What is Related to Towns' Prospering and Decaying in Pennsylvania?

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Abstract

This research aims to compare those degenerate towns and cities with booming ones to find out the strategies for rural and regional developments and help the decision-making through regional planning. Different from studies that only focus on decaying towns, this paper does not neglect those prosperous ones but compare the significant differences between them. The methods include 1) Principal Component Analysis (PCV) to create Development Index (DI) for every county subdivision from 2000 to 2015; and 2) spatial and temporal analysis to find whether some spatial patterns exist. Development Index (DI) is the core standard to evaluate some location's development.

1. Introduction

Nowadays, in terms of sustainability, considerable amounts of urban planners and researchers focus on the physical spaces of cities shirking rural areas and other social factors. However, whether a city is sustainable relies more on environmental, social and economic issues[3]. To achieve that, it is fundamental to analyze it at a bigger regional scale since there's an intimate relationship between urbanization and environmental sustainability [4]. Meanwhile, some factor, for example, economic development, is not only an indispensable part of sustainability but also a motivation to move cities forward.

In such a big regional scale, however, when zooming in, a city is too big to dig out to check development status and reasons. Usually, researchers use counties, tracts or blocks as boundaries. Here, the scale of towns will be used because the initial research purpose to zoom in widely-neglecting townships. All the boroughs, townships, municipalities and cities are studied. For each year, there are 2573 records in the past 15 years (2000 - 2015).

Some towns in Pennsylvania are decaying resulting from complicated reasons, for example, the shrink of industry and the diminution of the population. In contrast, other Pennsylvania towns survive and even boom. To find part of reasons for this phenomenon, thus, a model is built to evaluate a town's development level in terms of education, medical care, economy and social characteristics. Then, different metrics of towns are analyzed to check whether relationships between specific factors and town's development exist. Many researchers blame town's decay to the decline of the steel industry. That might be true. Nonetheless, we care more about recent 'peaceful' years without rapid change to find out the exact reasons to pull or push towns' development.

This research aims at comparing those degenerate towns with booming ones to find out the strategies for rural and regional developments and help the decision-making through the regional planning. Different from studies that only focus on decaying towns, those prosperous ones will not be neglected but be compared with the significant differences between them. Because 'role models' can inspire urban planners while decaying towns give them lessons. For example, a town in Tallinn experiences decaying. Those old buildings made of carbonate

stones release air pollution. However, the renovation plan at the town's scale makes no progress [5]. To renew a town is a big challenge.

The problem towns facing is complicated. Townships, regions, trade, and environment have complex spatial economy [6]. Thus, most statistic data (population, housing units, education percentage, health insurance percentage ......) of Pennsylvania are collected from U.S. Census[1], which cover various fields in comprehensive developing aspects. Data from 2010 to 2015 are highly detailed as well as the year of 2000 while comprehensive data from 2002 to 2009 are not available from United States Census Bureau. The probable reason is that the bureau gathered and analyzed data every five years before the year of 2010. But we can still draw an approximate conclusion since data of the year of 2000 are accessible.

1. Methods

1.1 Data

This study focuses on the spatial relations and different attributes contributing to the towns' thriving and shriveling. Development of a township, a borough or even a city is correlated with many attributes including population, employment status, local education, public facility, and medical facilities. U.S. census publicized statistical data in county subdivision scale of every state from 2000 to 2015. Pennsylvania Department of Health publicized county healthy profile on their website every year from 1998 to present [2]. 12 representative data are selected from plentiful data sets from 2010 to 2015 and 2000, 8 years' data in total. 12 representative data include three data sets of population and age groups, two of education and employment, three data sets of economic, two of housing conditions, one migration, and one medical treatment. Total population, the percent of population under 18 years old, and the percent of population over 65 years old are used to represent characteristics of population and age groups distribution. The percent of people holding bachelor's degree or higher represents local educational quality. The ratio of the amount of employment and total labor in force is used to evaluate employment status. Household income, percent of poverty households（annual income is less than $25,000）, and values of houses are selected to evaluate local economy. Percent of households that have comprehensive plump networks and percent of vacant units among the towns represent housing conditions. Moving-in population in a year is also selected because it reflects whether the town attracts people from other places. The amount of hospitals, nursing homes and drug and alcohol treatments in a county is used to evaluate the medical level of county subdivisions. These 12 data are selected to be considered as factors related to the development of sub-counties.

