White Paper: Evaluating the Economic Benefits of Nonmotorized Transportation

A group of riders celebrates the opening of new bicycle infrastructure in Minneapolis, Minnesota. Image courtesy of Bike Walk Twin Cities.

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13. ABSTRACT (Maximum 200 words)

This report examines potential methods for evaluating the economic benefits from nonmotorized transportation investments. The variety of potential economic benefits of bicycle and pedestrian infrastructure and programming investments discussed include commute cost savings for bicyclists and pedestrians, direct benefits to bicycle and tourism-related businesses, indirect economic benefits due to changing consumer behavior, and individual and societal cost savings associated with health and environmental benefits. This report reviews potential methods for analyzing these different economic benefits at the project, neighborhood, and larger community scale, highlighting case studies from Minneapolis, Toronto, New York City, and the State of Vermont. A review of previous economic evaluations of nonmotorized transportation investments and available analysis tools suggests that researchers should choose evaluation methods and scales of analysis appropriate to the project or program they intend to evaluate. Researchers should also consider the availability of baseline data and control data when designing an evaluation approach.

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List of Abbreviations

Abbreviation	Term
CDC	Centers for Disease Control and Prevention
FHWA	Federal Highway Administration
HEAT	Health Economic Assessment Tool
ITHIM	Integrated Transport and Health Impact Modeling Tool
MAP-21	Moving Ahead for Progress in the 21st Century
NTPP	Nonmotorized Transportation Pilot Program
NYCDOT	New York City Department of Transportation
REMI	Regional Economic Models, Inc.
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
WHO	World Health Organization
Volpe	Volpe National Transportation Systems Center
VTrans	Vermont Transportation Agency
WG	Working Group

Executive Summary

As communities across the United States consider enhancements to their nonmotorized transportation networks, there is a growing desire by both transportation planners and decision-makers to evaluate the impacts of these investments. Many communities begin new infrastructure programs with pilot projects to evaluate their efficacy before implementation on a broader scale. Therefore, it is important to provide a technical resource on the methods available for communities to evaluate the different types of outcomes from nonmotorized transportation investments, including: mode share changes; environmental benefits; increased accessibility; health benefits; and economic benefits. This white paper is intended to be a technical resource for local communities and others interested in understanding how they might better estimate the economic benefits of investments in nonmotorized transportation. It examines potential methods for evaluating the economic benefits from nonmotorized transportation investments.

The variety of potential economic benefits of bicycle and pedestrian infrastructure and programming investments include:

- Commute cost savings for bicyclists and pedestrians;
- Direct benefits to pedestrian, bicycle, and tourism-related businesses;
- Indirect economic benefits due to changing consumer behavior; and
- Individual and societal cost savings associated with health and environmental benefits.

This report provides information on the types of economic benefits realized from nonmotorized transportation investments and a review of measurement and analysis techniques to evaluate them. This analysis also examines the different scales at which researchers may focus their data collection and analysis, including: individual consumer behavior; economic impacts within a nonmotorized travel corridor; or community-wide economic impacts. The goal of this report is to provide a technical resource for communities seeking to measure the economic impacts from pedestrian and bicycle transportation projects in the future.

The report concludes that researchers should choose evaluation methods and scales of analysis appropriate to the project or program they intend to evaluate. Evaluating the effects of bicycle and pedestrian transportation investments also requires comparison to baseline or control data. Ideally, researchers or project planners should design research plans before implementation of nonmotorized transportation projects so that they can collect the relevant baseline data. Comparing communities or neighborhoods where nonmotorized transportation projects have been implemented to similar communities without those investments can establish a control comparison to avoid attributing impacts to nonmotorized transportation projects that may reflect more general trends.

Introduction

Investments in walking and bicycling are playing an increased role in establishing balanced transportation systems and supporting vibrant communities. As communities across the United States consider enhancements to their nonmotorized transportation networks, there is a growing desire by both transportation planners and decision-makers to evaluate the impacts of these investments. Many communities begin new infrastructure programs with pilot projects to evaluate their efficacy before implementation on a broader scale. Therefore, it is important to provide a technical resource on the methods available for communities to evaluate the different types of outcomes from nonmotorized transportation programs, including mode share changes, environmental benefits, increased accessibility, health benefits, and economic benefits.

This white paper is intended to be a technical resource for local communities and others interested in understanding the economic implications of investments in nonmotorized transportation.

This report examines potential methods for evaluating the economic benefits from nonmotorized transportation investments. It is one of several reports and working papers associated with the Nonmotorized Transportation Pilot Program (NTPP), a program established in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Section 1807. Through the NTPP, Congress provided approximately $28 million to each of four pilot communities of varying size, density, and other characteristics – Columbia, Missouri; Marin County, California; Minneapolis, Minnesota; and Sheboygan County, Wisconsin – "to construct … a network of nonmotorized transportation infrastructure facilities, including sidewalks, bicycle lanes, and pedestrian and bicycle trails, that connect directly with transit stations, schools, residences, businesses, recreation areas, and other community activity centers."

This white paper is intended to provide technical assistance to the NTPP and peer communities interested in expanding their pedestrian and bicycle infrastructure and measuring and evaluating the economic impacts of these investments. The report is a resource for planners, public officials, public health and transportation agencies, and advocacy groups interested in available and practical methods to evaluate the economic impacts of nonmotorized transportation programs. It describes several different types of potential economic impacts from nonmotorized transportation investments and different techniques available for measuring these impacts. The paper also examines the different scales at which researchers may focus their data collection and analysis, including individual consumer behavior, economic impacts within a nonmotorized travel corridor, or community-wide economic impacts. The aim of this paper is to provide information which communities across the United States can use when evaluating the economic impacts of pedestrian and bicycle projects.

