The Economic Impact of Increasing Congestion

Transportation systems are the arteries and capillaries of the economic body. Whether a commuter is using mass transit, a tractor-trailer is hauling produce, a real estate agent is going to a home showing, or a parent is delivering children to school, transportation is essential to our modern life style and quality of life. Transportation is so readily available that it is nearly invisible. Day after day we use transportation systems with little consideration of how they are provided or whether they are sufficient for the entire community. However, ***rising congestion threatens to undermine the very foundation of our economic prosperity.***

The economic context of transportation is frequently thought of in terms of freight or goods movement and less so for passenger transit. While freight is a vital component of the economic link, passenger traffic is equally important, especially in a services based economy like the U.S. Presently, services comprise 79.4% of the Gross Domestic Product. Beyond the economic considerations are those involving quality of life and the potential for disenfranchisement of basic freedoms measured in terms of access to jobs, education, religious pursuits, recreation, health care etc.

A practical example of the relationship of freight movement to economic vitality is the daily operation of a major U.S. city. On an average day, approximately 12 million pounds of food are transported into New York City: 53,600 pounds of butter, 2.2 million pounds of meat, poultry or fish, 1,340,000 pounds of fruits and juices, 3.3 million pounds of milk and cream, one million pounds of potatoes, one million pounds of sugar and sweeteners and 1.4 million pounds of flour and cereals.[i] The vast majority of this produce arrives on trucks. Imagine the tons of freight related to other industries, such as office goods, paper, furniture, and electronic equipment. Once goods are consumed, the waste must be transported out of the city. On average, there are approximately 4.5 pounds of refuse produced daily for every person in the United States.[ii] The population of New York City, not including the surrounding boroughs, was approximately 8 million in 2000; the daily refuse removal would have been 36 million pounds or 18,000 tons. All of this transportation must take place on increasingly congested highways resulting in more time required to transport the freight and ultimately the addition of more trucks to handle even existing demand. Each year more vehicles travel the nation's highways just to meet existing levels of economic activity without accounting for any economic growth. These events represent an introduced inefficiency to the economy.

Similar inefficiencies occur in the service industry. I recall a particularly salient presentation by the CEO of a large pest control company describing how congestion directly related to the need for more trucks and people to handle the same workload as the previous year because of increases in traffic congestion.

Freight traffic in the U.S. is inordinately carried by the nation's highways. Fully ***83% of the value of freight moved in the U.S. is moved by truck versus rail, water and air transport combined.*** Measured

another way 62% of the tonnage and 38% of the ton-miles are transported on the highway.[iii] This growth in ***truck freight has been the result of a kind of perfect storm that occurred initially in the 1990's when the North American Free Trade Agreement, truck deregulation and just-in-time inventory control coincided.*** These factors continue to amplify and the projections for truck freight traffic demonstrate tremendous growth on the highway system, particularly on the Interstate and other major arterial highways.

The Role of the Automobile

In the United States, access to transportation nearly equates to automobile access and ownership. There are 1.1 vehicles for every licensed driver in the United States today, up from .7 per licensed driver in 1969[iv] and this trend has been consistent for the last thirty years. In some of the larger cities of the United States mass transit is widely available and automobile ownership is not universal, but it is rare for a family not to own an automobile. From 1960 to 2000 the percentage of work trips made by public transit fell from 12.6 per cent to 4.7 per cent and the number of autos and light trucks per 1000 people rose from 340 to 766, resulting in the highest rate of personal vehicle ownership in the world.[v] This is about 50 per cent higher than most Western European countries.

