have different demands than students. This applies to the living standards, consumption patterns and leisure pastimes. Therefore, Amherst university graduates will more likely move to Boston agglomeration in search of work and Braintree with its location close to its core looks quite an appealing option.

9. Conclusion

As part of the study, an economic sustainability assessment methodology was developed. It factors in the context of American society and US urban economy and may be applied to other cities in other countries if adjusted accordingly, including the selection of the most significant indicators.

The principal goal was to analyze the economic sustainability of a university city, which required comparing it with an identically populated and geographically located town without a university. Amherst was selected as the subject for the case study of a university locale, while Braintree was designated as the subject of comparison.

The results showed that the presence of a large university does not guarantee advantages in achieving economic sustainability. In terms of all indicators connected with the social and economic differentiation (income inequality, unemployment level, cost of living, racial diversity, educational attainment, medical insurance coverage), Braintree proved to be more successful that Amherst. This is linked to Braintree's favorable economic and geographical location near Boston, the state's principal economic center. Thus, close economic connections with an important center of the services industry have more impact on economic sustainability than the presence of a large university (in a city).

The presence of a university in a municipality also has a considerable advantage. A university city is oriented to "green economy" that is not connected with harmful manufacturing facilities and does not produce large amounts of emissions. This is why air quality is higher in Amherst than in Braintree.

As a result, it may be stated that the pilot USCESI calculation demonstrated that both Amherst and Braintree have a high degree of economic sustainability. Considering that many indicators were based on the sustainable Massachusetts, these values look even more impressive.

USCESI can be used in reporting on sustainability in US cities. When such reports are compiled for a large sample of cities, new insights can be drawn about the relationship between sustainability and the socio-economic, demographic, and other factors that determine the diversity of American cities.

The proposed economic sustainability methodology certainly has limitations. It may be further elaborated in subsequent studies. The suggested improvement may be introduced through complicating the assessment method of the "environmental" dimension to include other metrics of environmental conditions: water and soil pollution, or greening (NDVI). However, the formula in this case will probably have to be supplemented with a certain scaling mechanism, as the focus on socio-economic aspects is a crucial methodological premise of economic sustainability assessment. For more focus on environmental issues, the current conceptual framework will have to be replaced with sustainable development.

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Another idea for a more complex analysis is to expand the methodology to other US cities and states. To allow this, the normalizing principle will have to be changed in the calculation algorithm to account for the substantial social and economic disproportions within the country.

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