About the NTPP

Established in SAFEATEA-LU Section 1807, the Nonmotorized Transportation Pilot Program (NTPP) provided approximately $28 million each to four communities (Columbia, MO; Marin County, CA; Minneapolis Area, MN; Sheboygan County, WI) to demonstrate how walking and bicycling infrastructure and programs can increase rates of walking and bicycling. The NTPP was a demonstration program to gather information on mode shifts before and after the implementation of nonmotorized transportation infrastructure and educational or promotional programs and to "demonstrate the extent to which bicycling and walking can carry a significant part of the transportation load, and represent a major portion of the transportation solution, within selected communities." Congress required the Federal Highway Administration (FHWA), working with the pilot communities, to report on the extent to which investments of program funds accomplished a range of goals, including environmental improvement, energy savings, and health, in addition to mode shifts to walking and bicycling. FHWA and the NTPP Working Group, comprised of FHWA, representatives of the pilot communities, the U.S. Department of Transportation's Volpe National Transportation Systems Center (Volpe Center), the U.S. Centers for Disease Control and Prevention (CDC), and the Rails to Trails Conservancy, reported results in the 2012 Report to Congress.[1] With support from the Volpe Center, the FHWA and pilot communities collected and analyzed additional data from 2012 and 2013 in the May 2014 report that includes an expanded focus on evaluating the NTPP's impact on public health and access in the pilot communities.[2]

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[1] FHWA. 2012. *Report to the U.S. Congress on the Outcomes of the Nonmotorized Transportation Pilot Program SAFETEA-LU Section 1807*. Accessed October 9, 2013: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/ntpp/2012_report/.

[2] Volpe Center for the FHWA. 2014a. *Nonmotorized Transportation Pilot Program: Continued Progress in Developing Walking and Bicycling Networks*. Accessed August 14, 2014: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/ntpp/2014_report/

Economic Benefits of Nonmotorized Transportation

There are many individual and societal impacts of investing in nonmotorized transportation. When considering the potential economic impacts of nonmotorized projects, planners and decision-makers must balance costs against a broad range of potential benefits. A recent white paper for the FHWA by the Volpe Center provides a comprehensive review on different approaches available to transportation planners to assess economic benefits of transportation projects. [3]

These potential benefits include conventional economic benefits as well as benefits that are not always easily expressed in monetary terms. Conventional considerations of economic benefits related to transportation infrastructure include travel time savings, reduced transportation operating expenses, and safety improvements. However, as transportation agencies' objectives expand to include increasing access and connectivity in addition to travel time and cost savings, transportation planners have begun to analyze a more complex set of economic impacts, such as improved access to employment centers, goods, and services.[4] Accessibility is considered in terms of physical access, such as network connectivity, or more broadly in terms of social barriers, such as financial or safety barriers.[5]

Accessibility can be framed as an economic benefit in terms of increased employment by improving access to jobs. In addition, transportation changes can indirectly affect local economies by altering the consumer behavior of users, who may change their consumer habits based on changes in transportation costs or accessibility to commercial opportunities. Nonmotorized transportation projects also have potential health and environmental benefits, which are analyzed in the 2012 NTPP Report to Congress and the May 2014 NTPP report.[6,7] These health and environmental benefits also have economic components. However, the ability to quantify these benefits to use in transportation planning is at an early stage.[8] This requires the ability to convert health benefits to a monetary measure for summation, aggregation, and comparison of alternative investments.[9,10] Many of these benefits are more complex to measure than travel time. Therefore, many transportation practitioners seek practical methods for estimating these types of benefits to aid in decision making processes.

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[3] Volpe Center for the FHWA. 2014b. "A Multi-Modal Approach to Economic Development in the Metropolitan Planning Process." Accessed September 15, 2014: http://www.planning.dot.gov/documents/EconDevelopmentFinal_8-11-14.pdf.

[4] Lorenz, Julie and Glen Weisbrod. 2013. "Getting Up to Speed with Transportation Economic Impact Tools." *Planning*, October 2013.

[5] Litman, Todd. 2012. "Evaluating Accessibility for Transportation Planning." Victoria Transport Policy Institute. Accessed October 9, 2013: http://www.vtpi.org/access.pdf.

[6] FHWA, 2012.

[7] Volpe Center for the FHWA, 2014a.

[8] Volpe Center for FHWA. 2012. *Metropolitan Area Transportation Planning for Healthy Communities*. Accessed October 9, 2013: http://www.planning.dot.gov/documents/Volpe_FHWA_MPOHealth_12122012.pdf.

[9] Krizek, Kevin, et al. 2006. *Guidelines for Analysis of Investments in Bicycle Facilities*. National Cooperative Highway Research Program Report 552, Transportation Research Board (TRB). Accessed October 9, 2013: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf.

[10] Pedestrian and Bicycle Information Center (PBIC). Benefit-Cost Analysis of Bicycle Facilities. Online tool, accessed October 16, 2014: http://www.pedbikeinfo.org/bikecost/.

A more detailed analysis of the different types of economic impacts from nonmotorized transportation projects follows.

Reduced User Costs

Low user cost and affordability are among the many benefits of walking or bicycling, especially compared to owning and operating a personal vehicle. Reduced travel costs result in a greater portion of pedestrians' and bicyclists' income that can be used for housing, necessities, and other consumer goods. In some cases bicycling may be faster than driving, especially for short trips in dense, urban locations. This creates a benefit in time savings, which can be monetized a number of ways.[11] Businesses that have programs encouraging their employees to commute using nonmotorized transportation may see an improvement in travel time reliability for employees, which could lead to improved productivity.[12] Providing greater access to lower-cost travel options can also have a social equity benefit by increasing access to jobs, opportunities, and community amenities for lower-income populations.[13]

Direct Economic Impacts

Direct economic impacts include money spent that benefits local commercial establishments in sales, produces tax revenues, and creates jobs as a direct result of the new nonmotorized infrastructure (e.g., jobs resulting from the design and construction of nonmotorized infrastructure, bicycle store sales and rentals, and bicycle and pedestrian infrastructure-supported tourism).[14] According to a case study in Baltimore, pedestrian and bicycle infrastructure projects created approximately 11 to 14 jobs per $1 million of spending, whereas road infrastructure projects created approximately 7 jobs per $1 million of spending.[15]

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[11] Interface for Cycling Expertise and Habitat Platform. 2000. *The Economic Significance of Cycling*. Accessed October 9, 2013: http://www.ocs.polito.it/biblioteca/mobilita/EconomicSignificance.pdf.