In the fourth of a series of articles produced for the Transportation Quarterly, titled "Socioeconomics of Urban Travel: Evidence From the 2001 National Household Transportation Survey", professors John Pucher and John Renne concluded the following:

The 2001 Nationwide Household Transportation Survey confirms most of the same travel trends and variations among socioeconomic groups documented by its predecessors, the Nationwide Personal Transportation Surveys of 1969, 1977, 1983, 1990, and 1995. The private car continues to dominate urban travel among every segment of the American population, including the poor, minorities, and the elderly.[vi]

Since 80% of the U.S. GDP is based on the service segment of the economy, it is not surprising that the automobile plays a large role in the transportation/economy equation. Real estate, medical, legal, advertising, and information services all depend upon the two axle vehicle and the growth in internet sales has created an increase in delivery services. Growth in population from immigration, growth in vehicle registrants have combined with other factors to create a disproportionate increase in vehicle miles traveled, VMT.

A great deal of research has been conducted on the subject of congestion and economic impact. Formal research has only recently begun to determine the quantitative relationship between transportation and the economy. Research, conducted by the National Research Council, found that a reduction of 10 per cent in travel times, which equates to a 2.5 per cent reduction of travel costs, had an annual economic impact of $980 million for the Chicago area and $240 million for the Philadelphia area.[vii] These are the effects for just two cities. Imagine the economic impact if travel times could be reduced 10 per cent in all of the major metropolitan areas of the United States. Conversely, if travel times increase 10 per cent because of increased congestion, a multi-billion dollar negative economic

impact results. The realization that congestion is a growing threat to the economy is well founded. Compounding the problem, congestion is not a linear phenomenon but increases geometrically.

Traffic growth in the U.S. has consistently increased 2.5-3.0% for several decades. While such growth does not seem extraordinary, why the increasing levels of congestion and concern for economic impacts? Traffic growth must be considered in the context of compound growth and the degree to which additional highway capacity is added to service such growth. Other than the significant capacity added by the construction of the Interstate system between 1960 and 1980, little additional roadway capacity has been constructed in the U.S.

Traffic congestion is like an increasing friction on the economic engine of the U.S. These congestion costs can be measured as time delay, increased vehicle operating costs, accident repair and increased air pollution. But for the purposes of the following example let's consider only travel delay. The friction in travel begins slowly at first and results from the interaction of vehicles in a traffic stream. As volumes grow and capacity remains stagnant, vehicular flow passes from a smooth, laminar condition, to a more turbulent flow and then stop and go conditions. It is generally agreed amongst traffic engineers that vehicle delay increases as a relatively linear function of traffic volume until the traffic flow reaches turbulent conditions. As turbulence increases the relationship between volume increase and time delay becomes less linear. This is particularly true as the hourly capacity of the roadway is approached and delay begins to cascade into subsequent hours. At this point the relationship function begins to demonstrate a nearly geometric function. Traffic increases generate quite different travel delays depending on whether the highway is near capacity or some lower level of usage. The following example considers a single lane of traffic in isolation from a highway network and presumes that traffic growth has no alternative but this single lane of traffic.

Imagine a one-lane roadway with a capacity of 2,250 vehicles per hour, a total theoretical capacity (24 hours per day) of 54,000. This, of course, assumes that the demand for the roadway is 2,250 per hour during each hour of the day and that perfect driving conditions and perfect driver behavior is in place. Actual demand, of course, varies by these factors and the time of day. Traffic in the peak demand periods of the morning and evening hours is heaviest and lightest in the late evening and early morning. Table 9 below shows a hypothetical distribution of travel demand. The exactness of this travel demand is not of crucial importance since differences between the available capacity and the demand are carried over to the following hour. Whether the delay occurs at 8 a.m. or 9 a.m. is somewhat irrelevant. The theoretical maximum capacity for each hour remains 2,250 vehicles per hour, the demand or volume of traffic varies and the difference, positive or negative, rolls to the following hour. If the traffic volume exceeds the 2,250 vehicles per hour capacity, then the roadway is assumed to be over capacity and the excess volume is carried to the next hour. When demand volume drops below 2,250 some of the accumulated excess demand can be accommodated. The delay is calculated by dividing the accumulated excess volume for the hour by 37.5, which is the theoretical capacity of the roadway per minute.

