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Freight Movement as an Economic Indicator for New Jersey / New York / Connecticut Tri-State Area

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16. Abstract

There is a large body of literature that studies the impact of transportation investment on the economy, mainly in the mid to long term. However, there is a potential to track the performance of the economy, to increase understanding of the short-term relationships among different sectors of the economy, and to forecast the performance of the economy-- particularly its business cycles--through the effective use of monthly transportation-related indicators in addition to other traditionally used economic indicators. Some traffic data, such as vehicle volumes and vehicle miles traveled, can now be measured quite accurately and almost in real time using emerging technologies such as Automatic Vehicle Identification (AVI) and Geographic Positioning Systems (GPS).

Until now freight movements were not included among these economic indicators. Preliminary work suggests that a freight indicator when used with other economic indicators could produce a better understanding of the current and future course of the economy. The movement of a freight index over time can be compared with other economic measures to understand the relationship of transportation to changes in the regional economy. To the extent that an indicator is a leading indicator it foreshadows changes in GDP—that is, when it goes up, GDP tends to go up some time later; when it goes down, GDP tends to eventually drop. Leading indicators are especially useful in forecasting turning points in the economy, and are therefore of particular interest for short-term economic decision-making.

The main purpose of this project is to investigate the relationship between truck movements and the economic performance of New Jersey, thereby, to test whether truck movements on the I-95 Corridor (NJ Turnpike) are a leading indicator of changes in the performance of the New Jersey economy.

The models produced in this study are promising in terms of developing a useful prediction methodology for the economic activity in New Jersey. This study showed that truck data collected by NJTA can be used for various important objectives such as the one studied in this project. The results of this study may also be used to inform the NJ state forecasting model (R/ECON) maintained at Rutger's Center for Urban Policy Research. However, more research and development are needed to further operationalize the models proposed in this study.

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Freight Movement as an Economic Indicator for New Jersey

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Final Report

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from the United States Bureau of Labor Statistics (BLS). The focus of this study as far as the use of freight (truck) data is concerned is the NJ Turnpike.

A number of regressions were estimated using the above data. They show that there is a strong positive relationship between truck traffic, employment, and expansions in the Turnpike, and a strong negative relationship between truck volume and tolls on the large trucks. This study showed that truck data collected by NJTA can be used for various important objectives such as the one studied in this project. The results of this study may be used to inform the NJ state forecasting model (R/ECON) maintained at Rutgers's Center for Urban Policy Research. They may also be incorporated into an article produced at the Bloustein School each month that appears in NJBiz.

1. INTRODUCTION

The economy is susceptible to fluctuations as conditions change over time. Economists, forecasters, and others frequently use monthly economic measures to track the performance of the economy to understand the short-term relationships among different sectors of the economy, and to forecast the performance of the economy, particularly business cycles. To do this they use measures called "indicators," such as employment, manufacturing production, sales, business inventories, and consumer confidence, among other things. In addition to giving information that is valuable in its own right, the indicators often have a relationship to the growth of the economy, measured by Gross Domestic Product (GDP) for the nation, or Gross State Product (GSP) for a state.

Understanding the policy implications of the link between transportation investment and economic development is of great importance. Much still needs to be understood about "*the various interactions of the two in order for the policy makers to make the right decisions about transportation investments in terms of not only the most efficient use of funds, but also land use and air quality, to name a few*" (Eberts, 2000). Elaborating further on transportation investment, policy implications can also derive from the nature of the transportation facilities and network and their roles in serving the drivers of the local or regional economy. It is from this perspective that the unique elements of this research afford a great opportunity to understand such interactions. Having the rich history of data on a true 'freight facility' in the nation can provide great insight, and allows for a careful tracking of the observed trends reported in this study. The participation and support of the New Jersey Turnpike Authority was instrumental in capturing the data that are newly and artfully described in this research study.

Many previous studies have identified causality relationships between transportation investment and economic development (e.g. Aschauer, 1991; Forkenbrock and Foster, 1990; Babcock et al., 1997; Ozbay et al., 2003; Ozbay et al., 2006). As mentioned in a study by Eberts (1990) that summarized the previous work at that time and provided an overall assessment of the relationship between public infrastructure and regional growth, *"…common to all of these classifications of public infrastructure are two characteristics that distinguish them from other types of investment. First, public infrastructure provides the basic foundation for economic activity. Second, it generates positive spillovers: that is, its social benefits far exceed what any individual would be willing to pay for its services."* The issue of spillover effects had been studied for quite a long time, though at very aggregate geographic levels (state, mostly). However, the lagged variable effect has not received much attention, despite being a crucial piece of the puzzle. In fact, Munnell (1992) stated the need for the use of lagged growth variables in the models. On the issue of the geographical level of analysis, Eberts (1999) stated that "… *studies at the sub-national level have not focused on specific regions when estimating the relation between transportation investment and the economy. Most studies have used specific state or metropolitan information as one of several observations to estimate the models, but these estimates per se do not provide insight into the effect of transportation investment within specific regions*."

There is a large body of literature that studies the impact of transportation investment on the economy, mainly in the mid to long term. However, there is a potential to track the performance of the economy, to increase understanding of the short-term relationships among different sectors of the economy, and to forecast the performance of the economy-- particularly its business cycles--through the effective use of monthly transportation-related indicators in addition to other traditionally used economic indicators. Some traffic data, such as vehicle volumes and vehicle miles traveled, can now be measured quite accurately and almost in real time using emerging technologies such as Automatic Vehicle Identification (AVI) and Geographic Positioning Systems (GPS).

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2. LITERATURE REVIEW

There are several past studies that aim to evaluate the use of freight as an economic indicator. The 1989 study by Layton and Moore titled, “Leading Indicators for the Service Sector”, evaluates particular indicators for the service sector of the economy. Another study conducted by Lahiri and Yao (2003) “attempts to explain the development of a monthly index to represent the economic activity of the transportation sector in the nation”. Transportation in this study was therefore studied alongside business cycles over time.