[12] Weisbrod, Glen and Arlee Reno. 2009. *Economic Impact of Public Transportation Investment*. Prepared for American Public Transportation Association (APTA). Accessed October 9, 2013: http://www.apta.com/resources/reportsandpublications/Documents/economic_impact_of_public_transportation_investment.pdf.

[13] Litman, Todd. 2007. "Economic Value of Walkability." *Transportation Research Record* 1828, Paper No. 03-2731:3-11: http://trb.metapress.com/content/M1573875U76T4223.

[14] Flusche, Darren. 2012. "Bicycling Means Business: The Economic Benefits of Bicycle Infrastructure," Advocacy Advance: a partnership of the League of American Bicyclists and the Alliance for Biking and Walking. Accessed October 11, 2013: http://www.advocacyadvance.org/site_images/content/Final_Econ_Update%28small%29.pdf.

[15] Garrett-Peltier, Heidi. 2010. "Estimating the Employment Impacts of Pedestrian, Bicycle, and Road Infrastructure: Case Study: Baltimore," Political Economy Research Institute, University of Massachusetts, Amherst. Accessed August 14, 2014: http://bikemd.org/files/public/documents/job%20Baltimore%20Case%20Study%20-%20Job%20Creation%20per%20Construction%20Projects.pdf

Indirect or Induced Economic Impacts

New bicycle and pedestrian infrastructure and programs can have economic impacts beyond sales by bicycle shops or other directly-related businesses (such as walking or bicycling tour companies). Transportation mode can also affect consumer behavior in terms of the frequency with which consumers visit a wider range of businesses and the average amount of money they spend.[16,17,18] There are a few potential reasons for consumer behavior to change with travel mode:

- Bicyclists and pedestrians who have more disposable income due to reduced travel expenses may be more willing to spend a greater portion of their income on local goods and services.
- Bicycle and pedestrian infrastructure may make a commercial corridor more accessible to foot traffic, increasing consumers' browsing opportunities and encouraging more access to local goods and services.
- Bicycle and pedestrian infrastructure, along with other forms of traffic calming, may make commercial streets more attractive to visitors and increase visitors' perceptions of safety.

Economic Impacts Due to Health Savings

The 2012 NTPP Report to Congress analyzed some important health benefits from the projects implemented in the NTPP communities. These benefits are further analyzed in the May 2014 report on the NTPP. It is important to note that these health outcomes have economic consequences. Increased levels of physical activity that result from use of bicycle and pedestrian infrastructure translate to a reduction in health care costs due to decreases in mortality (rate of death) and morbidity (rate of disease) related to obesity and other health conditions. According to the CDC , low levels of physical activity observed among Americans is a major contributor to rising rates of obesity, diabetes, heart disease, and stroke among other chronic diseases.[19] In addition, use of improved bicycling and walking facilities can produce safety benefits related to reduced traffic injuries and fatalities, which can also reduce medical costs and economic losses from injury or death.[20]

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[16] Ibid.

[17] Hass-Klau, Carmen. 1993. "A review of the evidence from Germany and the UK." *Transport Policy* 1(1):21-31. Accessed October 11, 2013: http://dx.doi.org/10.1016/0967-070X(93)90004-7.

[18] Lawrie, Judson et al. 2004. "The Economic Impact of Investments in Bicycle Facilities: A Case Study of the Northern Outer Banks." Prepared for the North Carolina Department of Transportation Division of Bicycle and Pedestrian Transportation. Accessed October 9, 2013: http://www.ncdot.gov/bikeped/download/bikeped_research_EIAoverview.pdf.

[19] Centers for Disease Control and Prevention (CDC). 2012. Transportation Recommendations. Accessed October 9, 2013: http://www.cdc.gov/transportation/.

[20] Ibid.

Economic Impacts Due to Environmental Benefits

Nonmotorized transportation projects also have environmental benefits, such as reduced air pollution and greenhouse gas emissions. For the NTPP, related benefits were described in the 2014 report.[21] These benefits also have an economic dimension. For example, there are human health benefits that result from improved air quality when automobile trips are replaced by nonmotorized trips. Air pollution from transportation-related emissions is one of the main contributors to poor air quality. Exposure to transportation-related pollutants is associated with several adverse health effects, such as premature mortality, cardiac symptoms, exacerbation of asthma symptoms, diminished lung function, and increased hospitalization.[22] Reducing exposure to air pollutants from motor vehicles can result in lowered medical expenses and economic loss due to adverse health effects. Current research in California is developing methods to quantify public health and other co-benefits from transportation-related greenhouse gas emissions reductions.[23,24] Improved air quality can also have other economic benefits. For example, improved visual air quality can benefit local tourist-related businesses. There are also economic benefits from reduced greenhouse gas emissions, with possible health implications, although they can be diffuse and difficult to measure at a local scale.

