Understanding Urban Quality of Life and Sustainability: Model Development and Validation

Abby Beck and Krystyna Stave[1]
School of Environmental and Public Affairs, University of Nevada Las Vegas
4505 Maryland Parkway Box 4030
Las Vegas, NV 89154
abbybeck1@gmail.com, krystyna.stave@unlv.edu

ABSTRACT

This paper describes the testing and preliminary analysis of a model examining the dynamics of urban quality of life (QOL) and sustainability. Initial model development was reported in Beck and Stave (2011). In the first study, we examined the factors and feedbacks that governed migration in and out of urban areas. Quality of life was assumed to be the short term motivator behind migration, while sustainability determined the long term livability of a city. Past studies on these topics all have a common thread: sustainability and QOL both pertain to people's relationship to capital. In this study, we illustrate how these forms of capital interact with a city's population and how the resulting attractiveness of those capital stocks creates in migration and out migration. We monitor the accumulation of different forms of capital to evaluate sustainability and use the distribution of capital as proxy for quality of life. Finally, we provide our experience in validating the model using historic population trends of three American cites.

INTRODUCTION

According to urban sociologist Harvey Moloch (1976), a city's primary economic and political goal is growth or expansion. This is often understood to mean increasing the population or expanding the physical footprint of the city. From this perspective, social, and natural resources are the support needed for the growing economic and physical base.

Many cities exhibit a pattern in which urban population grows, plateaus, and then declines (see, e.g., Forrester, 1969; Orum, 1995). This common pattern suggests that there is a corresponding fluctuation in the underlying social, natural, and economic resources that attract people to the area.

Discussions about urban sustainability increasingly focus on the role of quality of life (QOL) in urban dynamics. QOL research show it is a major element of city competitiveness, influencing the migration of people and capital between urban areas (Rogerson 1999). Because the size of the population requiring resources from the urban

[1] M.S. candidate and Associate Professor, respectively.

environment is a major determinant of sustainability (Wackernagel et al., 2006), it is important to examine the drivers of urban migration. Previous models of urban change have generally focused on economic and social factors (for example, Forrester, 1969; Qureshi 2009), or economic and environmental factors (for example, Guan et al., 2011; Hjorth & Bagheri, 2006; Jin et al., 2009). However no model includes what we find to be a comprehensive set of economic, social, and environmental factors.

In this paper, we consider the historic population dynamics of Cleveland, Ohio and Minneapolis – St. Paul, Minnesota to test the model and examine its contribution to the literature on urban sustainability. As we see in Figure 1, both of these Midwestern metropolitan areas experienced rapid growth followed by decline. Anthony Orum (1995) describes a classic "life cycle" of cities in his book, *City Building in America*. He argues cities experience a sequence of periods of incubation, in which the population grows slowly, followed by expansion, cohesion, decline, and, finally, decay. He presents Cleveland, Ohio as an example of this pattern, and we used this trend (shown in Figure 1) as our reference mode.

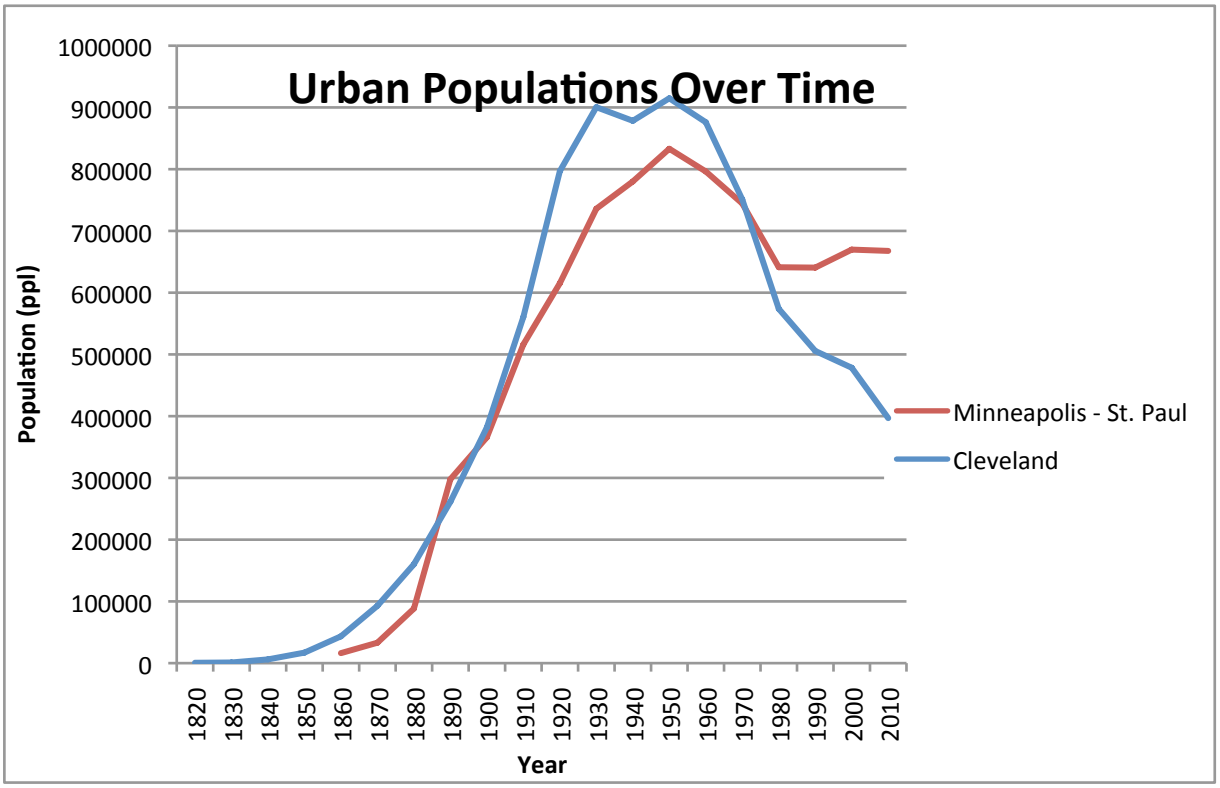

Figure 1: Historic Population Growth of Minneapolis - St. Paul, Cleveland, and Milwaukee. SOURCE: US Census Bureau

Sustainability encompasses the economic, social, and environmental dynamics of a city and quality of life measures how well a city satisfies the preferences of its citizens. From

this perspective, we attempt to determine if urban decline is the result of an unsustainable structure that fails to reconcile the economic, social, and environmental priorities of a city.

Sustainability We started our study by identifying the best current framework for understanding the components of sustainability (Beck and Stave, 2011). We described two illustrations as the best depictions of the relationship and conflict that exists between economic, social, and enviornmental sectors. First, we considered Campbell's (1996) modified "three ring" framework that comprises what he calls the "planners triangle." This urban scale model places sustainable development in the center of an equitable balance of physical, social, and evnironmental sectors, each placed at equal importance but constantly in conflict with one another. These conflicts are what Campbell describes as the tensions keeping us from fully realizing sustainability.

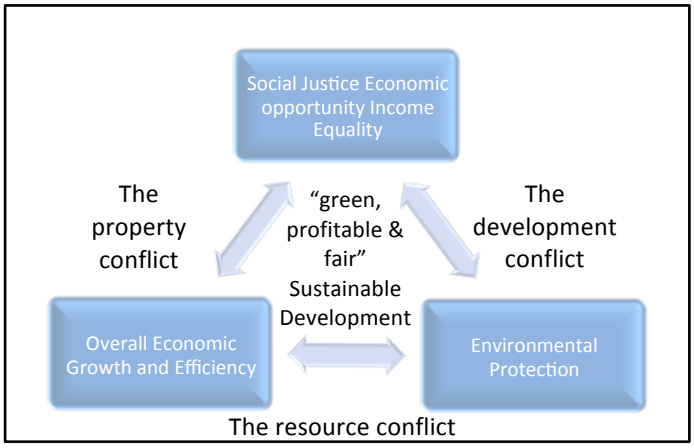

Figure 2: The planners triangle

While this model helps visualize and understand how these sectors relate, another important consideration is how they impose limits on one another. Levett's (1998) Russian Doll structure, depicted in Figure 3, adds a different dimension by illustrating the embedded nature of the sectors (Levett, 1998; Cato, 2010).