Another study conducted by Han and Fang (2000) proposed “four factors to measure transportation’s economic importance. These four measures include the transportation industry’s gross domestic product (GDP), transportation final demand, transportation-related GDP, and transportation-driven GDP. The study shows that the ways the transportation sector is evaluated in not always consistent. Certain measures fail to include a comprehensive view of transportation. While some may focus on transportation services, others take into account additional sectors that should be included in transportation GDP. Such as industries include those that manufacture materials utilized in providing transportation (i.e. materials used to make transport vehicles). A study conducted by Yuskavage (2001) for the Bureau of Economic Analysis (BEA), focuses on the difficulty in obtaining source data for measuring the transportation industry’s output. He explains that differences in the source data lead to large measurement disparities in levels and growth rates of transportation activity. The limitations of the data lead to measurement differences in evaluating the growth or outcomes of the transportation sector.

3. MOTIVATION

The main purpose of this project is to investigate the relationship between truck movements and the economic performance of New Jersey, thereby, to test whether truck movements on the I-95 Corridor (NJ Turnpike) are a leading indicator of changes in the performance of the New Jersey economy. The two phases envisioned to this project are:

1. **Phase 1:** Obtain truck data for a relatively long time period--1970 to 2005-- for the NJ Turnpike and estimate state econometric models to assess whether truck volumes can be used as an economic indicator.
2. **Phase 2:** Incorporate estimated models into an existing econometric model of New Jersey residing with Rutgers Economic Advisory Service. The Rutgers Economic Advisory Service(R/ECON^{TM}) produces economic analyses, forecasts, and impact assessments for a variety of clients in New Jersey and the rest of the US.[5]

This study will focus on the first phase of the project with the goal of moving to the next phase upon the completion of Phase 1 if additional funding is available to the research Team.

[5] R/ECON^{TM} is a service of Rutgers University's Center for Urban Policy Research. It produces economic analyses, forecasts, and impact assessments for a variety of clients in New Jersey and the rest of the US. The R/ECON econometric model of the state of New Jersey is used to produce state forecasts four times a year. The service makes 2 short-term (10 year) forecasts and 2 long-term (20 year) forecast each year. The forecasting service has been in existence since 1992.

4. RESEARCH METHODOLOGY OF PHASE 1

Figure 1 shows overall research methodology adopted in this project.

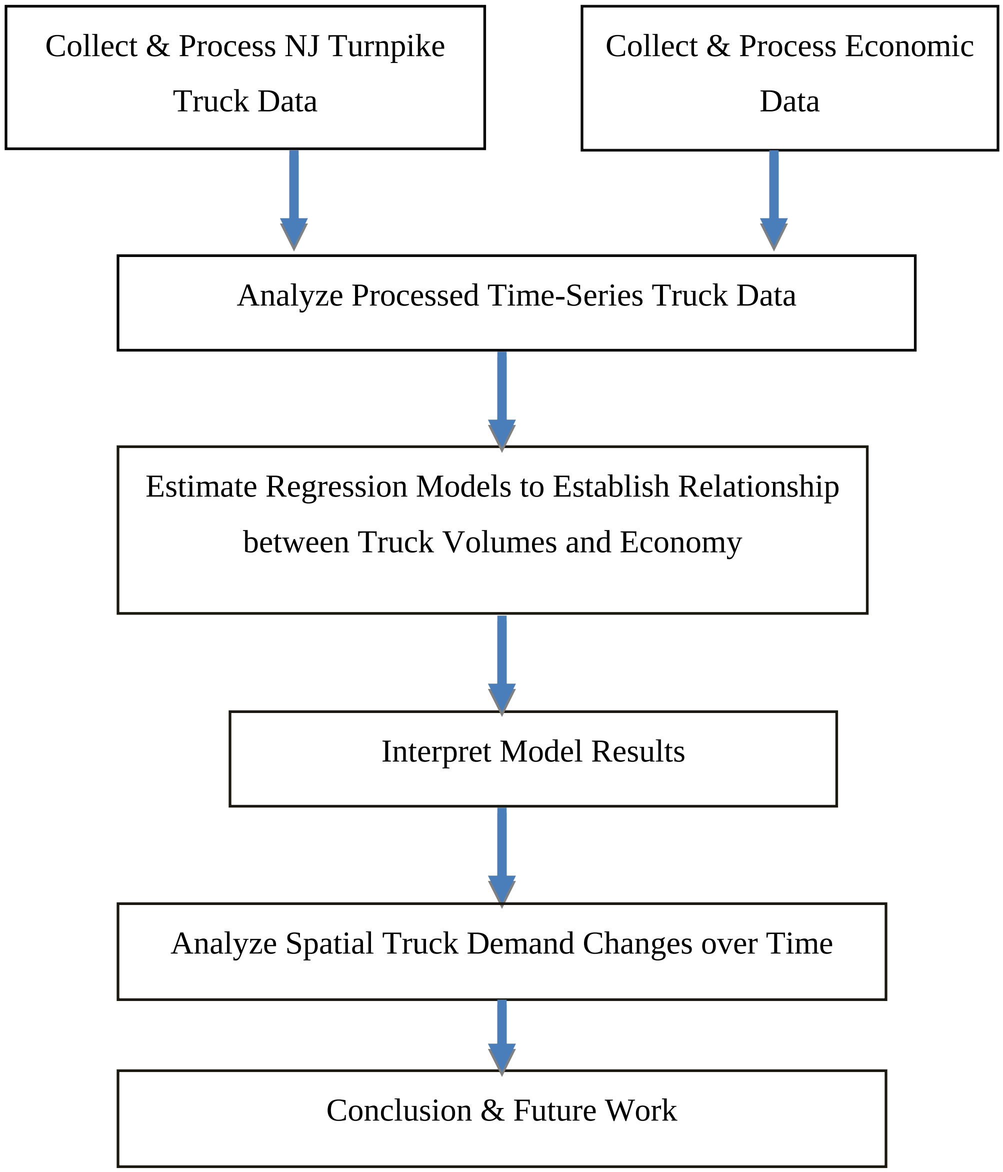


Figure 1: Research Methodology

This project developed a set of regression equations to test whether a correlation with a lag effect exists between truck movements on the NJ Turnpike and various economic time series data.

The Phase 1 research work is divided into two parts. The first part examines the feasibility of the project. It investigates the relationship between truck movements on the NJ Turnpike and the performance of the New Jersey economy. For this project we chose to use total non-agricultural employment (TNEMNJ) as the indicator of economic activity in New Jersey for several reasons. TNEMNJ is available on a monthly basis in a timely manner. It is published about 3 weeks after the end of each month – that is, the data for June is available by July 20. It is produced by the New Jersey Department of Labor (NJDOL). It is available for a long period of time, covering several business cycles, and is easily accessible on the internet from the NJDOL web site.