[21] Volpe Center for FHWA, 2014.
[22] Ibid.
[23] Maizlish, Neil, et al. 2011. "Health Co-Benefits and Transportation-Related Reductions in Greenhouse Gas Emissions in the Bay Area." California Department of Public Health. http://www.cdph.ca.gov/programs/CCDPHP/Documents/ITHIM_Technical_Report11-21-11.pdf
[24] Maizlish, Neil. 2010. "Public Health Benefits of Walking and Bicycling to Reduce Greenhouse Gas Emissions: The Woodcock Model of Active Transport." California Department of Public Health. http://www.arb.ca.gov/cc/ab32publichealth/meetings/091310/woodcock_model_health_co-benefits.pdf.

Measuring and Analyzing Economic Benefits

Different types of economic impacts may be most effectively measured in different ways and at different scales. Data can come from surveys, field observations, tax receipts, and many other sources. Researchers can also use economic models to study the impacts of nonmotorized investments. Some of these data categories can be translated into direct economic terms, as in the case of property values or retail sales. However, other impacts, such as health or environmental benefits, must be monetized indirectly. These data are often referred to as measurements of non-market goods. Methods for measuring these types of benefits include calculating willingness-to-pay,[25] user savings,[26] social cost,[27] risk avoidance,[28] control or mitigation costs, contingent valuation surveys, revealed preference studies, hedonic pricing studies, damage compensation rates,[29] and value of a statistical life,[30] which may be estimated at different levels in different countries or for different applications.

User Cost Savings

The economic benefits to users may be measured through user surveys of their travel behaviors and costs. Differences in travel costs can then be generalized based on documented changes in mode share from private vehicles or transit to nonmotorized transportation modes.

Direct Economic Benefits

Direct benefits to bicycle- or pedestrian-related businesses can be measured through business surveys, tax receipts, and a count of the number and size of such businesses in a community or geographic area. However, such an analysis requires baseline data from before the investment and established control

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[25] Organization for Economic Co-operation and Development (OECD). 2010. *Valuing Lives Saved from Environmental, Transport and Health Policies: A Meta-Analysis of Stated Preference Studies*. Working Party on National Environmental Policies. Accessed October 9, 2013: http://search.oecd.org/officialdocuments/displaydocumentpdf/?cote=env/epoc/wpnep(2008)10/final&doclanguage=en.

[26] Lawrie, et al, 2004.

[27] SQW. 2007. *Valuing the benefits of cycling*. Prepared for Cycling England. Accessed October 9, 2013: http://www.teespublichealth.nhs.uk/Download/Public/1012/DOCUMENT/5803/Valuing%20the%20benefits%20of%20cycling.pdf.

[28] Integrated Environmental Health Impact Assessment System, website. Accessed October 9, 2013: http://www.integrated-assessment.eu/guidebook/deriving_non_market_values.

[29] Flusche, 2012.

[30] United States Department of Transportation. 2013. “Economic Values Used in Analyses.” Accessed October 9, 2013: http://www.integrated-assessment.eu/guidebook/deriving_non_market_values.

communities or adjacent facilities for comparison. It is also important to consider whether increased sales represent a shift from an adjacent street without a bicycle facility to a street with a new facility.

Indirect Economic Benefits

Indirect benefits from nonmotorized transportation, such as increased sales due to changes in consumer behavior, can be measured in a number of ways. Similar to user cost savings, researchers can survey consumers about their travel and consumer behaviors and extrapolate larger trends based on measured mode shifts. However, this requires data on both mode shares and consumer behaviors before and after a project is implemented. In Minneapolis, researchers from the University of Minnesota surveyed consumers in commercial areas near bike share stations and found that bike share users spent an average of $1.29 more per week than others, which they extrapolated over all bike share users in the city to estimate an additional $150,000 per season generated in sales due to the bike share.[31] In Toronto, researchers used surveys to collect baseline data on travel and consumer behavior to evaluate the potential economic impacts of a proposed bike lane.[32] This study found that visitors who traveled to the commercial corridor by foot or bicycle tended to spend more money per month in the neighborhood than those who arrived by car or transit. Although this analysis was performed before project implementation, its methods could measure economic activity by mode after the project is complete. The collection of robust data before project implementation aids effective post-project evaluation.

In addition to survey data, researchers can measure economic impacts to a community's commercial sector by measuring sales tax receipts, commercial vacancy rates, property values, rents, and other economic indicators. These could be measured in the immediate vicinity of a completed nonmotorized transportation project, for a commercial corridor, or at a larger community scale. For example, the New York City Department of Transportation (NYCDOT) studied changes to commercial sales and vacancy rates in the areas surrounding new bicycle and pedestrian projects, compared with economic data for the borough as a whole or for similar neighborhoods to establish a control.[33]

Economic Measures of Health and Environmental Impacts

Economic measures of health benefits require models to estimate the economic savings due to

[31] University of Minnesota Center for Transportation Studies (CTS). 2012. "Nice Ride spurs spending near stations." Catalyst, July. Accessed October 9, 2013: http://www.cts.umn.edu/Publications/catalyst/2012/july/niceride/.
[32] The Clean Air Partnership. 2009. "Bike Lanes, On-Street Parking and Business: A Study of Bloor Street in Toronto's Annex Neighborhood." Accessed October 9, 2013: http://www.cleanairpartnership.org/pdf/bike-lanes-parking.pdf.
[33] New York City Department of Transportation (NYCDOT). 2012. "Measuring the Street: New Metrics for 21st Century Streets." Accessed October 9, 2013: http://www.nyc.gov/html/dot/downloads/pdf/2012-10-measuring-the-street.pdf.

increased health. One example is the Healthy Economic Assessment Tool (HEAT),[34] developed by the World Health Organization (WHO), which the CDC has adapted for use in the U.S. context. The HEAT model can estimate the economic cost of mortality (death) averted that results from the health benefits of increased bicycling, but the model does not currently estimate the economic cost of mortality averted due to increased walking in the United States or savings from reduced morbidity (disease) from walking or bicycling. These functions may be available in the future.