1.2 Principal Component Analysis

Principal component analysis (PCA) is a dimension reduction model to extract most vital information from multiple variables [7]. PCA eliminates multiple correlations in the data interior to calculate orthogonal components. Principal components are a few of orthogonal components, which explain most of the variances.

In this research, through principal component analysis, four factors are extracted from twelve variables, which are explained 71.545% variance (Table 2). Factor scores of these four principal components are stored for developing a new index to evaluate the overall performance of a township, a borough or a city.

Table2. Total variance explained by orthogonal components

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.757	31.306	31.306	3.757	31.306	31.306
2	1.997	16.640	47.946	1.997	16.640	47.946
3	1.754	14.616	62.562	1.754	14.616	62.562
4	1.078	8.983	71.545	1.078	8.983	71.545
5	.909	7.577	79.122			
6	.693	5.776	84.898			
7	.643	5.355	90.253			
8	.464	3.866	94.119			
9	.355	2.960	97.079			
10	.215	1.788	98.868			
11	.107	.888	99.756			
12	.029	.244	100.000			

2.3 Development Index (DI)

Principal Components Analysis method to reduce the dimension of data is collected. Then we create an index named a developing index for every borough, township, municipality, and city. PCA-based indices are effectively used for socio-economic status study. PCA-based indices also make it easy to classify all samples to several cluster groups [8]. The Developing index represents a relative degree of developing and sustainability of the town.

We define a development index using weighted principal factor scores, in which the weight is the percent of variance explained by every factor. In this study, four principal components are extracted, so, four factors are used to calculate DI (2.1).

$$DI = p_1 * FS_1 + p_2 * FS_2 + p_3 * FS_3 + p_4 * FS_4 \qquad (2.1)$$

DI: Develop Index

Pn: percent of variance explained by factor n

FSn: factor score of factor n

DI reflects a comprehensive performance of a town comparing with others. In order to analyze each factors' contribution to DI, we return back to PCA factors and obtain an equation using factor score coefficient matrix. DI and original twelve factors equation are shown (2.2).

$$DI = 0.119 * Zpopulation - 0.076 * Zunder18 + 0.069 * Zover65 + 0.139 * Zeducaiton$$
$$+0.024 * Zemployment + 0.116 * Zmigration + 0.116 * Zmigration - 0.055 * Poverty \qquad (2.2)$$
$$+0.106 * Zhousevalue - 0.039 * Zhousevacant + 0.120 * Zplumbing + 0.122 * Zhealth$$