Other variables which might be used to measure economic activity are less suitable. For instance, the unemployment rate is available monthly at the same time and from the same source. However, the sample on which it is based is small and it tends to bounce around. Furthermore it can be considered to be a lagging indicator. Another variable to use might be personal income. However, it is available at the state level only on a quarterly basis and comes out with a lag of 1 to 2 quarters, thus reducing its usefulness as a measure of current activity.

The Phase 2, which is not included in the original scope of this project, includes an examination of truck movements along the I-95. It investigates the relationship between truck movements on the I-95 Corridor and the performance of the Downstate New York City and New Jersey economies. However due to the time and budget limitations of the current project, the focus is on the first part.

When considering truck flows as an economic indicator, it is important to consider for the distribution of truck movements over the entire NJ transportation network. When physical, policy, or pricing changes occur in the transportation network they can be very important, in particular, for long-term modeling. For example, if highway capacity is added or a freight railroad is constructed, trucks or goods movements that would normally use the NJ Turnpike might shift to the alternative highway or freight railroad. Thus, in the long run, there might be a decrease in the number of trucks using the NJ Turnpike. This possible decrease in truck traffic on the NJ Turnpike would be a consequence of the network-wide route choice behavior of truckers and not a result of changes in underlying economic conditions. On the other hand, policy changes that impose restrictions on the use of local roads by trucks may increase the amount of truck movement on the NJ Turnpike. This increase in truck traffic would also be independent of changes in economic conditions. Thus, in investigating the relationship between truck movements and the economic performance of the New York/New Jersey region, an enhanced econometric model should try to account for both infrastructure and policy changes in the transportation network as well as on the NJ Turnpike itself. However, Phase 1 of the project exclusively focuses on the NJ Turnpike data leaving out the rest of the NJ network as a possible future enhancement. Moreover, type of accurate and detailed historical truck data used for the NJ Turnpike is not readily available for the rest of NJ network and relatively larger research effort than this project is needed to obtain similar data for the complete NJ network.

5. DATA DESCRIPTION

Research was conducted through data analysis of truck volume information from the New Jersey Turnpike Authority as well as economic data received from the United States Bureau of Labor Statistics (BLS). The focus of this study as far as the use of freight (truck) data is concerned is the NJ Turnpike which is a 148 mile-toll road extending from the Delaware Memorial Bridge in the South of New Jersey to George Washington Bridge in New York City. A schematic of the NJ Turnpike and the surrounding transportation network is shown in Figure 2.

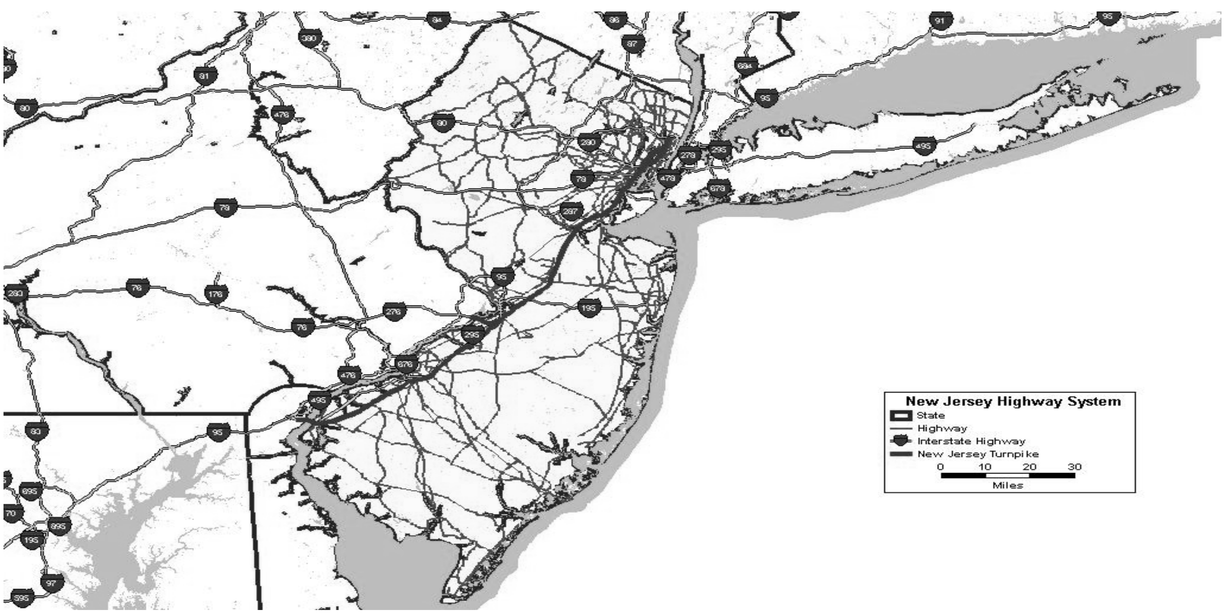


Figure 2: Map of NJ Turnpike

Since its completion in 1952, NJ Turnpike has played a key role in facilitating the economic development of the State of New Jersey, and the entire mid-Atlantic region.

Currently, the road has 28 interchanges, commonly referred to as exits, with an average daily traffic that exceeds 700,000 vehicles. To minimize queuing delays, NJ turnpike was designed to have a minimal number of toll plazas over its 148 miles and the toll plazas were located at the Turnpike's exits. The interchanges connect to New Jersey's major highways, its vast transportation network, its institutions, and its economic hubs. Table 1 shows a brief history of the New Jersey Turnpike. This information is important because as it will be observed from the data later in this paper, major changes in terms of geometry, policy and tolls all affected the NJ Turnpike's traffic volumes at different levels.