Research on economic impacts from nonmotorized transportation could also analyze a more comprehensive set of health benefits from nonmotorized transportation due to changes in physical activity, reduced air pollution, and reduced injury. The Integrated Transport and Health Impacts Model (ITHIM), developed by James Woodcock and colleagues, provides another tool for measuring the consequences of a more comprehensive suite of health impacts.[35,36] The model was initially used in a London study on greenhouse gas (GHG) reduction strategies and is being reviewed by the California Department of Public Health for application in selected California communities.[37,38] It is important to note that ITHIM is in early stages of development and application. ITHIM also does not measure health benefits in monetary terms, but in Daily Adjusted Life Years (DALYs).[39]

Measures of Cumulative Economic Impacts

There are a number of models that allow researchers to estimate a project's cumulative economic effects. They include the REMI,[40] Impact Analysis for Planning (IMPLAN),[41] and TREDIS models,[42] and the United Kingdom Department for Transportation's Guidance on the Appraisal of Walking and Cycling Schemes,[43] described in Table 1 in the appendix.

Some of the tools described in Table 1 provide cost-benefit ratios as part of their output. Others simply assess the impacts themselves but do not provide a measure of feasibility for the project being assessed. As such, some models can be used for pre-project cost-benefit analysis as well as post-project evaluation,

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[34] World Health Organization (WHO). 2013. "Health economic assessment tool (HEAT) for cycling and walking." Accessed October 9, 2013: http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health/Transport-and-health/activities/promotion-of-safe-walking-and-cycling-in-urban-areas/quantifying-the-positive-health-effects-of-cycling-and-walking/health-economic-assessment-tool-heat-for-cycling-and-walking.

[35] Woodcock, James, et al. 2009. "Public health benefits of strategies to reduce greenhouse-gas emission: urban land transport." *The Lancet* (374):1930-1943.

[36] Woodcock, James, et al. 2013. "Health Impact Modelling of Active Travel Visions for England and Wales Using an Integrated Transport and Health Impact Modelling Tool (ITHIM)." *PLOS ONE* 8(1): e51462.

[37] Maizlish, et al, 2011.

[38] Maizlish, 2010.

[39] Woodcock, et al. 2013.

[40] Regional Economic Models, Inc., website. Accessed October 11, 2013: http://www.remi.com/.

[41] IMPLAN Group, website. Accessed October 11, 2013: http://implan.com/.

[42] TREDIS, website. Accessed October 11, 2013: http://tredis.com/.

[43] United Kingdom Department for Transportation. 2012. "Guidance on the Appraisal of Walking and Cycling Schemes." Accessed October 11, 2013: http://www.dft.gov.uk/webtag/documents/expert/unit3.14.php.

whereas others are only appropriate for post-project analysis. For models based on cost-benefit analyses, all costs and benefits must be monetized, which may involve making some of the same assumptions noted in the previous section regarding non-market goods. It is critical to document assumptions to establish credibility of economic benefit outputs, and to allow others to modify assumptions when appropriate for their applications. Once all costs and benefits are monetized, the ratio of benefits to costs are calculated and evaluated to determine feasibility and desirability. Some of the tools available to help decision- makers conduct cost-benefit analyses of nonmotorized transportation initiatives are described and compared in
Table 2.

Scales of Observation and Analysis

Researchers must also consider the appropriate scale of observation and analysis to evaluate economic impacts from nonmotorized transportation investments. Each scale has benefits and drawbacks and may be more or less appropriate for different projects and community contexts.

Micro Scale – Individual Businesses and Consumer Behavior

Some researchers have observed economic impacts on a micro scale and extrapolated small-scale behavior to estimate the effects of broader trends. The aforementioned studies of consumer behavior in Toronto[44] and Minneapolis[45] are examples of micro-scale observation, collecting data on individual consumers' spending habits by mode share. An advantage to this approach is that data collection is relatively simple and can provide a concrete glimpse at the potential impacts of travel cost savings and indirect economic benefits from consumer spending changes. Another example of micro-scale observations may be surveys of individual business owners, such as bicycle shops or tourism-related businesses that utilize nonmotorized transportation investments. However, the relationship between micro-scale data and larger trends may be more complex than researchers assume in their models, making assumptions about broader economic impacts difficult to demonstrate through micro-scale data alone. For example, the University of Minnesota researchers studying the economic impacts of Minneapolis's bike share system hypothesize that the additional spending they observe near bike share stations may not be newly generated consumer spending, but spending displaced from other areas of the city due to the greater accessibility a bike share station provides to the businesses nearby.[46] If a community wants to understand economic impacts on a larger scale, additional observation and analysis may be necessary.

Meso Scale – Neighborhoods and Commercial Corridors

The meso scale of observation and analysis is an intermediate scale between the scale of individual businesses or consumers and the larger scale of a city or county. Meso-scale analyses may measure indicators such as sales tax receipts, vacancy rates, or property values for a commercial area or neighborhood. The benefit of the meso scale of analysis is that it is a scale at which the impacts from small infrastructure projects may be detected and measured directly, without the challenges of extrapolation required in micro scale studies. However, researchers may struggle to obtain the necessary data, especially in cities that do not collect data on local businesses.

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[44] The Clean Air Project, 2009.
[45] CTS, 2012.
[46] Ibid.

Example: New York City Department of Transportation's "Measuring the Street"

In 2012, NYCDOT developed "Measuring the Street," which includes assessment of results of nonmotorized investments in New York City, and provides a notable example of measuring related economic benefits.[47,48] NYCDOT demonstrates the applicability of a specific set of measures related to key aspects economic benefits as a practical alternative to a more extensive approach that might derive an overall cost-benefit ratio or region-wide economic changes. NYCDOT used the city's goals to guide the impacts to be measured, and isolated the scale of impacts to single corridors and specific projects of priority interest, such as pedestrian plazas and individual segments of bike lanes. This kept the analysis to a manageable initial scale, and allowed for a more tangible focus on changes over a series of years for a small subset of economic benefits. The approach resulted in an analysis that might provide a proxy for broader economic benefits or a wider geographic scale of results.