Levett (1998) proposes two advantages to thinking about sustainability as embedded systems rather than independent realms. The environment provides the life supporting services necessary to keep people and societies alive. The economy is a social construct that is meant to serve society. Therefore, there are real and physical limitations that each of the underlying spheres place on the one above it (Cato, 2010; Daly, 1990). Instead of the term "balance," Levett (1998) describes sustainable development as reconciliation of quality of life and environmental limits. Economic priorities cannot be weighed equally against environmental priorities if the economy is pushing beyond the boundaries of environmental capacity.

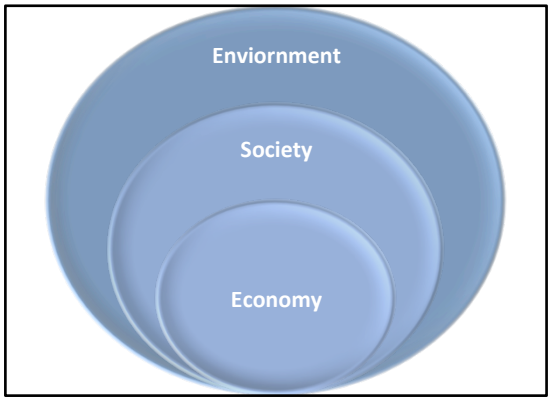

Figure 3: Pillars of sustainability in Russian Dolls framework

A city has many important roles to fill. "The city needs to meet social, environmental, political and cultural objectives as well as economic and physical ones" (Egger, 2006, p.1239). Highly developed American cities have placed economic growth as their

central focus, and have in turn created a ecological deficit, indicating an unsustainable, though high short- to medium-term quality of life. But the question remains: is there a way to sustain or improve QOL without sacrificing longevity?

Quality of Life Quality of Life (QOL) is "meant to represent either how well human needs are met or the extent to which individuals or groups perceive satisfaction or dissatisfaction in various life domains" (Costanza, et al. 2006, p. 268). QOL can be studied from a number of different angles and at different scales. Rogerson (1999) reviewed twenty years of QOL research to find the most commonly cited research dimensions. He went on to categorize the studies based on their conceptualization of QOL. Figure 4 illustrates the three main conceptualizations and how they are related.

To the left, studies that fall into Type A are characterized by its focus on objective, environmental conditions. To the right, studies under Type B focus on the characteristic of people, and studies found under Type C evaluate environmental conditions compared to people's preferences. Below is a review of each type.

QOL studies that fall into Type A are objective measures of the quantity and quality of environmental attributes. A company may evaluate the environment based on access to resources, proximity to markets, growth potential and other means of production (Rogerson, 1999). An individual may look at the parks and community space per capita, weather, or certain well represented services, like health facilitates (Sawicki, 2005).

Type B looks at the characteristics of the residents. An early congressional report from the U.S. Department of Health, Education and Welfare focused on health and illness, social mobility, income and poverty, public order and safety, learning, science and art, participation and alienation (Sawicki, 2002). Other common objective or social indicators include high school graduation rates and volunteerism. These measures have the benefit of being easily quantified. Diener and Diener (1995) found measuring the wealth of a nation to be so strongly correlated with other social indicators (such as infant mortality and literacy) that they raised the questioned anything other than economic measures was necessary. Despite the strength in these correlations, Diener and Diener (1995) proceed to compare countries of similar economic status that vary widely in QOL, concluding that other indicators are indeed necessary for estimating QOL. Therefore, social indicators are widely used today in conjunction with economic indicators to provide a more robust look at society (Bognar, 2005).

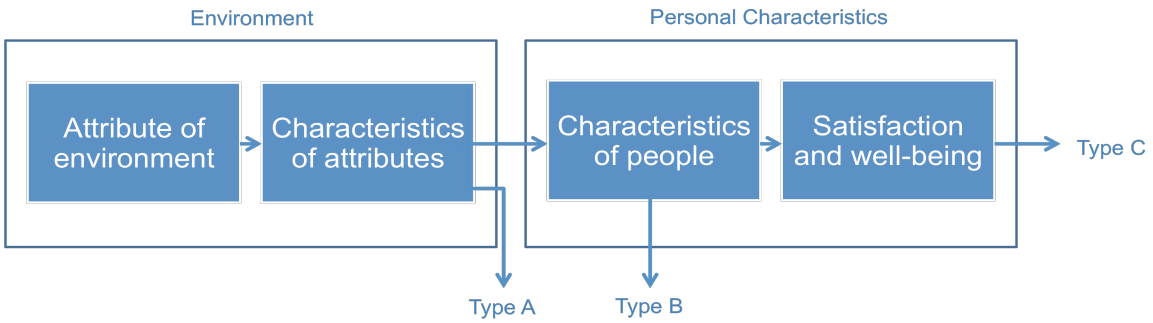

Figure 4 Conceptualization of QOL (Rogerson, 1999)

While the strength and stability of the economy is often cited as a major indicator of quality of life (QOL), it certainly does not tell the whole story. Elements of social cohesiveness, health, and education also weigh heavily on people's standard of living and how high they rate their personal well being (Diener and Suh, 1997; Bognar, 2005).

Type C is the comparison between Types A and B (Rogerson, 1999). For place based indicators to be relevant, they must be perceived by residents to be important, thus fulfilling some aspect of their quality of life (Sawicki, 2005). "It is of course possible to live in a healthy environment and not be happy or satisfied with one's life" (Egger, 2006 p. 1234). Because what one resident may value may differ from another, an urban area should be evaluated both in terms of its objective qualities as well as its residents' perception and appreciation for those qualities. Also, when polled, individuals often indicate their "most important problem" is a QOP or sustainability issues.

Subjective well being (SWB) studies are "concerned with individual's subjective experience of their own life" (Diener and Suh, 1997 p. 191) and seeks to understand "people's happiness or life satisfaction" (Bognar, 2005 p. 563). While this is harder to capture, it is highly indicative of reality when used in conjunction with objective social indicators. Levett (1998 p. 200) argues, "'Objective' proxies are only valid in so far as they reflect people's preferences and values." From this perspective, researchers have an objective sense of the state of a community and the satisfaction of preferences among citizens. "The basic premise of SWB research is that in order to understand the well being of an individual, it is important to directly measure the individuals cognitive and affective reactions to her or his whole life as well as to specific domains of life" (Levett, 1998 p. 200).

The concept of QOL has been applied to urban areas, and many cities have used some measure of QOL in marketing attempts to grow the population and attract business. With the United States becoming increasingly a service based economy with firms being highly mobile, maintaining an amenity package that satisfies residents is more important than ever to community stability (Rogerson, 1999).

Therefore, to understand urban sustainability, the drivers of population change must also be understood. If population change is the main pressure on urban resources, understanding the drivers of in and out migration is also critical. Therefore, this review provides the foundation for operationalizing the complex relationship between quality of life and sustainability.

MODEL DEVELOPMENT

The model represents the hypothesis that urban migrants seek a package of things when they move, including economic opportunity, but also including social amenities and services such as education and health care, a sense of community and social diversity. These factors form the basis for an overall perceived quality of life, which will fall if the resources available are not used at a sustainable rate.

In Beck and Stave, 2011, we summarized discussions about sustainability and quality of life as having a common thread: both pertain to people's relationship to capital, illustrated in Figure 5. As urban areas grow and gain popularity, they then must compete with each other to maintain stability and viability, typically achieved through the retention of people and capital (Rogerson, 1999). Therefore, examining how people use, deplete, replenish and transform capital combined with how they view and perceive its benefits is important for understanding the way people view an urban area.

Figure 5: Sustainability and QOL are a function of the interaction between people and capital. SOURCE: Beck and Stave, 2011

In our previous study, we then expanded our definition of capital to include the forms most commonly found in the sustainability and quality of life literature: Human capital, social capital, economic capital, and natural capital. Human capital includes the skills and capabilities of a person (Coleman, 1988; Bourdieu, 1986) and is modeled as an index of education and health (Qureshi, 2008 & 2009). Social capital "comes about through changes in the relations among persons that facilitate action" (Coleman, 1988 p. 83). Natural capital includes the "resources provided by nature that are in some way essential to human well-being" (Beddoe et al, 2009 p. 2488) and in our study includes both the physical resources and services provided by nature. Economic capital describes the infrastructure necessary to transform natural capital into goods. (For a full review of these forms, see Beck and Stave, 2011).