DI: Develop Index
Z: normalized variables

2.4 Spatial Analysis

Using GIS to analyze whether those decaying towns or prosperous towns have spatial relations or the reasons behind this. When we get the statistic results of every borough, township, municipality, and city, we plot them on the map of Pennsylvania to better show whether spatial relationship exists, in other words, whether there's some certain pattern with a spatial connection, or whether there are some 'peculiar' spots appealing to our eyes. The detailed steps include: a) arranging all the data including the index in Micro-Soft Excel; b) joining this Excel table (using Geo-Id to match the data) to the Pennsylvania Map with comprehensive administrative units (boroughs, townships, municipalities, and cities); and 3) Plotting out the data by five categories based on standard deviation.
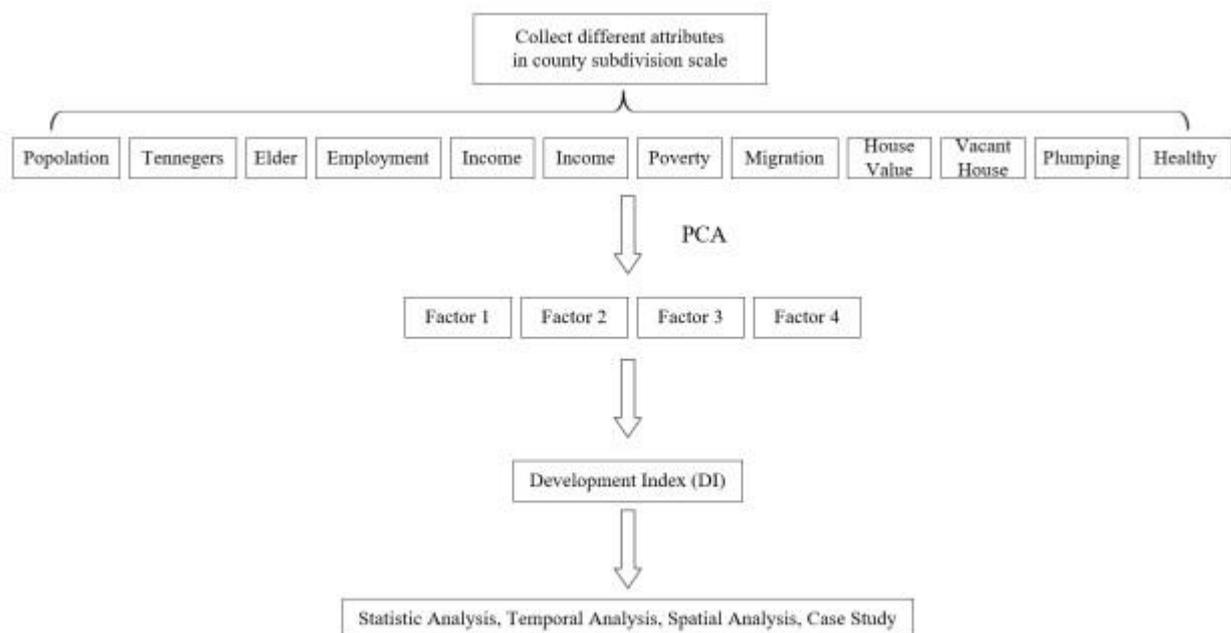

Figure. 1 Workflow

1. Results

1.1 Statistical Analysis

Table 1 Yearly Index Percentage

	2000	2010	2011	2012	2013	2014	2015
level1	0.16	0.35	0.31	0.31	0.31	0.27	0.19
level2	2.65	1.44	1.52	1.36	0.89	0.86	1.13
level3	61.85	39.67	36.57	34.45	32.62	30.43	27.72
level4	26.62	42.08	44.46	45.92	47.57	49.24	50.80
level5	6.74	10.66	11.31	12.01	12.43	12.83	13.27
level6	1.56	4.05	3.96	4.16	4.16	4.39	4.87
level7	0.43	1.75	1.87	1.79	2.02	1.98	2.02

Every year's data are divided into several categories (level 1, level 2, level 3, level 4, level 5, level 6, and level7). These categories are relative percentages that mean the number falling into this category divided by the this year's total record. The range for every category is based on the standard deviation (SD). Level 1 is the index below 2.5 SDs while level 7 is the index above 2.5 SDs. Level 2 is the index from -2.5 SDs to -1.5 SDs, level 3 is from -1.5 SDs to

0.5 SD, level 4 is from -0.5 SD to 0.5 SD, level 5 is from 0.5 SD to 1.5 SDs, and level 6 is from 1.5 SDs to 2.5 SDs. From level 1 to level 7, the performance index goes up, which means the overall performance of all 12 factors goes better. For example, level 7 demonstrates the best performance while level 1 is the worst.