In this study, NYCDOT limited its economic impact analysis to city sales tax receipts from retail and restaurants, commercial vacancies, and number of visitors at properties along or near a project site. NYCDOT obtained before and after data to determine changes in economic activity. To establish control for comparison, NYCDOT compared these values to those at a borough level within which a project is located and also to areas with land use mix and traffic characteristics similar to the project site.

NYCDOT staff conducted the economic analysis on 12 projects. The DOT also coordinated with the City Department of Finance and the State Division of Tax and Finance to obtain aggregated sales tax data, and worked with a private contractor with access to an extensive commercial real estate database to identify commercial vacancy rates within the vicinity of these corridors and projects. NYCDOT staff conducted surveys and logged observations of project areas. NYCDOT considered using residential property tax returns, asking rents for residential and commercial properties, and property values, but the data were not available. However, the same analysis methodology would have been used, except over a longer time period, to account for the lag time associated with these indicators.

Early results of the study are promising. Some highlights include:

- 49% increase in retail sales near the protected bike lanes on 8th and 9th Avenues in Manhattan (compared to a 3% increase borough-wide);
- 49% fewer commercial vacancies near the reconfigured pedestrian plaza at Union Square North (compared to 5% more borough-wide); and
- 172% increase in retail sales at Pearl Street in Brooklyn, where an underused parking area was converted to a pedestrian plaza (compared to an 18% increase borough-wide).

The study also identified some significant pedestrian and bicyclist crash reductions. While NYCDOT did not monetize these benefits, reduced crashes may have economic implications, such as reduced economic loss due to death or serious injury or reduced medical costs. Estimating these benefits is

[47] NYCDOT, 2012.
[48] Maguire, Thomas, Assistant Commissioner, NYCDOT. Personal communication on July 15, 2013.

complex but could be informed by the value of a statistical life, similar to the WHO's HEAT model.[49] Safety improvements include:

- 67% decrease in pedestrian crashes at the site of traffic calming on East 180th Street in the Bronx;
- 37% decrease in injury crashes on 1st and 2nd Avenues in Manhattan where dedicated bus and bike lanes were installed; and
- 58% decrease in injuries to all street users on 9th Avenue in Manhattan where a protected bike lane was installed.

Macro Scale – The City, Zip Code, County, or State Level

To understand larger-scale economic impacts, researchers may choose to analyze economic impacts on a macro scale, such as city-, county-, or state-wide. The economic models described in this paper, including REMI, IMPLAN, and TREDIS, are most suited to this scale of analysis. The value of this larger scale of analysis is that it can help researchers understand the cumulative economic impacts of a project or program without having to worry about the potential for mistaking economic displacement within the region for newly generated economic activity. However, macro-scale data may be too coarse-grained for researchers to detect small, localized economic changes within a larger geographic region. In addition, many of the models that can estimate macro-scale changes can be expensive or complex to use.

Example: *Economic Impact of Bicycling and Walking in Vermont*

Inspired by the 2008 Vermont Pedestrian and Bicycle Policy Plan, the Vermont Agency of Transportation (VTrans) conducted a study called Economic Impact of Bicycling and Walking in Vermont.[50] VTrans hired a consultant team of Resource Systems Group, Inc., Economic and Policy Resources, Inc., and Local Motion to assist with analysis. The study looked at one year (2009) of direct, indirect, and induced economic activity attributed to bicycling and walking. The analysis team set out to estimate the following benefits:

- The economic returns of capital investments in bicycling and walking infrastructure;
- Economic returns of capital investments in bicycling and walking infrastructure;
- Avoided transportation user costs of pedestrians and bicyclists compared to automobile drivers (e.g., vehicle ownership and operations, value of time lost in congest, and health savings);

[49] WHO, 2013.

[50] Vermont Agency of Transportation (VTrans). 2012. *Economic Impact of Bicycling and Walking in Vermont*. Accessed October 9, 2013: http://www.localmotion.org/documents/advocacy/Final_Draft_Report_Econ_Impact_Walking_and_Biking_030812.pdf.

- Avoided societal costs related to a mode shift from automobile travel to bicycling and walking (e.g., reduction of greenhouse gas and other emissions, traffic enforcement, noise impacts, and safety);
- The effect of bicycling and walking facilities on real estate values; and
- Output and jobs created by bicycling and walking related businesses.

According to VTrans' report, the analysis team determined that they could not obtain sufficient data for some of the benefits that they had intended to assess.[51] Specifically, the user and societal costs associated with transportation mode choice and the effects of bicycling and walking infrastructure on real estate values suffered from unavailable or unreliable data. The team decided to leave these three benefits out of the analysis.

In the report, VTrans concluded that:

- Vermont hosted over 40 running and cycling events in 2009, which attracted over 16,000 participants spending over $6 million in the state. The running- and cycling-related spending from these events supported an estimated 160 workers;
- A business survey found that bicycle- and pedestrian-oriented businesses in Vermont generated $37.8 million in output and directly employed 820 workers with $18.0 million in labor earnings; and
- The state budget fiscal impact from bicycle and pedestrian activities in 2009 were a net positive $1.6 million in taxes and fee revenues.[52]

[51] Ibid, 25.
[52] Ibid, 24-25.