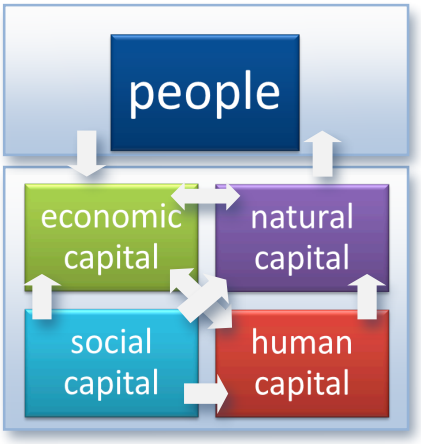

Figure 6: Expansion of the interaction between people and capital to include the main forms of urban capital. SOURCE: Beck and Stave, 2011

To develop our model, we focused on the population trend of Cleveland, Ohio illustrated in Figure 1, a period of strong growth followed by decline, as the reference mode of problem behavior. The four forms of capital were integrated into a generic causal loop diagram illustrating the relationship between people and capital, then combined together to form a full picture of the interactions between people and capital, and different forms of capital with each other.

Since the initial study, this model has been operationalized based on a city experiencing growth followed by decline using aggregate data and thought experiments. Below is a description of the subsystems included in the model and details on how parameters were estimated.

Economic Capital Subsystem The economic capital subsystem describes the process of developing the means to production – the machinery, buildings and other infrastructure needed to transport and transform natural capital into goods and services. The building of economic capital requires the use of natural capital, and therefore is a stock connected through an investment flow representing the extraction of natural capital for the use in economic capital. As with all forms of capital, there is also a

depreciation rate which diminishes this stock. Economic capital is used as an input to production, captured in GDP. The structural components are illustrated with natural capital in Figure 7.

Users can manipulate economic capital in the following ways. First, adjusting units per resource will affect how much natural capital is necessary to make a unit of economic capital. Also, the stock of economic capital can be affected by changing the depreciation rate which shortens or lengthens the amount of time between equipment replacements.

Natural Capital Subsystem To operationalize the natural capital sub-model, we used population and ecological footprint data from the Footprint Network (2012) to get estimates of initial levels of available biocapacity and per capita demand. Since an urban area is a leaking system, much like the United States, we can assume that this hypothetical city has access to resources beyond what it available within its boundaries. As Rees (1992) explains, "the total area of land required to sustain an urban region (its "ecological footprint") is typically at least an order of magnitude greater than that contained within municipal boundaries or the associated built-up area."

Figure 7 illustrates the natural capital and economic stocks. The flows out of natural capital go into economic capital and a stock of products. This is the natural capital in use. This flow is dictated by the amount of people in the city and the resource necessary to sustain them each year at a given level of material demand, or the ecological footprint (Rees, 1992). There are also two inflows to this stock. Growth is a function of how much natural capital is left in the stock, and waste assimilation is the rate at which the waste created by product disposal and obsolete economic capital gets regenerated back into productive resources.

Users have the power to control the following aspects of the natural capital system. First, there is the growth rate. Increasing this will increase the rate at which natural capital can reproduce. Similarly, the assimilation rate will affect the rate at which waste can return to usable natural capital. Third, the disposal rate dictates the amount of goods and services sent to the waste stock each year. Finally, the material standard of living (illustrated in the GDP sub model, Figure 10) is a function of resources per person per year, or their ecological footprint. This can be increased or decreased to a user's preference.

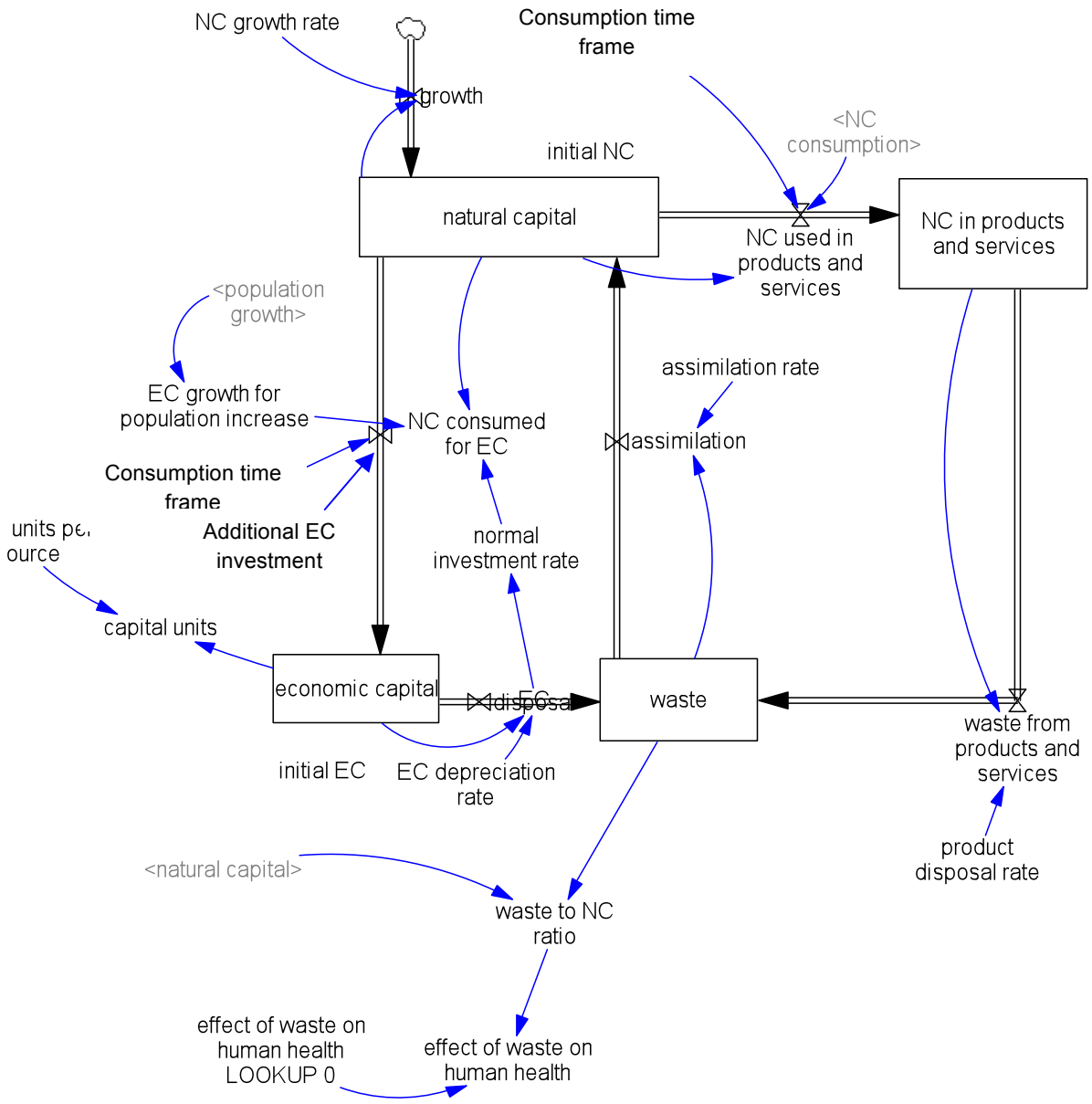

Figure 7 Economic and Natural Capital

Social Capital Subsystem The stock of social capital, illustrated in Figure 8, represents how many connections exist between the people in the city. (For a more detailed look at the dynamics of social capital, see Dudley, 2009). The rate at which connections are added is a function of how easy it is and how willing people are to make new connections. Willingness is a function of the benefits gained through social capital connections. Ability is a function of how close a person is to the per capita max on personal connections.

Investing in social capital is a way to increase residents' exposure to new people which can lead to a greater degree of interpersonal trust, reciprocity and the exchange of resources and ideas. Doing so increases the normal rate of connections. There is also a normal rate of connection loss, or the depreciation of social capital. This is caused by a natural "losing touch" that happens between people over time. It is accelerated the more connections a person has.

Users have the power to control the investment in social capital and the normal connections per person.