Table 1: Brief History of New Jersey Turnpike (New Jersey Turnpike - Historic Overview. Available online at **http://www.nycroads.com/roads/nj-turnpike/**. Accessed on Feb 18, 2008)

DATE	EVENT
1952	Opened to traffic (2-lanes each direction)
1955	83-miles expansion project started: • EXIT 4 in Mount Laurel Township to EXIT 10 in Edison Township: six lanes (three in each direction) • EXIT 10 to EXIT 14 in Newark: eight-lane, dual-dual configuration (2-2-2-2, two express lanes and two local lanes in each direction)
1956	The Newark Bay Extension was opened and is a part of **Interstate 78**. It connects **Newark** with **Lower Manhattan** via the **Holland Tunnel** in **Jersey City** and intersects the mainline near **Newark Liberty International Airport**. This extension contains three exits (Exits 14A, 14B, and 14C) and due to its design (four lanes with a shoulderless **Jersey barrier** divider), it has a 50 **mph** (80 **km/h**) speed limit.
1956	Pennsylvania Extension: Connected the New Jersey Turnpike and Pennsylvania Turnpike between interchanges 5 and 7. This portion of the Turnpike was recently renamed the Pearl Harbor Memorial Turnpike Extension.
1964	A 4-mile-link opened to connect the George Washington Bridge approach in Fort Lee with Interstate 80 (Bergen-Passaic Expressway) in Teaneck. The 10-lane section, which is signed exclusively as I-95, is comprised of local and express lanes in a 3-2-2-3 configuration.
1966	The second widening project began between EXIT 10 and EXIT 14: This project provided the turnpike's "dual-dual" roadway system in which passenger cars used the inner roadways, while the outer roadways were open to all vehicles. The widening project brought the number of traffic from 8- lanes to 12- lanes.
1970	Congestion near the turnpike's northern terminus prompted the Turnpike Authority to construct a "western spur," a 12-mile section that branches off the turnpike mainline in Newark and reconnects to it in Ridgefield Park. The "western spur," carries through traffic between the George Washington Bridge and points south, and accommodates traffic bound for the Meadowlands Sports Complex. The original mainline, now known as the "eastern spur," primarily carries traffic bound for the Lincoln Tunnel. Both "spurs" post signs for I-95.
1971	The New Jersey Department of Transportation (NJDOT) opened a 1-mile-long I-95 link that connected the New Jersey Turnpike with the I-80 / I-95 interchange in Teaneck. The NJDOT constructed a modified "directional-T" interchange with separate ramps to the local and express lanes on I-80 and I-95.
Mid 1970s	New growth along the turnpike corridor prompted construction of new interchanges. 2 new interchanges - EXIT 7A (I-195) and EXIT 8A (NJ 32) - opened to traffic.
1973	The dual-dual system was extended south to EXIT 9 in East Brunswick, where the turnpike was widened from 6-lanes to 12-lanes.
1982	EXIT 13A (NJ 81 Freeway) opened to serve Newark Airport and Elizabeth Seaport.

1990	The dual-dual system was extended to EXIT 8A in Monroe Township, where the turnpike was widened from 6-lanes to 10-lanes.
1990	The New Jersey Turnpike Authority reconstructed EXIT 7 (US 206) in Bordentown to accommodate the growing number of trucks using nearby I-295. It did replace five toll lanes with 12 new ones in a new toll plaza about one-half mile north of the existing plaza. New ramps and bridge were constructed between the turnpike and the relocated plaza.
1992	The NJDOT transferred jurisdiction over both I-95 sections to the New Jersey Turnpike Authority.
1996	The New Jersey Turnpike was widened once again, this time from 12-lanes to 14-lanes, between EXIT 11 and EXIT 14. An additional lane provided to the outer roadways between these exits is reserved for HOV use during peak hours. The HOV lanes are open to all vehicles in non-peak hours.
1997	Improvements were made on a 1.5-mile stretch between EXIT 14 and EXIT 15E in Newark. This stretch, known as the "mixing bowl" because of the many converging and diverging roadways (i.e., entrance and exit ramps, splits for the inner and outer roadways), experienced high accident rates over the years.
2000	The New Jersey Turnpike Authority implemented one of the first variable toll systems in the nation at all of the turnpike's toll plazas. The new EZ-Pass system uses variable demand pricing so that motorists using the turnpike during non-peak hours may do so at reduced rates.
2003	The New Jersey Turnpike Authority assumed control of the maintenance and operations of the 172.5-mile-long Garden State Parkway from the former New Jersey Highway Authority.
2004	The Turnpike Authority completed the new EXIT 1 toll plaza in Carneys Point Township. The new 23-lane toll plaza, which provides 4 high-speed EZ-Pass lanes (two in each direction), was built approximately 1.2 miles north of the old 15-lane toll plaza, which had not been altered since the turnpike opened.
2004	In January 2004, the New Jersey Turnpike authority opened new high-speed EZ-Pass lanes at EXIT 18W, at the northern terminus of the western spur. The high-speed EZ-Pass lanes allow motorists to go through the toll plaza at 45 MPH instead of the current 15 MPH.
2005	The Turnpike Authority opened EXIT 15X on the Eastern Spur (just south of EXIT 16E) on December 1, 2005. The new interchange serves the new Secaucus Junction rail transfer station.
2006	In May 2006, hybrid vehicles were permitted to use the HOV lanes during peak periods
2006	In February 2006, the Authority updated Exit 8A in **Monroe Township**. The former exit ramp that allowed traffic onto **Route 32** westbound, has been closed off. Instead, a new ramp leads to a traffic light at the intersection of the ramp and **County Route 535** in **South Brunswick Township**. Route 535 was expanded between the new ramp intersection and Route 32.

As shown in Table 2, since 1952 the NJ Turnpike has experienced several toll structure change. Based on information received from NJTA (2003), from the toll increase in 1991 until September 2000, a single toll value was charged for each type of vehicle, regardless of time-of-day. After September 2000, several operational changes have occurred potentially impacting on the use of the facility. These changes include:

1. Inaugurated in September 2000, E-ZPass technology (a form of electronic toll collection system) was introduced to the facility
2. In September 2000, NJTA implemented the first stage of time-of-day pricing and increased the toll levels for cash users and peak E-Z Pass users. E-Z Pass off-peak users continued to pay the same toll amounts as in 1991. As part of this program, different toll levels were charged to users depending on time-of-day and vehicle type: E-Z Pass users started to pay discounted tolls during off-peak hours. Peak hour tolls were made effective on weekdays from 7:00 to 9:00 a.m. and from 4:30 to 6:30 p.m.; on weekends, peak-hour tolls are effective throughout the day.
3. In January 2003, toll levels for each time period and vehicle type were increased in the second stage of the NJ Turnpike time-of-day pricing program. In January 2006, discounts for E-Z Pass peak users were eliminated, and E-ZPass peak users started to pay the same amount of toll as cash users.