Observations and Conclusion

This review of available tools suggests that there are a wide variety of options available for the measurement and assessment of the economic benefits of nonmotorized transportation projects. Before deciding on a tool or set of tools for analysis, researchers should determine the goals of their analysis:

1. What kinds of economic impacts should the researcher evaluate?
2. Which methods for measurement and data collection will the researcher employ?
3. What is the most appropriate scale for analysis to evaluate a particular project or program?

Different tools are more appropriate for different scales of analysis. While an input-output model may be most effective at the State-, county-, or city-scale, analysis of sales tax receipts or vacancy rates may be a more effective way to measure economic impacts of nonmotorized investments in individual neighborhoods, and surveys may be the most effective way to measure individuals' cost savings or changes in economic behavior. Researchers must also consider the availability of baseline data or data for a statistical control. Ideally, communities planning new bicycle or pedestrian infrastructure should begin collecting baseline data before project implementation so that they have an adequate dataset in a form that will be comparable to post-project evaluation data requirements. This requires designing an evaluation strategy in advance. In cases where such pre-planning is infeasible, familiarity with available sources of pre-project data is valuable and recommended.

In terms of usability, each tool or technique has different advantages, disadvantages, and limitations including:

- Cost;
- Complexity and required learning curve;
- Data requirements;
- Geographic scale of analysis;
- Temporal constraints; and
- Availability of documentation of successful applications by practitioners.

The process of selecting a tool is critical to the success of the economic analysis. Communities must consider the goals of the project to be analyzed and available resources, including budget, staff time, and data, before determining which tool (or tools) is appropriate, based on how those goals and available resources relate to the tool's advantages, disadvantages, and limitations.

There is a wide spectrum of available tools and models. On one end of the scale, robust models like REMI, IMPLAN, and TREDIS use sophisticated mathematical simulations to consider a wide range of economic benefits on a regional scale. These input-output models may be very useful for macro-scale applications, such as assessing the regional economic benefits of a bicycle and pedestrian plan, with a large group of projects, or to evaluate the impacts after the plan is implemented. However, these resources may be too complex or costly for smaller communities interested in analysis of single projects or corridors. On the other hand, specialized tools such as the HEAT and ITHIM models, and guidance such as that available from the United Kingdom, take a more focused approach to consider a specific type of economic benefit and can be used on a smaller scale. The type of economic benefit considered could be one that has been identified as especially important to the project or the community it serves. Consequently, some nonmotorized transportation planners and practitioners may find that their needs can be met by focusing on specific aspects of economic benefits, such as those that are attributed to public health, reduced congestion, or benefits measured practically through the use of proxies such as changes in retail sales or property assessments.

For example, the HEAT model focuses specifically on economic benefits of health improvement – a very important component of economic benefits but less inclusive than using the input-output models to consider broadly based impacts on the regional economy, or comprehensive cost-benefit analysis that can generate an estimate of return on investment. It is important to note that models such as HEAT and ITHIM continue to be developed and refined as described in this white paper.

NYCDOT's "Measuring the Street" is a good example of a practical approach to identifying some specific economic benefits, such as retail sales, to demonstrate the impact of nonmotorized transportation projects; this might be considered a "proxy" for a broader, more ambitious, macro-scale analysis of economic benefits. On the other end of the spectrum, the consumer surveys that the University of Minnesota and the City of Toronto used to understand individual behavior can be particularly useful ways to study the economic impacts that pedestrian and bicycle infrastructure may have on individual consumers.

Recommendations for Evaluating Economic Impacts from Nonmotorized Transportation

A combined approach that incorporates select methods from studies like those reviewed in this paper would provide the NTPP communities and peer communities with a balanced and practical look into the economic benefits of their nonmotorized projects. This approach would consider health benefits from increased physical activity, reduced GHG emissions, and improved safety, as well as local economic development impacts, covering some of the most important benefits associated with nonmotorized transportation. Macro-scale economic analyses, although useful, can be expensive and complex, and may not be able to identify more localized impacts of bicycle and pedestrian transportation projects individually or in site specific groupings.

Models such as HEAT and ITHIM are also available to enhance and validate such analyses. The NTPP pilot communities used the HEAT model to measure and monetize some of the range of possible health impacts of pedestrian and bicycle projects due to increased physical activity. As obesity is a major contributor to several chronic diseases of great concern in the U.S.,[53] many communities are looking for ways to increase physical activity among their residents. Monetizing these benefits can be a helpful method to demonstrate gains toward reducing health care costs and economic loss due to obesity and produces measures that are comparable and understandable by both the public and decision-makers. This area of analysis allows a more comprehensive assessment of important potential important benefits of active transportation. Although the model does not currently produce monetized outputs, the ITHIM model could potentially add other health benefits to the analysis, broadening the scope of health impacts considered. As noted, the ITHIM model is at early stages of development and application.

Similarly, the economic benefits from safety improvements, such as those measured by NYCDOT, could be analyzed using the methods presented in the Guidance on Appraisal of Walking and Cycling Schemes from the United Kingdom, referenced in Table 1, complementing the methods with data from technical resources that may be more specific to the U.S., as suggested by California Department of Public Health in its use of the British Woodcock model.[54] Safety of users of various modes is another important component of encouraging physical activity through nonmotorized transportation, in addition to clear measurements of injuries and fatalities.

This hybrid approach is a practical option for communities with a need to assess the benefits of nonmotorized investments. They provide a focused assessment of some important benefits applicable to a community scale and an alternative to more complex input-output models that consider the wider economic impacts of transportation improvements to the region or county as a whole.

[53] CDC, 2012.
[54] Maizlish, et al., 2011.