Human Capital Subsystem The human capital stock (see Figure 9) represents the societal level of human capabilities. It is an index of health and education (Qureshi, 2008) and is measured as productivity units. As with the other forms of capital, it is increased based on the level of investment and decreased with the depreciation or loss of capital units.

In the model, investment comes in the form of social support. As social capital increases, it increases the productivity of the people. Bourdieu (1986) found social capital to be the main difference between the academic successes of students from similar economic backgrounds. Therefore, the economic investment is not a control variable, but rather it is assumed that if the society is invested, their financial support is present as well. (This is assuming the norms of the society are pro-education and health which is not necessarily the case, and thus this relationship can be turned off.)

The levers available for user control are productivity units per person per year and the fraction of human capital lost per person due to out migration. Cities are inherently "leaky" systems. People may leave a city to live, but still work there. In this way, they are contributing some portion of their existence to the local GDP, but not their everyday living purchases, home property taxes, etc.

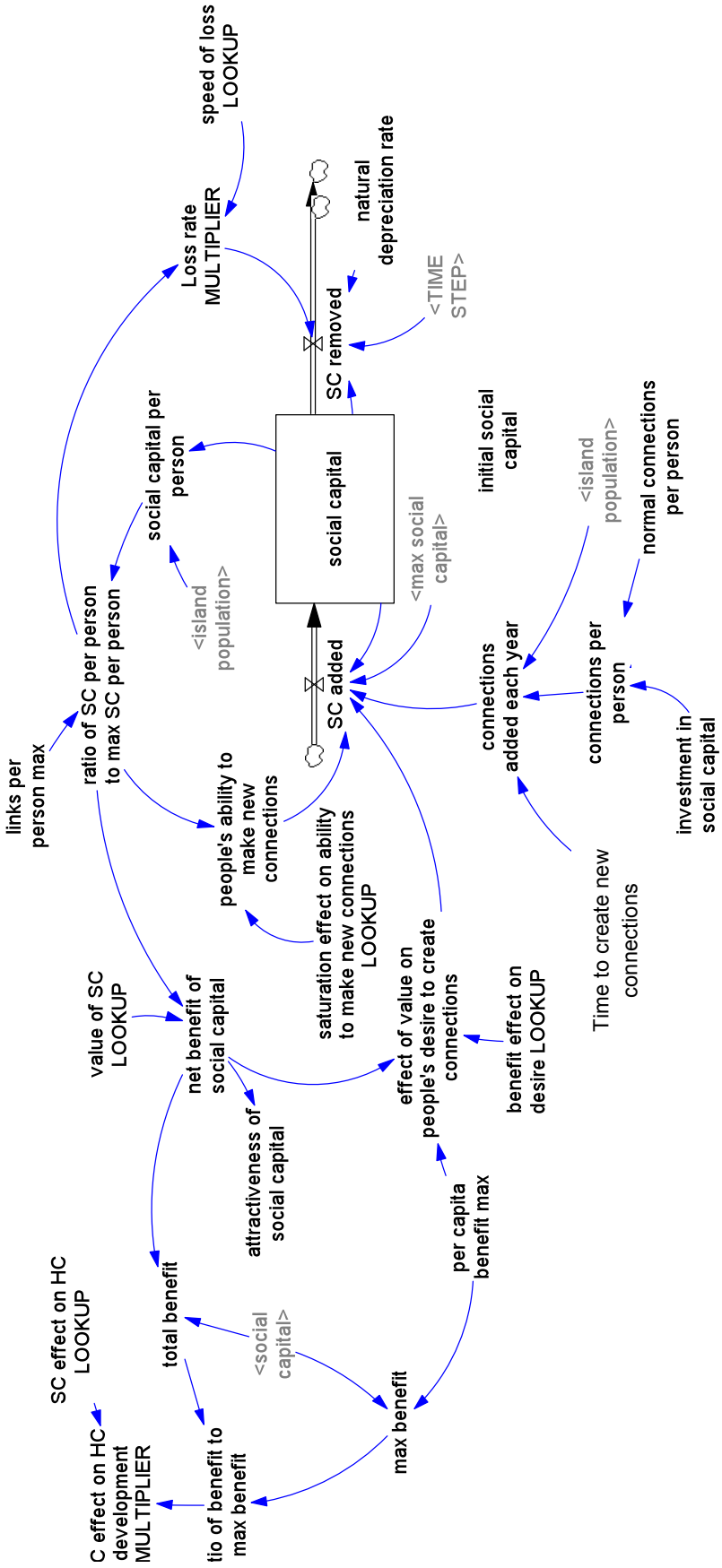

Figure 8 Social Capital

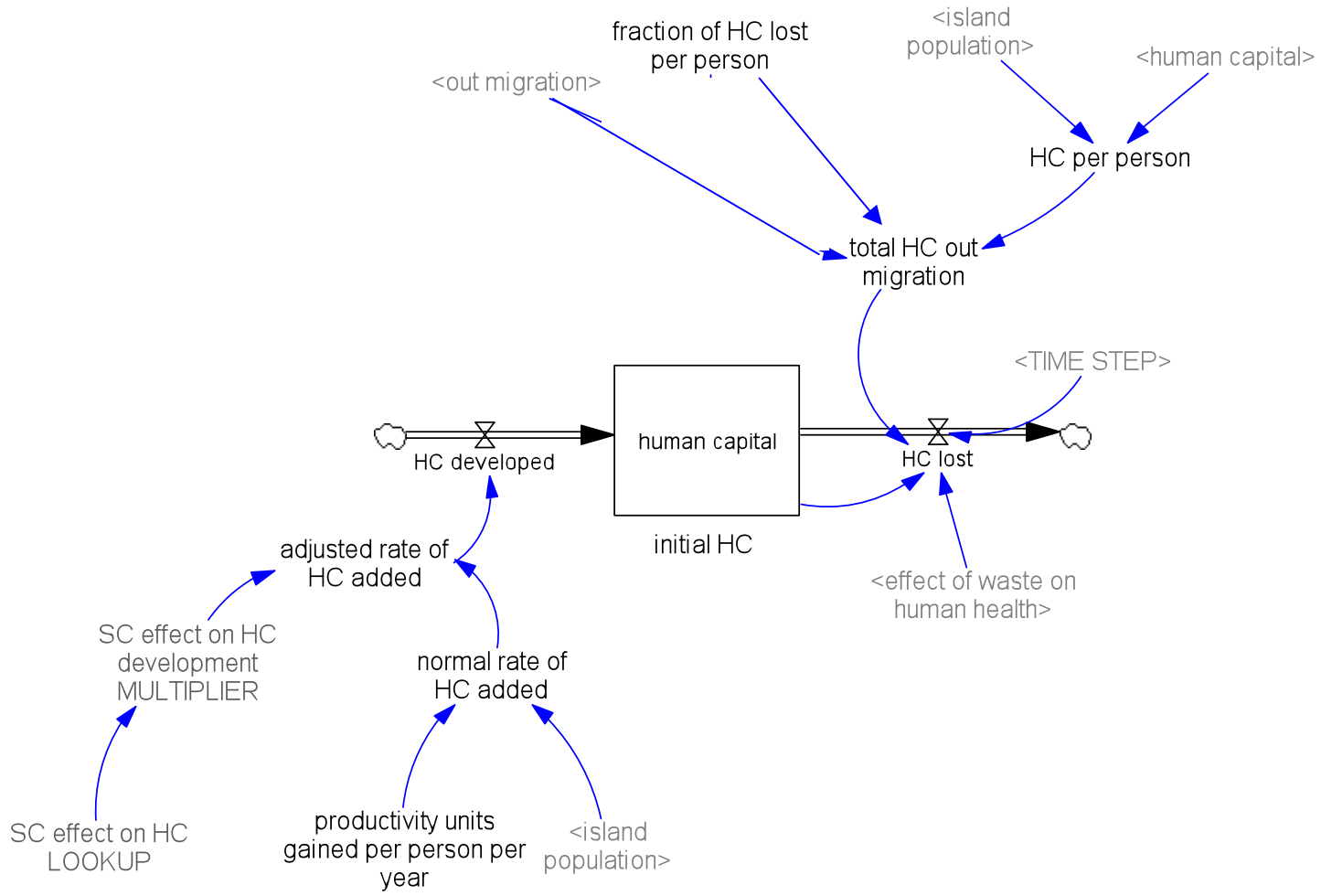

Figure 9 Human Capital

Gross Domestic Product (GDP) GDP is commonly used as a measure of community health and stability and is used in multiple system models to capture the productivity of people, capital, and natural resources. It is done by using the Cobb-Douglas formulation, shown in equation 1 (Cobb and Douglas, 1928). We use it here to provide a common economic yardstick for judging the overall productivity of a hypothetical city.