Currently, the price differentiation in NJ Turnpike is employed based on (NJTA, 2006):

1. Use of Facility: The distance traveled between entrance and exit pairs (the longer the distance the higher the toll level)

2. Vehicle Classification: The amount of toll is based on number of axles, vehicle type, and tare weight (2 classes for busses, 5 classes for trucks, and 1 class for passenger cars)
3. Time-of-day: Toll discounts during off-peak hours (only passenger cars with E-ZPass tag are eligible for toll discounts)
4. E-Z Pass Availability: Toll discounts only for E-ZPass users traveling during off-peak hours.

Thus NJ Turnpike time-of-day pricing program consists of two broad classes of users; those who are eligible for time-of-day pricing toll discount and those who are not.

The percent increase in the toll amount and the resulting toll amounts for the toll structure as part of these structural changes are shown in Table 2.The percentage values in Table 2 represent the percent of increase in the toll amount, and the values in the parenthesis represent the resulting toll amount between entry-exit pairs (1-18W), the highest toll amount.

Table 2: History of Tolls for the NJ Turnpike (1951-2005)

Toll			Passenger Cars						Tractor Trailers			
	1951[1]	**1974[2,3,4]**	**1991**	**Sept. 2000**	**Jan. 2003**	**Jan. 2006**	**1951[1]**	**1974[2,3,4]**	**1991**	**Sep. 2000**	**Jan. 2003**	**Jan. 2006**
Cash all day	($2.00)	37% ($2.70)	70 % ($4.60)	20% ($5.50)	17% ($6.45)	0% ($6.45)	($6.60)	37% ($9.10)	100 % ($18.20)	13% ($20.55)	13% ($23.20)	0% ($23.20)
E-ZPass peak	-		-	8% ($4.95)	10% ($5.45)	18% ($6.45)	-		-	8% ($19.65)	8% ($21.20)	10% ($23.20)
E-ZPass off peak	-		-	0% ($4.60)	5 % (%4.85)	5 % (%4.85)	-		-	8% ($19.65)	8% ($21.20)	0% ($21.20)
E-ZPass (weekend)	-		-	8% ($4.95)	10 % ($5.45)	18 % ($6.45)	-		-	8 % ($19.65)	8 % ($21.20)	10 % ($23.20)

5.1 Data Processing

NJ Turnpike keeps track of its traffic data in terms of types of vehicles, entry and exit points along with the entry and exit times, and tolls paid. Vehicles are classified into eight distinct categories as follows (http://www.state.nj.us/turnpike/nj-vcenter-classes.htm):

1. Class 1: 2 axle passenger cars
2. Classes 2 to 6: 2 to 6 axle trucks
3. Classes B2 and B3: 2 to 3 axle buses

For the period after 2003, this dataset is available in electronic format. However, detailed NJ Turnpike traffic volume dataset was not available in electronic format for the period before 2003. Thus, hard copies of traffic data on the New Jersey Turnpike from 1970 to 2003 were obtained and entered into an Microsoft Excel spreadsheet. Subsequently, the monthly traffic volumes for each year were compiled for analysis.

Statewide monthly data for total non-agricultural employment from 1970 to 2005 were obtained from the NJDOL. Employment data for several industrial sectors were obtained from the NJDOL for the period 1990 to 2005. Data for earlier years could not be used because of the lack of compatibility of industry data under to old U.S. Standard Industrial Classification (SIC) and new North American Industry Classification System (NAICS) industry definitions.

Employment data for the following sectors (based on NAICS definitions) were included in this study:

1. Agriculture
2. Mining
3. Construction
4. Manufacturing
5. Transportation
6. Information
7. Utilities
8. Wholesale trade
9. Retail trade
10. Finance, Insurance, and Real Estate
11. Services
12. Public Administration

As aforementioned, employment data for years 1970-1989 were difficult to determine on a monthly or yearly level. With annual averages provided for by the NJ Department of Labor and Workforce Development, only 1980, 1985, and 1989 annual employment data by industrial sector was provided. 2005 data were not included in the study because only partial data has been published for both 2005 employment and New Jersey Turnpike truck volumes. Annual average numbers of employees for each of the sectors aforementioned were compared with truck volumes for the years provided above.

6. ANALYSIS OF THE RELATIONSHIP BETWEEN TRUCK VOLUMES AND ECONOMY

Before going to the regression analysis we tried to get some understanding of the possible relationship between trucking and the economy first from a visual comparison of the data and then from a correlation analysis.

Figure 3 shows monthly employment and truck volume. Visually it seems that the two series are closely related; however there is a lot of noise in the data which appears to reflect seasonality. Figure 4 shows the same two data series adjusted for seasonality. The series are considerably smoother and still reflect the same general patterns. That is, turning points in truck volume on the turnpike appear to occur slightly before turning points in employment. However, the relationship seems to break down in the early 1980s when truck volume fell sharply and then barely changed for about 3 years while employment continued to grow weakly, and again in the early part of this century when truck volume rose rapidly but employment was relatively static.