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Appendix A: Comparisons of Reviewed Tools[55]

Table 1: Comparison of Reviewed Economic Analysis Tools

	Developer	Description	Data Needs (i.e. inputs)	Output	Usefulness/ Applicability	Case Study
REMI	Regional Economic Models, Inc. (REMI)	• Input-output model • Considers employment, output and demand, GDP, consumption, relative costs, compensation, and occupation • Multiple time periods at county or sub-county level	• Construction, operations, financing information • Emissions • Fuel efficiency • Safety • Operating costs • Occupancy	Cost-benefit ratio	• Allows for multiple considerations at both county and sub-county levels • Complex • Time-intensive • Cost: depends on scale of analysis	Vermont Agency of Transportation: *Economic Impact of Bicycling and Walking*, 2012
IMPLAN	MIG, Inc.	• Input-output model Estimates cumulative impact on economy as whole or specific sector	• Economic information about county/zip code • Information about bike/ped facility capital investment • Bicycle industry in the study area • Visitor spending related to bicycles	• Sales • Tax revenues • Jobs • Secondary effects on suppliers of an industry • Effects resulting from changes in household	• Provides several outputs applicable for both bicycle and pedestrian projects • Complex • Time-intensive • Static—does not look at changes over time • Available data are limited to 2009-2011 • Costs: depends on application for software and data	North Carolina Department of Transportation: "Economic Impact of Bicycle Facilities," 2004

[55] Information on commercial products is provided as a technical resource to readers and does not imply endorsement by the US Department of Transportation, the Federal Highway Administration, or the Volpe National Transportation Systems Center.

	Developer	Description	Data Needs (i.e. inputs)	Output	Usefulness/ Applicability	Case Study
TREDIS	TREDIS Software Group	• Web-based • Dynamic • Considers economic impact, cost-benefit analysis, and public-private financial analysis for any transportation mode	At a minimum: • Number of trips or people affected • One indicator variable (e.g. changes in speed, travel time, etc.)	• Impact on economy • Return-on-investment • Cash flow • Demographics • Performance measures • Societal benefits	• Available online; free 30-day trial • Cost: depends on product and application	Virginia Department of Transportation: Multi-modal Transportation Plans
HEAT	World Health Organization	Estimates economic benefit from reduced mortality due to physical activity	• "Value of a statistical life" (VSL) (local value must be obtained) • Number of people bicycling • Average time spent bicycling (duration, distance, trips, or steps) • Mortality rate • Analysis period • Discount rate (optional) • Cost of promoting bicycling (for cost-benefit analysis)	• Maximum annual benefit • Mean annual benefit • Net Present Value (NPV) of annual benefit	• Useful for evaluating benefits at varying levels of bicycling • Currently has not been calibrated in the U.S. for estimating economic savings from reduced mortality from increased walking • Analyzes a point in time or time series data • Does not consider decreased morbidity, health benefits from improved safety,or air quality • Could be used in partnership with public health agency • Free; available online	Federal Highway Administration/Volpe Center: *Report to Congress on the Outcomes of the NTPP*, 2012[56]; and NTPP 2014 Report[57]

[56] FHWA, 2012.
[57] Volpe for the FHWA, 2014a.

	Developer	Description	Data Needs (i.e. inputs)	Output	Usefulness/ Applicability	Case Study
Integrated Transport and Health Impacts Model (ITHIM)	Woodcock, et al.	• Estimates health impacts of initiatives that reduce carbon emissions • Considers health as it relates to physical activity, air pollution, and injuries	• Travel distance by mode • Population • Distribution of active travel time • Travel speeds for walking and bicycling (age/sex-stratified) • Ratios of bicycling • Walking travel times • Metabolic equivalent of task (MET) for walking and bicycling at various speeds MET hours for non-transport physical activity	• Disability Adjusted Life Years (DALYs) • Comparative risk assessment - calculates difference in DALYs of two different scenarios	• Useful for comparing project alternatives • Based on data that is likely to be available from public health departments • Might require partnership with public health professionals for analysis • Free	California Department of Public Health[58]
Guidance on Appraisal of Walking and Cycling Schemes	United Kingdom Department for Transport	Includes tables and approaches for assessing a broad range of health and environmental impacts: • Safety • Journey ambience • Absenteeism • Air quality • GHG emissions • Landscape • Townscape • Historic resources • Biodiversity • Water • Physical activity	Varies	Varies	• Very extensive Able to select most desired methods • Data-intensive • Standard values given are specific to UK and may not be relevant to US • Free; available online	Case studies are presented at end of guidance

[58] Maizlish and Woodcock, et al., 2011, 2013.

Table 2: Comparison of Reviewed Cost-Benefit Analysis Tools

	Developer	Description	Data Needs (i.e. inputs)	Output	Usefulness/ Applicability	Case Study
Benefit-Cost Analysis of Bicycle Facilities	Active Communities / Transportation (ACT) Research Group	Defines economic benefits as: • Time savings • Decreased health care costs • Enjoyable bike ride Decreased pollution All are dependent on the estimated demand (available for 53 metro areas)	• Year of construction • Type of facility • Bicycle commute share • Residential density near the facility • Facility length	Benefit-cost ratio	• Very straight-forward • Free; available online • Customizable • Many metro areas loaded into tool • Only makes future projections - not estimates of benefits from completed projects • Made for bicycle facilities, not pedestrian or multi-use	None
NZTA Economic Evaluation Manual (EEM)	New Zealand Transport Agency	Considers: • Total project costs • Travel time cost savings • Environmental costs • Health from physical activity and safety • Journey ambience • Accident cost savings	• Duration of construction • Current and estimated bike/pedestrian volumes • Estimated motor vehicle volumes and speed • Bike/pedestrian growth rate • Width of bike/pedestrian facility before and after • Walking/bicycling distance before and after construction, • Expected reduction in VMT • Many others	Benefit-cost ratio	• Complex • Time-intensive • Data-intensive • Free; available online • Provides guide for estimating bicycling demand based on population, density, and existing commute share • Standard values are specific to NZ; may not be relevant to US	Report with eight case studies in Christchurch

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