Equation 1: $Y = AL^{\alpha}K^{\beta}$

Y = total production
L = labor input
K = capital input
A = total factor productivity

GDP counts the extraction and consumption of natural capital as production rather than count it as a reduction of the resource stock. In this model, the amount of natural capital that contributes to gross domestic product is the same quantity that determines the rate at which natural capital flows from its original stock to the stock of goods and services.

As mentioned above, the natural capital input can be changed by a user by the material standard of living desired constant. This reduces resources used per person and subsequently GDP. Or, a user can change the productivity of resources, which measures how much economic output can be gained per unit of natural capital extracted. A user can also change the total factor productivity variable, used to represent the level of technology and efficiency in the production sphere.

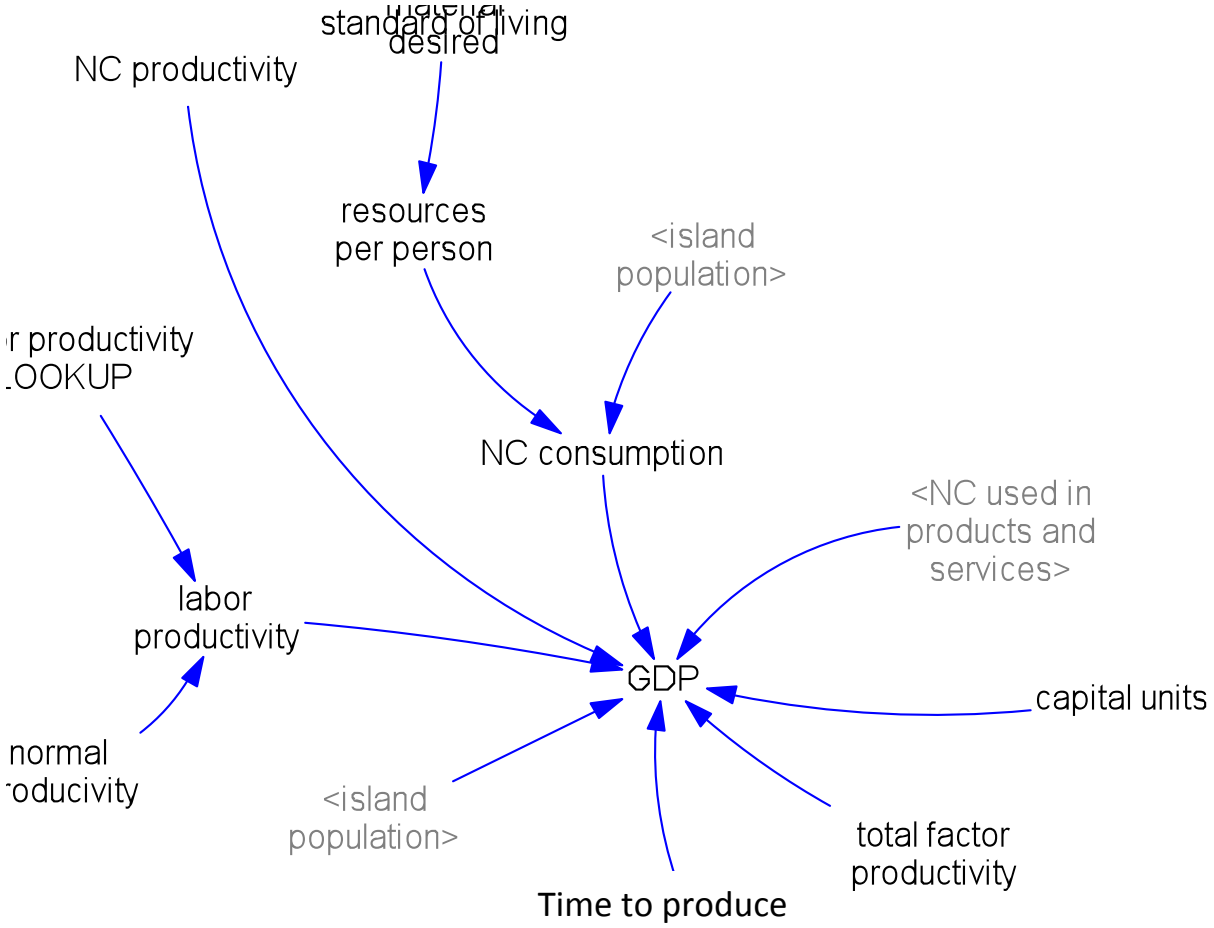

Figure 10 Gross Domestic Product

Quality of Life and Population Subsystems

Quality of life is used as a measure of city competitiveness (Rogerson, 1999) and illustrates whether the city has the amenity package desired by the average resident. Therefore, in this model, in migration and out migration are based on the ratio of existing to desired levels of GDP per capita, natural resources per capita, connections per capita, and well being per capita. The general structure is illustrated in Figure 11.

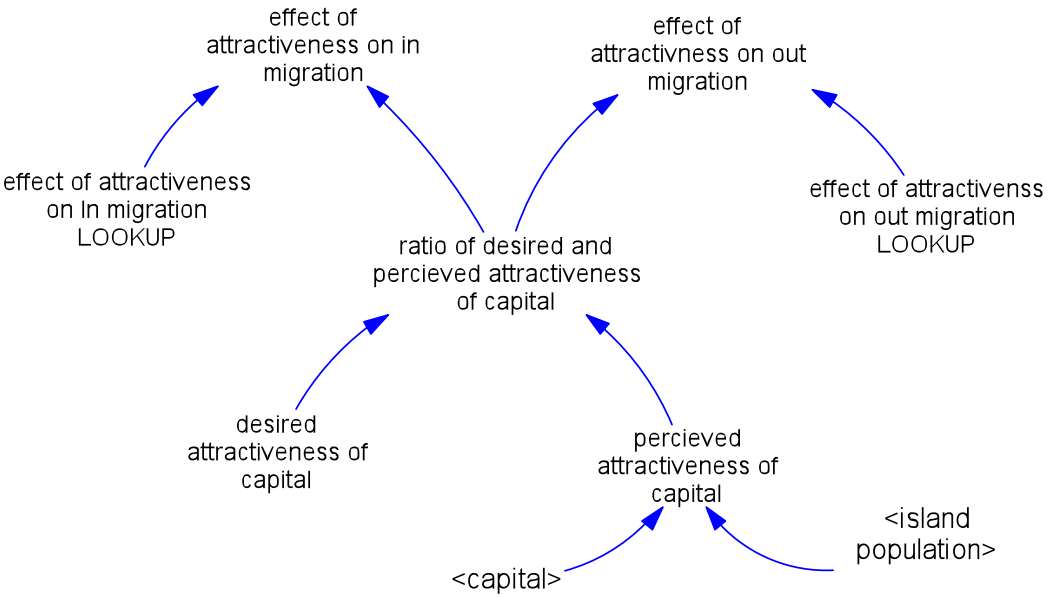

Figure 11 Quality of Life

Each of these sectors weighs differently a person's decision to move in or out of a place. As mentioned above, objective measures of a society and environment are more robust when compared to the subjective preferences of a resident (Diener and Diener, 1996; Rogerson, 1999; Bognar, 2005). Therefore, the desired levels of each form of capital per person and the relative importance of each sector over in and out migration are constants that a user can change based on their preferences.