From 2000 to 2015, moderate performance (level 4) and slightly above moderate one keep ascending. Meanwhile, slight below moderate performance (level 3) continues dropping. In general, the overall performance goes up from the year of 2000 to the year of 2010. So, is Pennsylvania decaying or developing at the state's (regional) scale? The answer is positive.

According to (2.2), DI: Develop Index. Z: normalized variables

$$DI = 0.119 * Zpopulation - 0.075 * Zunder_{18} + 0.069 * Zover_{65} + 0.139 * Zemployment + 0.024 Zincome + 0.116 * Zmigration$$
$$-0.054 * Zpoverty + 0.107 * housevalue - 0.038 * Zhousevacant + 0.120 * Zplumping + 0.121 * Zhealth \tag{2.2}$$

12 factors are analyzed. Their normalized values demonstrate how much a particular factor contributes to the overall performance (index). The following factors have positive impacts on development: total population, 65 years above, employment, income, immigration, house value, plumbing, and health. However, the number of kids under 18 years old, poverty and house vacancy have negative effects on the development. Education has the most impact on town's decay or boom, as table 2 shows.

Table 2 Index - normalized variables Coefficient Metrics

Overall Index for whole population	0.119
Percent of Population under 18 years old	-0.0755
Percent of Population over 65 years old	0.0687
Percent of population who own bachelor's degree or higher	0.139
Employment/Population Ratio	0.024
Mean Income (dollars)	0.116
Migration	0.116
Percent of Poverty	-0.054
House Value	0.107
House Vacancy Rate	-0.038
Plumping	0.120
Health Facilities	0.122

3.2 Spatial Analysis

In this part, spatial pattern is studied to find whether there are some spatial relations between those decaying towns and cities or their counterparts.

For the year of 2000, the urban areas, most of which lay in the city of Pittsburg and the city of Philadelphia, were further developed than rural areas. Allentown and Erie performed worse than these two cities but better than remaining areas. In addition, the eastern Pennsylvania was better than the west, which was better than others where towns were located.

For the year of 2010, it differs from the year of 2000. Urban areas still performed well. Moreover, good performance spread from the cities to towns surrounding them, such as Allentown, Pittsburg, and Philadelphia. Philadelphia's west developed well. Towns developed well around Pittsburg. Moreover, Northern Pittsburg spread better than the south. Some towns started to perform well scattering in the center, north and south of Pennsylvania.

From 2010 to 2015, most towns continue growing except for few towns that decline during those years. The overall performance of the whole state was better and better from 2000 to 2015.