EXISTING

Hour	Volume	Vol>Cap.	Cum.	Delay (Min.)
12-1AM	150	-2100		
1-	150	-2100		
2-	150	-2100		
3--	150	-2100		
4-	150	-2100		
5-	150	-2100		
6-	600	-1650		
7-	900	-1350		
8-	1500	-750		
9-	1950	-300		
10-	2100	-150		
11-	1650	-600		
Noon-1	1800	-450		
1-	1650	-600		
2-	1500	-750		
3-	1800	-450		
4-	1950	-300		
5-	1650	-600		
6-	900	-1350		
7-	600	-1650		
8-	300	-1950		
9-	300	-1950		
10-	300	-1950		
11-Mid.	300	-1950		

22650	-31350	0
Volume	Vol>Cap.	(Min.)

Table 9: Existing Conditions of Hypothetical Roadway Delay

In the "existing" condition travel volumes do not exceed the capacity of the roadway at any point during the day. This facility is operating at free flow conditions. If the volumes continue to grow at the national average of 3.0% over a five year period and no additional capacity were added, delays would increase.[viii] A growth of 3% compounded over five years would be 16 per cent. Table 10 shows the results.

		16%	Increase	
		5 yr @ 3%		Delay
Hour	Volume	Vol>Cap.	Cum.	(Min.)
12-1AM	174	-2076		
1-	174	-2076		
2-	174	-2076		
3--	174	-2076		
4-	174	-2076		
5-	174	-2076		
6-	696	-1554		
7-	1044	-1206		
8-	1740	-510		
9-	2262	12	12	0
10-	2436	186	198	6
11-	1914	-336		
Noon-1	2088	-162		
1-	1914	-336		
2-	1740	-510		
3-	2088	-162		

4-	2262	12
5-	1914	-336
6-	1044	-1206
7-	696	-1554
8-	348	-1902
9-	348	-1902
10-	348	-1902
11-Mid.	348	-1902
	26274	-27726
	Volume	Vol>Cap.

6

(Min.)

Table 10: Traffic Growth and Delay After 5 Years

A five-year average growth in traffic in this hypothetical example, which is a compounded 16 per cent, results in two hours of the day in which the hourly capacity of the roadway is exceeded by demand in that hour and no hours in which capacity is exceeded due to carry over of volume. The total delay is 6 minutes for the one lane of traffic over a twenty four hour period. A similar analysis was performed for 10, 15 and 20-year growth and the results are depicted in Table 11. Effectively a small 3% growth rate in volume in this restricted example results in a roadway in gridlock in a short twenty years.

Years	Growth	Hours Vol>Cap	Accum Vol>Cap	Delay Minutes
Today	0	0	0	0
5	16	2	2	6
10	34	5	10	243
15	56	10	13	936
20	81	10	19	3977

Table 11: Hypothetical Effects of Growth on Highway Delay

As shown in the Table, delay begins to carry over from one hour to the next and by year ten the total minutes of delay increases from 6 minutes to 243 minutes. However, at the end of twenty years of linear 3% growth, there are ten hours that are over capacity but nineteen hours that experience delay. The delay that would be theoretically experienced by the driving public would increase from 0 minutes

to 3977 minutes in the following progression 0, 6, 243, 936, 3977 while traffic volumes would grow 81% linearly over the twenty-year period.

Obviously, there are many caveats to this hypothetical case. First, there is no provision for interaction with the surrounding highway network or other modes of transportation. Most highways in America have alternative routes or alternative modes of transportation that can be taken once congestion leads to unacceptable delay.

Secondly, there is no provision for modification in behavior, traveling different times of the day etc. and lastly, it is assumed that no new capacity of any kind is provided in the corridor. There is also an inherent assumption that volumes will continue, even if it is nearly impossible to navigate the corridor. Finally, it is assumed that no additional accidents or other roadside incidents occur as a result of traveling close in an increasingly congested environment. The example is intended only as a demonstration that after a point, congestion delay is a non-linear function resulting from linear growth in traffic volumes.