Figure 3: Time Dependent Change in NJ Turnpike Truck Volumes and NJ Employment

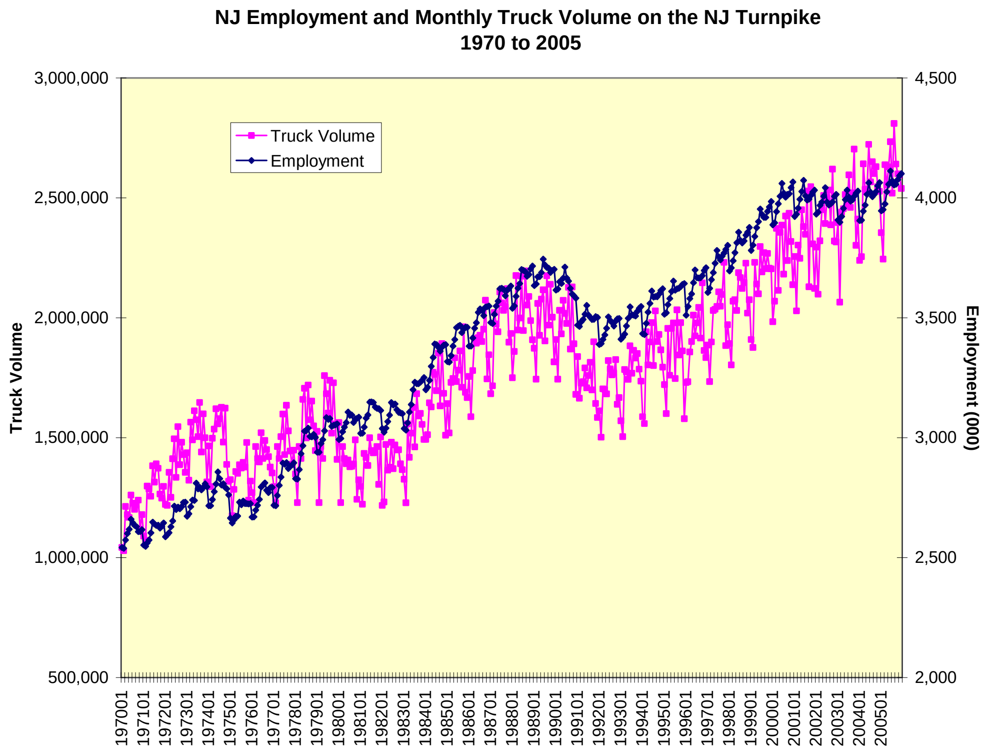
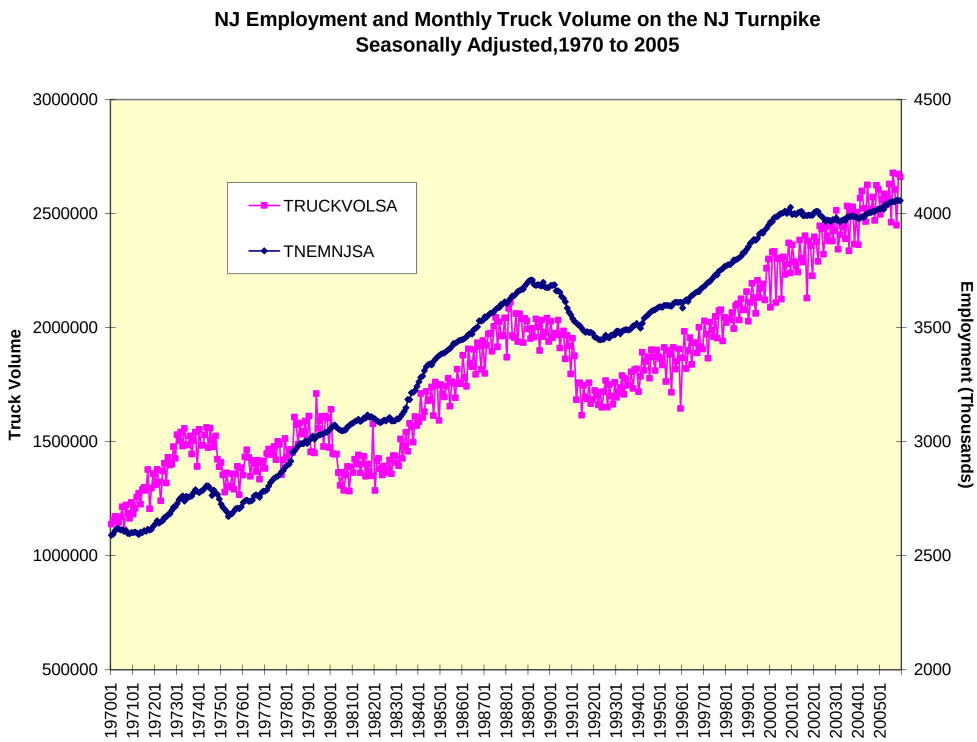


Figure 4: Seasonally Time Dependent Change in NJ Turnpike Truck Volumes and NJ Employment



The initial statistical analysis consisted of correlating TNEMNJ in the current month with Turnpike truck volume (TRUCKVOL) in the current month and in several previous months. The full set of data is for the period from January 1970 to December 2005. Correlations were calculated for the period from 1971 to 2005 as well as for several sub-periods. The correlations were calculated using employment and truck volume both seasonally adjusted and not seasonally adjusted.

Table 1 shows the results of the correlations for the period from 1971 to 2005 and for the several sub-periods using monthly data for the non-seasonally adjusted and seasonally adjusted data.

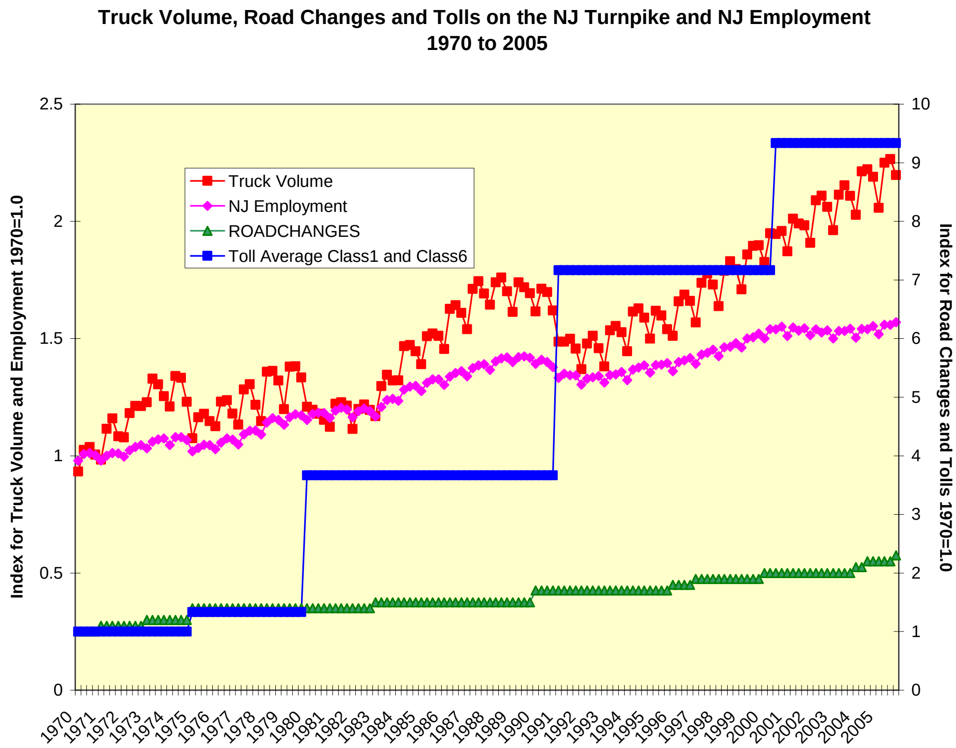
The correlations indicate that there is a strong relationship between employment and Turnpike truck volume except in the period beginning in 2000. The problem period is specifically 2001 to 2003 when the correlations turn negative. The correlations also indicate that, again except for the period beginning 2000, the relationships are stronger between the seasonally adjusted series than between the non-seasonally adjusted series.