- Normal in migration weights of SC, HC, EC, NC
- Normal out migration weights of SC, HC, EC, NC
- Desired EC/capita
- Desired SC/capital
- Desired HC/capita
- Desired NC/capita

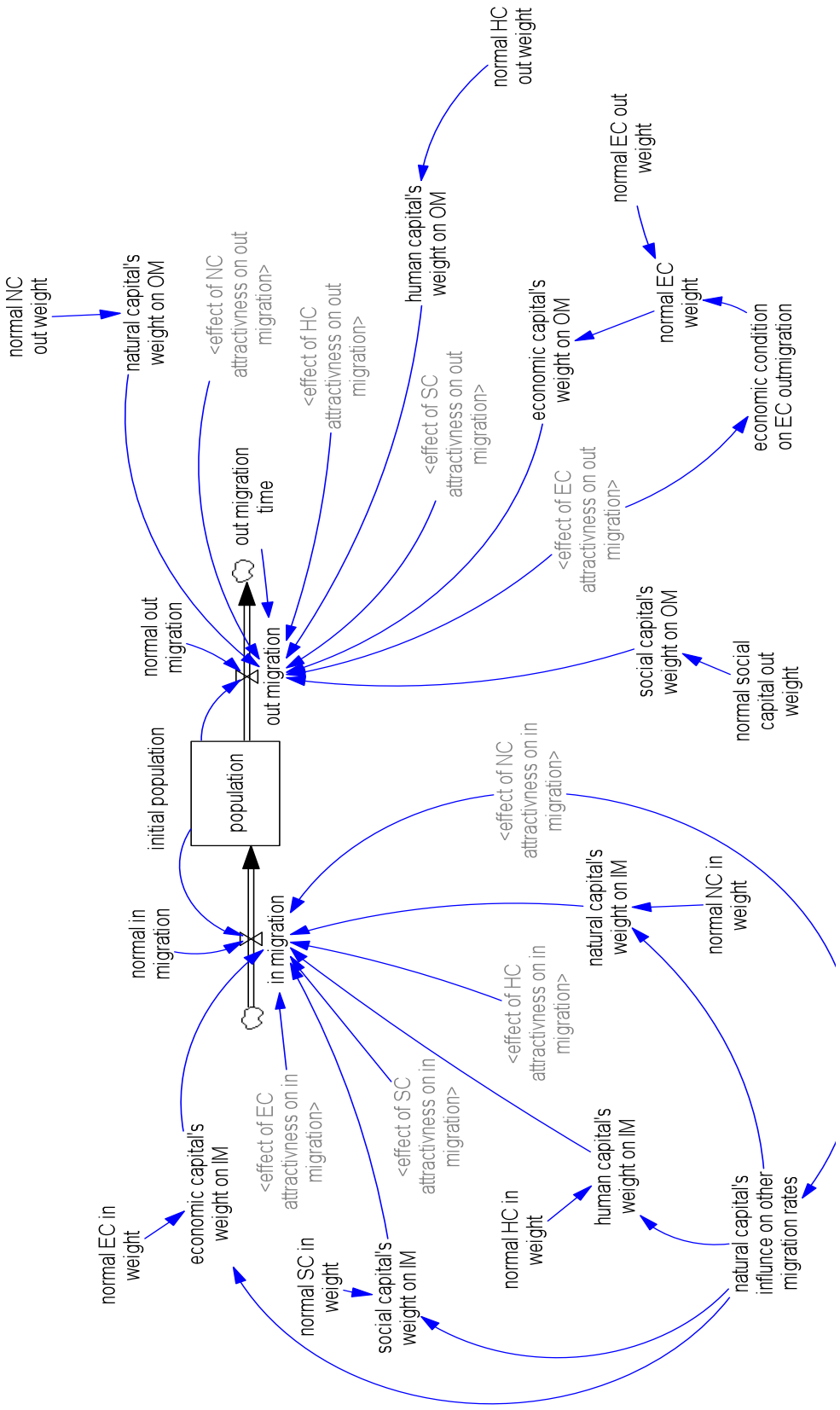

Figure 12 Population

TWO CITY HISTORIES

To validate our model, we use the rise and decline of two American pre-industrial cities in the Midwest and compare the factors that contributed to their population growth. Specifically, we were interested in what caused the declines in Minneapolis – St. Paul and Cleveland and what was different about Minneapolis that provided greater ability to stabilize and begin to re-grow its population before the others.

Many Midwestern industrial towns all experienced a similar path of growth, maturation, and decline. Minneapolis – St. Paul and Cleveland experienced rapid growth between the 1900s and the 1950s due to booming economies. Natural resources such as abundant and fertile land and easy access via water ways determined the level of success when competing for industry. Heavy machinery, factories and other fixed and inflexible economic capital brought high profits when demand was high, providing a city life that was rich with amenities. Cities grew in physical size as local governments annexed as much as the outlying areas as possible. But, with population growth, came a growing problem with crowding, crime, and poverty. This led many able citizens to seek kinder surroundings in the suburbs leaving the poor to dominate the inner core.

Then, in the 1950s-1960s, as the national economy began to shift from a manufacturing to a service dominant economy, industry left for cheaper resources in other cities or for other countries all together. The buildings, machinery and expertise built in these pre-industrial cities were highly specialized and inflexible (Orum, 1995) making it difficult to adapt both the workers and infrastructure to new business. This perpetuated the economic decline. By this time, these cities were also landlocked by a ring of suburbs restricting growth via increased resource or population revenue (Orum, 1995). Population continued to drop as people left the inner city for both suburbs and job opportunities in other cities.

Orum (1995) found this common trend to exemplify a city life cycle. However, when compared to Cleveland, there are a few key differences to Minneapolis – St. Paul's history which have aided in the city's quicker stabilization and highly regarded standard of living. First, it did not reach the same level of industrialization and therefore did not have the same level of investment in fixed, inflexible economic capital. This allowed Minneapolis – St. Paul to more quickly adapt to a changing economy at less cost.

Also facilitating this adaptability was the presence of a large state research university. This focus and investment in education provided a higher degree of human capital and a stronger job market for white collar workers than Cleveland. This population was prepared to not only work in the new economies, but were the ones driving and designing new industries (Orum, 1995).

Finally, Minneapolis-St. Paul was able to form a metropolitan governance structure that served both its suburban and urban development. This reduced the divide and struggle for resources that occurred between the wealthy and poor as suburbs were growing. In doing so, Minneapolis-St. Paul has been more successful in investing in their downtowns, which are, to this day, considered very livable. This level of cooperation was attempted but not achieved in places like Milwaukee, WI, and indicates a greater

degree of social cohesion and inclusiveness among the residents of Minneapolis - St. Paul (Orum, 1995).

Do these differences explain why Minneapolis – St. Paul did not experience the same deterioration as Cleveland, as Orum (1995) suggests? In the following sections, we describe the use of our model based on the understanding of how the structure of city economics, culture, environment, and education lead to its behavior and therefore its attractiveness and viability. We then use it to test whether these differences in priorities, investment, and social cohesion can account for the differences found between urban population sizes in Cleveland and Minneapolis – St. Paul.

MODEL VALIDATION

As the basis of our analysis, we wanted to ensure the model could replicate real urban behavior.

If the model is an appropriate representation of reality, it should be able to reproduce behaviors witnessed in the real system. To do this, we referred to the histories provided by Anthony Orum (1995) of Cleveland and Minneapolis – St. Paul. To summarize the points made above, the story of Minneapolis –St. Paul's revitalization was due to the following:

1. It did not experience the same extent of industrialization (which indicates a smaller amount of fixed, inflexible economic capital), so there were less working class residents and more white-collar workers better prepared to work in a post-industrial society.
2. There was less economic and racial diversity and a more equitable distribution of resources between the inner city and suburban areas, aided by the development of the metropolitan council. This indicates a higher degree of social cohesiveness and support for fellow community members.
3. There was a long term commitment of wealthy and prosperous families to the Twin Cities that maintained their dedication to the area despite its decline.
4. Minneapolis – St. Paul had a higher degree of human capital investment and development in the form of a major state research university.