2a

figure 2a Development Index of 2000

2b

figure 2b Development Index of 2010

2c

figure 2c Development Index of 2011

2d

figure 2d Development Index of 2012

2e

figure 2e Development Index of 2013

2f

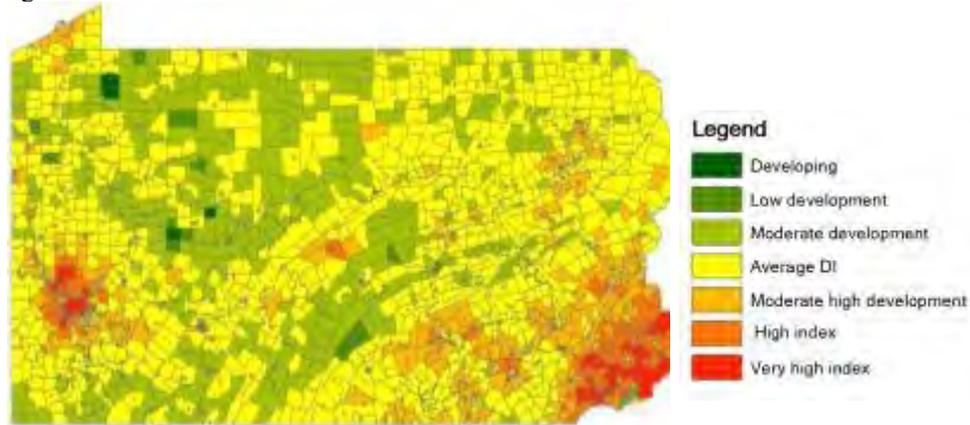figure 2f Development Index of 2014

2g

figure 2g Development Index of 2015

3.2 Temporal Analysis
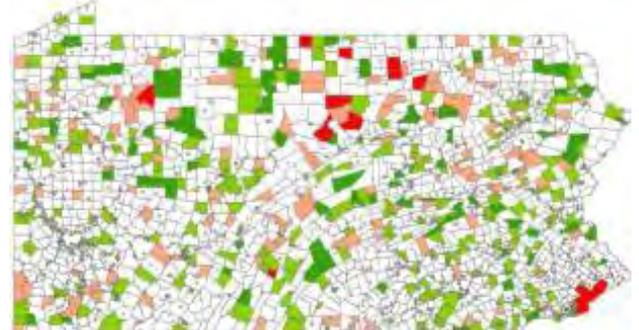
3a

figure 3a Index change 2010-2000

3b

figure 3b Index change 2015-2010

From 2000 to 2010, the Philadelphia urban area grew extensively as well as some towns scattering around the whole state. The eastern Pennsylvania had the highest intensive growth. Inevitably, some towns experienced decay which was far less than the booming ones. Meanwhile, from 2010 to 2015, some towns were decaying which was more than those booming ones, although the overall performance went up. Generally, changes from the year of 2010 to 2015 are more stable than ones from 2000 to 2010.

Comparing changes of 2000 – 2010 with ones of 2010 – 2015, the latter one's decay area is larger than the former. It explains a potential problem that Pennsylvania is growing in general. However, this could not cover the fact that some townships and boroughs are increasingly decaying. More and more townships and boroughs experience the population decrease because of people immigrating to other regions. In turn, the socio-economic status is inevitably decreasing with less employment, less median income or increasing slowly, house values decline, and vacant house rate increasing. In future, these towns might disappear merging to other administrative units. So, scholars should pay more attention to townships and boroughs development.