This year marks the 50th anniversary of the interstate system. Much of the construction of that system occurred in the sixties and seventies and the latter quarter of the century was dedicated predominantly to the completion of urban beltways. While the 46,769 mile interstate system makes up about 1.2% of the total highway miles, it carries 23.6% of the vehicle miles traveled[ix]. The interstate system is somewhat analogous to the arteries of the human body. It carries the economic lifeblood of the economic system of the United States. Since 83% of all of the freight value is carried on highway system versus other modes of transportation, the aging of the interstate system is especially significant. Since 1990 Federal reauthorization legislation has assumed that the interstate system has been completed and its construction. Funds for new capital construction on the interstate system have not been made available in recent Federal legislation. The policy assumption appears to be that new highways are not the solution needed to address rising congestion. ***Perhaps it is the political conclusion that new taxes are not an option that has led us to the policy conclusion that new capacity is not the solution.*** Whatever the reason, it seems clear that congestion is occurring at an increasing rate.

If the entire highway network is viewed as a system, it becomes clear that the capacity of the highway network is being exceeded by the volume demand on the entire system. Routing alternatives and diversions become less possible as this occurs and peak periods lengthen. The ability of the entire highway network to absorb additional volume and relieve the arterial highway system of congestion becomes less of an alternative. ***As the entire highway system becomes congested for longer peak periods, the economic impact becomes more prominent and is recognizable to the user and the policymaker alike.***

If the last 40 years of history is any indication of the future, the situation is likely to worsen. Population will continue to rise with vehicle registrations exceeding the rate of population growth and vehicle miles traveled expanding even more quickly. The growth of vehicle miles traveled has continued at a 3% pace and has demonstrated no diminishment. The American Association of State Highway and

Transportation Officials, AASHTO has indicated that if two trillion dollars will be needed over the next twenty years to provide the necessary capacity.

Research reported in NCHRP 463 would tend to indicate that each 2.5% increase in travel time would result in an economic impact of $1.2 billion to just Chicago and Philadelphia. If it is assumed that similar results could be expected for the other major metropolitan areas of the U.S., it is clear that the economic impact of increasing congestion is significant. When this is coupled with considerations outside the urban area, it seems clear that investment and changes in transportation policy are required to avert a crisis in transportation and the economy.

[i] Coyle, John;Bardi, Edward;Novack Robert; Transportation - Fourth Edition; West Publishing Company; 1994, page 5.
[ii] American Society of Civil Engineers, Report Card for America's Infrastructure, 1998, http://www.pubs.asce.org/news/sep5.html.
[iii] Bureau of Transportation Statistics, USDOT, Freight Shipments in America 2004, http://www.bts.gov/publications/freight_shipments_in_america/excel/table_01.xls.
[iv] Federal Highway Administration and Bureau of Transportation Statistics, Washington, DC: United States Department of Transportation, 2003.

[v] Federal Highway Administration, *Highway Statistics*, Washington, DC: U.S Department of Transportation; and International Road Federation, *World Road Statistics 2002*,

Washington, DC: International Road Federation, 2002.

[vi] Transportation Quarterly, Summer 2003, Vol. 57, No. 3, March 20, 2003, John Pucher and John L. Renne.
[vii] Economic Implications of Congestion; Glen Weisbrod, Donald Vary, and George Treyz; National Cooperative Highway Research Program, Report Number 463, Page 42, National Academy Press, Washington D.C., 2001.
[viii] National Transportation Statistics 2003, Bureau of Transportation Statistics, United States Department of Transportation, 1960-2000, Table 1-32, Page 53.
[ix] USDOT, Bureau of Transportation statistics, National Transportation Statistics 2005, December 2005.