In all the time periods the correlations indicate that the truck volume to employment relationship is strongest with a one month lag between not seasonally adjusted truck volume and employment. That is, for instance, an increase in truck volume in June should indicate an improving economy—as measured by employment—in July. Most of the correlations on the seasonally adjusted data also indicate that the strongest relationship is with a one month lag. However, for the full period (1971 to 2005) the correlation is the same for the current month back as far as a four month lag, while for the period from 1990 to 2005 the correlation is at a high for both the current and previous month.

The very strong relationship between truck volume and employment appears to break down during the period from 2000 to 2003. Whether this is because of the recession, the impact of 9/11 on the economy, the impact of the most recent change in truck tolls, changes in the structure of the economy, or some combination of these possibilities is not clear.

Regression analysis was used to try to understand better the interactions of the economy, toll changes, and road changes on Turnpike truck traffic. Figure 5 shows the change in the variables over time.

Figure 5: Seasonally Time Dependent Change in NJ Turnpike Truck Volumes, Road Changes and Toll on the NJ Turnpike and NJ Employment



The regressions use monthly data for 1971 to 2005. A typical regression equation is of the following general form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots + \beta_i X_i \qquad (1)$$

where

$Y =$ Dependent variable

$\beta_0 =$ Constant

$X_i =$ Independent variable "i"

$\beta_i =$ Respective parameter of independent variable "i"

The regressions shown below are the best fit final forms using the monthly data for raw and seasonally adjusted truck volume and employment. Definitions of the variables used in our models are as follows:

Dependent Variables:

TRUCKVOL Total number of trucks in month "i" on the NJ Turnpike or

TRUCKVOLSA: Seasonally adjusted total number of trucks in month "i" on the NJ Turnpike

Independent Variables:

TRUCKVOL\12: Average truck volumes in month "i - 12" on the NJ Turnpike or

TRUCKVOLSA\12: Average seasonally adjusted truck volumes in month "i - 12" on the NJ Turnpike

$TNEMNJ_i$: Total number of jobs in month "i" in NJ or

TNEMNJSA: Seasonally adjusted total number of jobs in month "i" in NJ

$ROADCHANGES_i$: Variable that shows the existence of a major road change in month "i" on the NJ Turnpike

TOLL6: Tolls on Class 6 trucks on the NJ Turnpike

Figure 3 shows the path of truck traffic, employment, road changes, and tolls over time.

Table 3: Regression Model-1 for the period from 1971 to 2005

MONTHLY (1971:1 TO 2005:12) 420 OBSERVATIONS			
	COEFFICIENT	**STD. ERROR**	**T-STAT**
DEPENDENT VARIABLE: TRUCKVOL			
INDEPENDENT VARIABLES			
CONSTANT	-680194	7.943E+04	-8.563
TRUCKVOL\12	0.674783	0.03307	20.41
TNEMNJ	330.154	35.73	9.241
ROADCHANGES	195819	5.295E+04	3.698
TOLL6	-19908.3	3026	-6.578
R-BAR SQUARED: 0.9325			
DURBIN-WATSON STATISTIC: 1.1972			
STANDARD ERROR OF THE REGRESSION: 9.993E+04 **NORMALIZED:** 0.05527			

Table 4: Second Model-2 for the period from 1971 to 2005

MONTHLY (1971:1 TO 2005:12) 420 OBSERVATIONS			
	COEFFICIENT	**STD. ERROR**	**T-STAT**
DEPENDENT VARIABLE: TRUCKVOLSA			
INDEPENDENT VARIABLES			
CONSTANT	502462	8.097E+04	-6.206
TRUCKVOL\1	0.649229	0.03812	17.03
TNEMNJSA	251.096	37.51	6.694
ROADCHANGES	237217	4.938E+04	4.804
TOLL6	-13527.8	2882	-4.694
R-BAR SQUARED: 0.9457			
DURBIN-WATSON STATISTIC: 2.6300			
STANDARD ERROR OF THE REGRESSION: 8.627E+04 NORMALIZED: 0.04772			

Regression Model-1 shown in Table 1 uses not seasonally adjusted employment and truck volume data. It indicates that over the period from 1971 to 2005 truck volume has a strong positive relationship to employment and physical changes in the turnpike. It also has a strong negative relationship to increases in tolls on Class 6 trucks. A regression using the average of tolls on Class 1 and Class 6 trucks has similar, but weaker, results.

Regression Model-2 shown in Table 2 uses seasonally adjusted employment and truck volume data. The second regression has slightly better regression statistics but is otherwise quite similar to the regression using the raw data. The lesson from the correlations and regressions is reasonably clear. That is, the direction of truck volume on the Turnpike has been a relatively good indicator of the direction of the economy, with the caveat that changes in the physical road must be taken into account, as must changes in tolls.

The regressions show that there is a strong positive relationship between truck traffic, employment, and expansions in the Turnpike, and a strong negative relationship between truck volume and tolls on the large trucks.

7. DISCUSSIONS AND MAJOR FINDINGS

As seen in Figures 3 and 4, a strong relationship between "Truck Volumes" and "NJ Employment" can be visually depicted. The only exception to this parallel trend appears to be around 1991 where an increase in tolls is observed. However, after a few years the trend appears to return with truck volumes increasing constantly.

This visual observation was also confirmed with the estimation results obtained from linear regression models. Some of the estimated models are quite promising. A statistically significant relationship between freight traffic on the NJ Turnpike and the State economy is shown to exist. However, the strength of this statistical relationship is observed to change over time as follows:

1. Stronger from 1971 to 2000 and 2004 to 2005
2. Weaker from 2001 to 2003

There are also some important caveats that need to be taken into account when interpreting our results.