3.4 Typical Sample Analysis
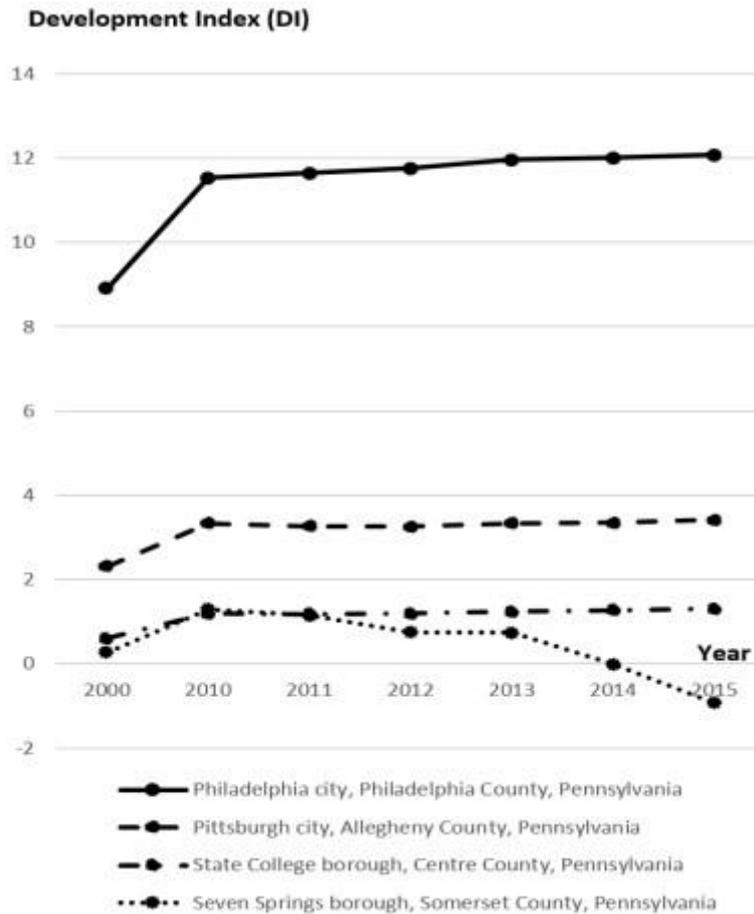
Development Index (DI)

Figure 4 Index change for 4 towns and cities

These four cities and towns typically stand for other ones in Pennsylvania. The Philadelphia city is always the Number 1 performance. High socio-economic status of Philadelphia attributes to the big population, high annual income per household, highly educated population, low percentage of poverty households, low percent of vacant house units. Philadelphia comprehensive development index increases rapidly from 2000 to 2010, and continuously increase from 2010 to 2015. Philadelphia is far better than the second one Pittsburg let alone other cities and towns. Pittsburg has grown striking but smoother than Philadelphia before 2010 and settled to stability after it, even a little decrease. State College Borough is a typical town. Because The Pennsylvania State University sits here attracting students from home and abroad. It results in State College's higher Development Index than surrounding towns.

The industry of education attains more population, especially those well-educated ones, which promotes its employment rate and the immigration. Meanwhile, it elevates the environmental protection, infrastructure construction, property maintenance, housing values etc. Thus, the Development index is higher. From 3.2 spatial analysis, it's not hard to find that towns near State College, such as Ferguson Township, Half-moon Township, Patton Township, College township and Harris township, owns bigger Development index than those remote villages far from it. In 2000, as a tiny borough, State College performed similarly to other average towns. As many boroughs fell behind, State College whose performance was worse than cities but comparatively stable and grew steadily advocated townships around it to development. Seven springs borough represents those decaying towns that perform the worst among 2573 records. From 2000 to 2010, it still moved forward while the population was decreasing after 2010. In 2010, only 40 persons resided here while in 2015 only one. The increasingly depressed town is going to disappear.

4. Conclusions

Among all the typical statistic data collected from U.S census and Pennsylvania Department of Health, 8 factors -- population, percent of educated population, employment, household income, migration population, house value, physical facilities and health facilities are positively correlated with socio-economic status of a borough, a township or a city, while other 2 factors – percent of poverty and vacant house rate are negatively related to

Development Index. Surprisingly, other two factors' contribution to the DI is out of expectation. Percent of population over 65 is correlated

positively with DI while the percentage of population under 18 negatively. This demonstrates that cities, townships, boroughs' development does not show at the age groups distribution. Probably, developed may attract to senior citizens who have savings and pensions, which will promote the development. However, the number of teenagers may bring economic burdens for a family. Thus, the percent of population under18 is negatively correlated with the development.

It is true that some townships boroughs and cities have been decaying. However, talking about the whole Pennsylvania state, the overall tendency for both townships boroughs and cities is growing. Temporally, it performed better from 2000 to 2010 than from 2010 to 2015, in terms of growth and its intensity. Spatially, before 2010, the urban areas performed better and grew faster. After it, the rural area started to grow intensively. Overall, the eastern Pennsylvania grew faster than the west, both of which grew faster than other areas. Towns surrounding cities grow faster than those remote villages.The gap between cities and towns are still very large but has the tendency to narrow down. Towns start to differ largely after the year of 2010 in terms of development. Most of them grow steadily while some of them decay.

The limitation is that data vary from 2000 to 2015. From the year of 2010 to the year of 2015, comprehensive and detailed data are gathered from U.S Census Bureau, as well as the year of 2000. However, a gap of data from 2001 to 2009 results from data shortage. Because data from 2001 to 2009 have more general categories without the comprehensive and detailed records required by the research. If data from 2001 to 2009 were generalized from the county level and applied to town, borough level, the accuracy would be negatively affected. Thus, those years without detailed data are skipped. In future, the temporal scale of this study could be extended to get more accurate analysis and outcomes.

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