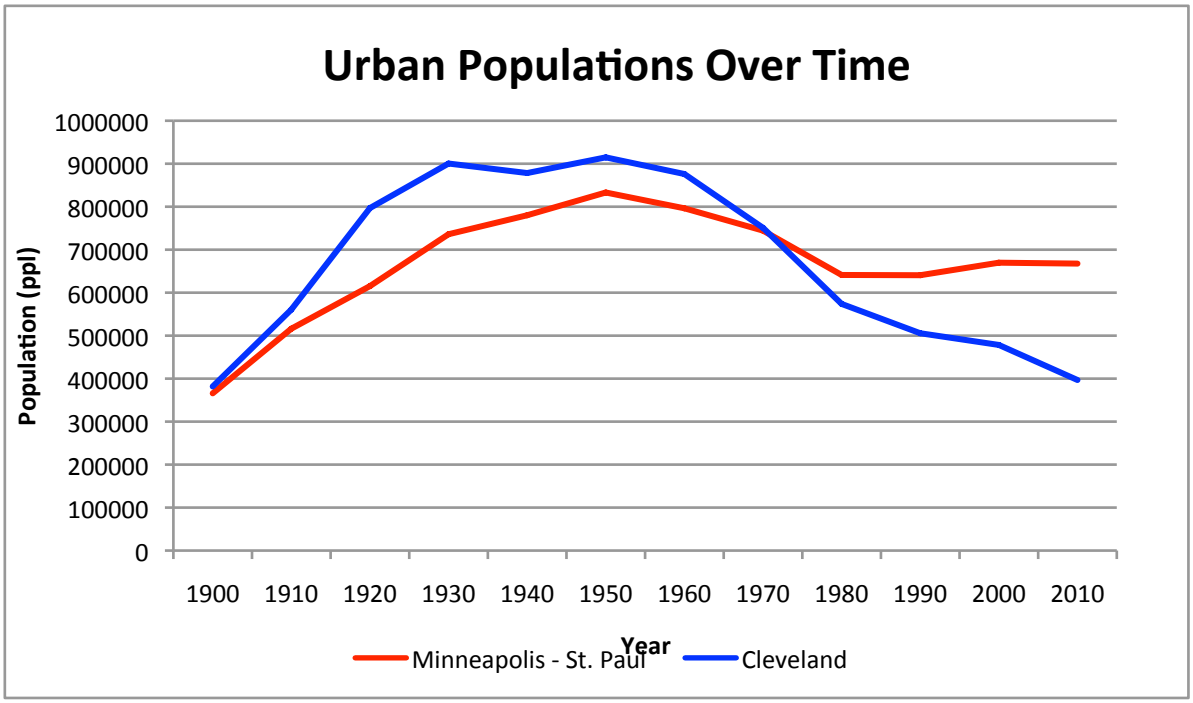

Figure 13 Population data for Cleveland and Minneapolis - St. Paul. SOURCE: US Census Bureau

In the base run, we parameterized the model to represent the conditions of a city that experience tremendous growth, followed by decline in their population. It is the trend represented by Cleveland in Figure 13. Between the years of 1900 and 2010, the city grew to over twice its size, only to return to almost 1900 levels by the end of the century. In our base run, labeled "Cleveland" in Figure 14, illustrates a similar growth trend.

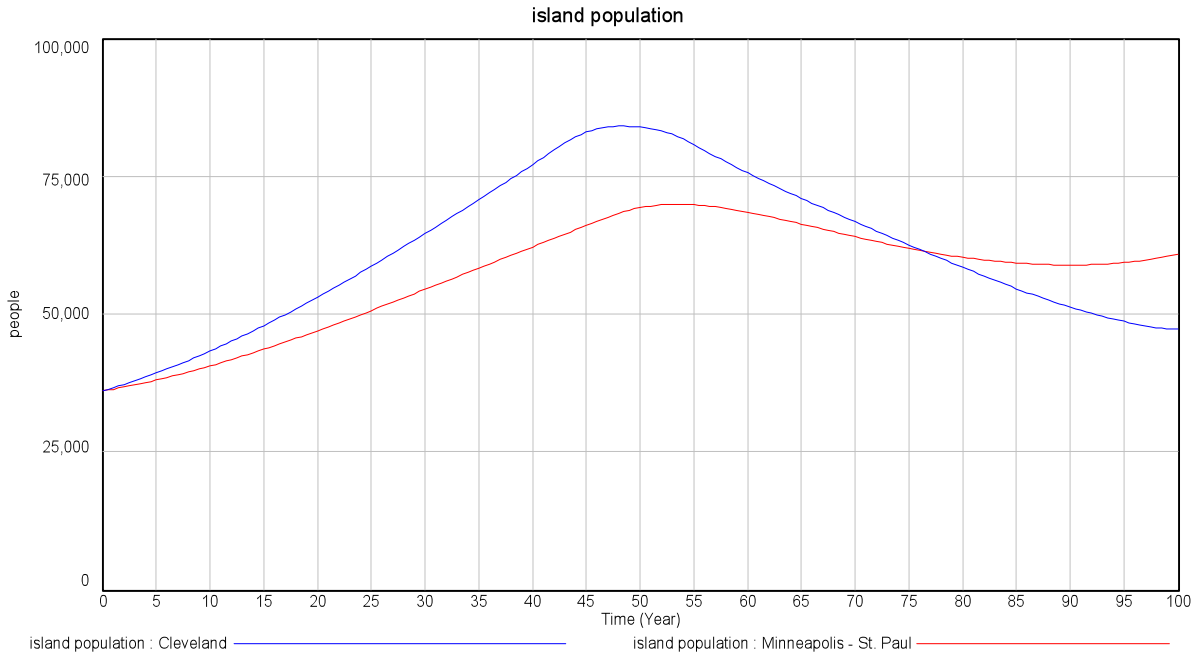

Figure 14: Base run (Cleveland) and modification based on the conditions of Minneapolis - St. Paul during the 20th century

To recreate the growth and decline of Minneapolis – St. Paul, we estimated approximate differences in the different capital systems and made the following adjustments:

1. Decreased the initial level of economic capital by 1/3. This estimates the degree of industrialization at the turn of the century between the two cities. As Orum (1995) reports, Minneapolis – St. Paul did not industrialize to the same level as Cleveland.
2. Decreased the annual investment in new economic capital by ½. Similar to change number 1, Minneapolis – St. Paul did not have same industrial base which required heavy annual investment to grow and develop that sector of the economy. Rather, the city was already transitioning into more flexible forms of economic capital, represented better as human capital in this model.
3. Increased the annual investment in human capital by 10%. Because Minneapolis – St. Paul had the state university, there was a greater investment in human capital. The population had a higher percentage of white-collar, college graduates than its Midwestern neighbors like Cleveland, and therefore the model indicates a higher level of annual development of human capital.
4. Increased the annual investment in social capital by .1 people/year. The increase in social capital, quantified by personal connections per person added per year, represents a few different characteristics of Minneapolis – St. Paul's social structure. First, there was the development of a metropolitan governing body that maintained a more equitable distribution of jobs, finances, and wealth between the city and the suburbs. In other instances, we see a greater divide between political power and wealth as the inner city loses resources to the suburbs. Reducing this divisiveness created a more tolerant and diverse community. Second, there were wealthy family businesses that had profound impacts on the economic development of the city. Those families were loyal to the area and maintained their involvement over the generations.
5. Decreased the fraction of human capital lost in outmigration to half the base level. Because the metropolitan area was successful in establishing an overarching governing body, they were able to prevent the leak of business and wealth to the suburbs. Therefore, the downtown area is still highly livable and maintains a healthy economic base where other cities had experienced deterioration. In our model, some of the expertise the population develops (counted as human capital) remains as part of systems and best practices. Outmigration from cities is in large part for outlying suburbs. If people are moving from the city to the suburbs, it is reasonable to believe that Minneapolis – St. Paul's thriving downtown means more people will remain employed and commute in, reducing the amount of human capital that is lost when a person migrates away from the city.

By making these changes, the model produces the red trend line in Figure 14, where growth is slower than Cleveland's, a plateau occurs around the same time, but the decline is not as drastic. Minneapolis- St. Paul's population exceeds Cleveland's in the 1970s and increases toward the end of the model's run.

DISCUSSION

This paper describes the development and validation of sustainability and quality of life at the urban scale to help explain why cities often experience the growth and decline trend described by Orum (1995) as a city's "life cycle." The model expands on previous work in the following ways:

Broader inclusion of urban capital forms This study expands upon and combines the current models of urban change that currently do not incorporate all the relevant forms of urban capital. Previous models had a narrower problem they were trying to address, whereas we are attempting to address longevity and stability among all aspects of society, and therefore our system is much broader in scope.