1. We are only relating a single yet very significant transportation facility to changes in the State's economy
2. NJ Turnpike has its own dynamics that affect its freight demand such as:
    a) Changes in tolls
    b) Changes in delays
    c) Changes in facility characteristics

8. INTERCHANGE PATTERNS

Another set of information which, may have some suggestive power is the distribution of truck traffic on the Turnpike. We have collected data for the entry and exit interchanges used by trucks on the Turnpike for 1975 and 2005. Some interesting patterns are revealed by the data as shown inTable 5. The total number of truck trips on the Turnpike increased by 92 percent between 1975 and 2005, going from 16.1 million to 30.9 million. Over that period two new interchanges were added to the system—13A and 15X. Those two interchanges accounted for 2 million trips in 2005, or 6.5 percent of the traffic, in 2005. Even without the traffic traveling to those 2 interchanges truck traffic on the Turnpike increased by 80 percent between 1975 and 2005.

The distribution of truck traffic entries and exits on the Turnpike changed considerably over the same period. Most interchanges gained traffic. However, a few, including Interchanges 14C, 17N, and 17S, lost considerable amounts of traffic. These 3 interchanges, all on the Turnpike's eastern spur, go to the Holland Tunnel by way of Jersey City (14C) and to the Lincoln Tunnel (Exits 17S and 17N).

Table 5: Change in Truck Exit / Entry Volumes

Truck Traffic on NJ Turnpike
Total of Entrances and Exits by Interchange
1975 and 2005, in Thousands

	1975	2005	1975 to 2005		% of Total Traffic	
INTERCHANGE			**Change**	**%Change**	**1975**	**2005**
Total Traffic	32,130	61,747	29,583	92%	100%	100%
Southern NJ						
1	1,144	3,154	2,010	176%	4%	5%
2	78	347	270	346%	0%	1%
3	185	635	450	244%	1%	1%
4	562	973	411	73%	2%	2%
5	147	405	258	175%	0%	1%
6	700	2,293	1,593	228%	2%	4%
6A	167	504	337	202%	1%	1%
7	1,267	1,589	322	25%	4%	3%
Central NJ						
7A	227	1,901	1,674	739%	1%	3%
8	303	522	220	73%	1%	1%
8A	270	2,064	1,794	666%	1%	3%
9	1,078	1,898	820	76%	3%	3%
10	1,890	4,561	2,671	141%	6%	7%
11	1,405	2,097	692	49%	4%	3%
12	987	2,120	1,133	115%	3%	3%
Northern NJ						
13	2,552	3,445	893	35%	8%	6%
13A	0	3,277				5%
14*	3,206	4,937	5,008	156%	10%	8%
14A	1,303	1,773	470	36%	4%	3%
14B	350	568	218	62%	1%	1%
14C	1,425	869	-555	-39%	4%	1%
15E	1,999	3,410	1,411	71%	6%	6%
15W	889	2,451	1,562	176%	3%	4%
15X	0	34				
16E	2,246	2,624	378	17%	7%	4%
16W	1,413	2,884	1,471	104%	4%	5%
17N	969	818	-151	-16%	3%	1%
17S	1,015	818	-197	-19%	3%	1%
18E	1,137	2,050	913	80%	4%	3%
18W	3,218	6,725	3,506	109%	10%	11%

***Change in traffic at Interchange 14 includes traffic at 13A.**

Overall, traffic at the interchanges in northern New Jersey (13 to 18W) increased by about 69 percent, while that in central New Jersey (7A to 12) increased by about 150 percent (137 percent for entrances and 156 percent for exits), and traffic increased by about 132 percent (144 percent for entrances and 122 percent for exits) in southern New Jersey (1 to 7).

Thus, the proportion of traffic originating and exiting in the north declined by about 8 percent, while that in the center of the state increased about 5 percent and that in the south increased by about 3 percent. This essentially mimics the economic behavior of the state, with the north becoming a smaller part of the state's economy while the center and south have become larger parts. Between 1990 and 2005 northern New Jersey declined from 52 percent to 49 percent of employment, while southern New Jersey increased its job share from 19 percent to 20 percent, and central New Jersey increased its job share from 28 percent to 31 percent.

Looking at individual interchanges, by far the largest percentage traffic increases were in central New Jersey at interchanges 7A and 8A—the warehouse center of the state. Truck traffic at the larger warehouse area, from Interchange 6 to Interchange 8A, increased from about 1.5 million trucks in 1975 to about 4.4 million in 2005, an increase of about 2.9 million trucks, or 200 percent. That area now accounts for about 15 percent of all truck traffic on the Turnpike, up from 9 percent in 1975. The largest numeric increase was at interchanges 13A and 14 taken together—that is at Newark Liberty International

Airport and Port Newark-Elizabeth. Thus the addition of interchange 13A allowed an increase in traffic at the Port/Airport of 2.4 million trucks in 2005 compared to 1975, translating into ease of use at the facilities and a major increase in toll revenue to the NJTA. Other large traffic increases were at interchange 18W—from the George Washington Bridge and towards Interstate 80 and west; at interchange 10 into and out of the fast growing Edison area; and at interchange 1 from Delaware.

9. CONCLUSION AND FUTURE WORK

The models produced in this study are promising in terms of developing a useful prediction methodology for the economic activity in New Jersey. This study showed that truck data collected by NJTA can be used for various important objectives such as the one studied in this project. The results of this study may be used to inform the NJ state forecasting model (R/ECON) maintained at Rutger's Center for Urban Policy Research.

They may also be incorporated into an article produced at the Bloustein School each month that appears in NJBiz.

This study effort also provided a first look at specific interchange traffic activity. Taking a look at traffic activity three decades apart, in 1975 and again in 2005, reveals that there have been significant changes in both the amount of traffic and in its distribution along the facility.

Important future work includes:

1. Improve the estimated regression models by adding additional freight data from other facilities in New Jersey.

2. Study the impact of the changes in State's economy using the developed models and the freight data (transition from a manufacturing to a service economy)
3. Conduct a more focused exit by exit analysis coupled with the individual economic and demographic characteristics of areas around each exit
4. Use of Rutgers data processing software to process the transaction data to provide this and other studies with customized data sets.

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