Our results support the argument that the dynamics of urban areas are based on more than economic development. Development of other forms of capital is also critical. The results support developmental policies that can maintain high levels human/social capital that raise quality of life without material or physical growth, what Meadows (1992) calls "smart development, not dumb growth". As philosopher Jeremy Bentham wrote in 1789, "The best society is one where citizens are happiest." (Quoted in Schmalz, Ackbarow and Kapmeier 2007)

Enhanced conceptualization of sustainability at the city scale As stated above, a key starting place for sustainability discussions is a clear framework to conceptualize the complex components of an urban system and how they interact to either promote or resist sustainable development. Levett (1998) and Campbell (1996) provided the most useful framework for understanding sustainability, and Hjorth and Bagheri (2006) provided the clearest example of a system representation of how the dynamics underlying sustainability are to be monitored where the scope is longevity and stability of capital stocks.

Hjorth and Bagheri's (2006) discussion of sustainability was based on a qualitative model of the interactions between environmental and economic capital. Our model differs in that it incorporates the social interaction that heavily influence behavior at the city level, for example how people relate to each other and develop new skills and knowledge and how these affect their relationship to natural capital and economic capital.

Our goal was to create model to capture the common behavior of cities (Orum's (1995) life cycle) with the capability of being applied to different cities by adjusting its parameters. But like Hjorth and Bagheri (2006), it is simple and general enough to be informative and useful without direct application. The idea of reconciling economic, social, and environmental priorities is abstract and complex. Without a way to visualize how this can be accomplished amid their numerous interactions, sustainability

discussions often default to mental models where economics is king and little else matters.

Method for capturing objective and subjective QOL This model also introduces a method for monitoring objective and subjective measures of quality of life, which has not been done in the system dynamics literature. This is still a rough and developing index for measuring QOL, one that continues to evolve as the model is refined. A user can input their desired amenity package by choosing a desired level of GDP per capita, natural resources per capita, personal connections per capita, and well being per capita. Then, as the model runs, the actual level of these indicators is compared to the user's preferences, and by this measure determines whether an average person decides to stay or leave.

REFERENCES

Beck, A and K. Stave. (2011). Understanding Urban Quality of Life and Sustainability. Proceedings of the 29th International Conference of the System Dynamics Society. Washington, DC, July 24-28, 2011.

Beddoe, R., Costanza, R., Farley, J., Garza, E., Kent, J., Kubiszewski, I., Martinez, L., McCowen, T., Murphy, K., Normal, M., Ogden, Z., Stapleton., K. and Woodward., J. (2009). Overcoming systemic roadblocks to sustainability: The evolutionary redesign of worldviews, institutions, and technologies. *PNAS*. 106(8): 2483-2489.

Bognar, G. (2005). The Concept of Quality of Life. *Social Theory and Practice, 31*(4): 561-580.

Bourdieu, P. (1986). The Forms of Capital. In A. H. Hasley, H. Lauder, P. Brown, and A. S. Wells (Eds.), *Education: Culture, Economy, and Society.* (46-58). Oxford: Oxford University Press.

Campbell, S. (1996). Green Cities, Growing Cities, Just Cities? Urban Planning and the Contradictions of Sustainable Development. *Journal of the American Planning Association.* 62(3): 296-312.

Cato, M. (2009). *Green Economics: An Introduction to Theory, Policy and Practice*. London: Earthscan.

Coleman, J. (1988). In A. H. Hasley, H. Lauder, P. Brown, and A. S. Wells (Eds.), *Education: Culture, Economy, and Society.* (80-95). Oxford: Oxford University Press.

Cobb, C. W. and P. H. Douglas. (1928). A theory of production. American Economic Review. Supplement, Papers and Proceedings of the Fortieth Annual Meeting of the American Economic Association. 18(1):139-165.

Costanza,R., Fisher,B., Ali, S., Beer, C., Bond,L., Boumans, R., Danigelis, N., Dickinson,J., Elliott, C., Farley, J., Gayer,D., MacDonald Glenn,L., Hudspeth, T., Mahoney, D., McCahill, L., McIntosh, B., Reed, B., Rizvi, S., Rizzo,M., Simpatico, T., Snapp, R. (2006). Quality of life: An approach integrating opportunities, human needs, and subjective well-being, Ecological Economics, 61(2-3): 267-276.

Costanza, R., Fisher, B., Ali, S., Beer, C., Bond, L., Boumans, R., et al. (2007). Quality of life: An approach integrating opportunities, human needs, and subjective well-being. *Ecological Economics, 61*(2-3), 267-276.

Daly, H. (1990). *Sustainable Growth: An Impossibility Theorem.* Development. 3(4): 45-47.

Diener, E. D., & Diener, C. (1995). The wealth of nations revisited: Income and quality of life. *Social Indicators Research, 36*(3), 275-286.

Diener, E., & Suh, E. (1997). Measuring quality of life: Economic, social, and subjective indicators. *Social Indicators Research*, *40*(1), 189-216.

Dudley, R. (2009). The Dynamic Structure of Social Capital: How Interpersonal Connections Create Communitywide Benefits. *In Proceedings of the 22nd International Conference of the System Dynamics Society.* Oxford, England.

Egger, S. (2006). Determining a sustainable city model. *Environmental Modeling and Software.* 21(9):1235-1246.

Florida, R. (2003). Cities and the Creative Class. From City and Community. Urban Sociology Reader. Eds: Jan Lin and Christopher Mele. 2007 New York: Routledge.

Forrester, J. (1969). Urban Dynamics. Cambridge: M.I.T Press.

Levett, R. (1998). Sustainability Indicators – Integrating quality of life and environmental protection. *Journal of the Royal Statistical Society.Series A: Statistics in Society, 161*(3), 291-302.

McGranahan, G., Marcotullio, P., Bai, X., Balk,D., Braga, T., Douglas, I., Elmpvist, T., Rees, W., Satterthwaite, J., Zlotnik, H. (2005). Urban Systems. In *Ecosystems and Human Well-being: Current State and Trends, Volume 1.* (chap. 267). Retrieved March 1, 2011, from http://www.maweb.org/en/Condition.aspx.

Motoch, H. (1976). "The City as a Growth Machine: Toward a Political Economy of Place." The American Journal of Sociology, Vol. 82, No. 2, pp. 309–332.

Orum, A. (1999). City Building in America. Boulder: Westview Press, Inc.

Page, M. (1999). Four Ways of Looking at City Building in America. *Journal Of Urban History.* 25(6): 848-859.

Qureshi, M. A. (2008). Challenging trickle-down approach: Modeling and simulation of public expenditure and human development—the case of Pakistan. *International Journal of Social Economics, 35*(4), 269-282.

Qureshi, M. A. (2009). Human development, public expenditure and economic growth: A system dynamics approach. *International Journal of Social Economics, 36*(1/2):93-104.

Rees, W. (1992). Ecological footprints and appropriated carrying capacity: What urban economics leaves out. *Environment and Urbanization* 4, 2, 121 -130.

Rogerson, R. (1999). Quality of Life and City Competitiveness. Urban Studies, 36(5-6): 969-985.

Sawicki, D. (2002). Improving Community Indicator Systems: Injecting More Social Science into the Folk Movement. *Planning Theory & Practice, 3*(1): 13-32.

Schmalz, M., Ackbarow, T., Kapmeier, F., (2007). Happiness – Cracking the Equilibrium State of People's Well-Being. Proceedings of the 29[5h] International Conference of the System Dynamics Society. Boston, MA July 29-August 2, 2007.

Schnaiberg, Allan and Kenneth A. Gould. (1994). *Environment and Society: The Enduring Conflict*. New York: St. Martin's Press.

Senge, P., Seville, D., Lovins, A., and Lotspeich, C. (2000). Systems Thinking Primer for Natural Capitalism: Four Basic Shifts. (DRAFT). Retrieved March 1 2011, from http://www.sustainabilityinstitute.org

Wackernagel, M; Wermer, P; Goldfinger, S., (2007) Introduciton ot the Ecological Footprint: Underlying Research Question and Current Calculation Strategy. Entry preparted for the Internet Encyclopedia of Ecological Economics. Accessed from: footprintnetwork.org.

Wackernagel, M; Kitzes, J; Moran, D; Goldfinger, S; Thomas, M. (2006) The Ecological Footprint of cities and regions: comparing resource availability with resource demand. Environment and Urbanization.18:103, 104-112.

World Commission on Economic Development. (1987) *Our Common Future.* Oxford: Oxford University Press.