Economic Papers Vol. 27 No. 4 December 2008 pp. 381–392

MEASURING THE EQUITY BURDEN IN PUBLIC SERVICE PROVISION: THE CASE OF NEW JERSEY TOLL ROADS

by

JONATHAN PETERS AND CAMERON GORDON

Economic theory recognises equity dimensions of social welfare as well as efficiency issues. This paper examines three measures of equity—horizontal, vertical and locational—analysing data from the toll collections on the New Jersey Turnpike and Garden State Parkway. Policy implications are provided.

JEL Classification: H22, H23, H27, H41, H71

Key words: Economic equity, Toll roads, Transportation, Transport, US, New Jersey

1 Introduction

The basic research questions addressed in this paper are: (1) How can equity in public services be measured? and (2) How equitable is the provision of particular public services by particular agencies?

We begin to answer these questions by focusing on a case study: an analysis of existing tolls in the US State of New Jersey based upon electronic toll collection data. Through this case study some of the data and methodological issues surrounding the measurement of equity in public services, as well as some policy issues that arise, are illustrated.

Economic theory recognises two major dimensions of social welfare: efficiency and equity. Equity broadly refers to the distribution of resources across different groups and (more subjectively) whether that distribution matches some socially preferred ideal. Technical efficiency implies being on the boundary of a production possibilities frontier and delimits a technically feasible set of outcomes that can be expanded through exchange; it is a necessary but not sufficient condition for a Pareto optimum. If exchange occurs from a technically efficient point and through which a Pareto optimum is reached then allocative efficiency has been achieved. If both allocative efficiency and equity are achieved then a complete social optimum has been reached.

Both efficiency and equity are important when it comes to the provision of public services, such as police protection, garbage collection, schools and, the area examined in this article, transportation. There has been a great deal of study of the technical efficiency of various public services (Fried *et al*., 1993), though less so for allocative efficiency, which is harder to measure (Brueckner, 1982). There is relatively little analysis of whether the provision of existing services is equitable, or even of ‘who gets what’ (Litman, 1996). This statement does not apply, of course, to taxation, where there is a large body of work on ‘burden’ and ‘impact’ (Sørensen, 2004).

Technical and allocative efficiency is a prerequisite to achieving better equity. The more that there is to distribute generally, the more each individual can, potentially, receive. To measure technical efficiency requires input and output data only. But allocative efficiency requires additional data about prices and market conditions, which may not be readily available for public services. To measure equity requires knowledge of both sorts of efficiency and also information about which parties are providing the inputs and which are getting the outputs. This difficulty in measuring equity may explain why there has been relatively little actual measurement of it.

However, equity is often the critical element of many debates about how to allocate public resources. Moreover, while efficiency should clearly be sought before equity in a first-best world, in a second- or even third-best world, there may be cases where efficient sub-optima will in fact be socially inferior to less efficient but more equitable alternatives. Thus equity in public services is, in general, an area of analysis that deserves much more attention than it currently gets.

Roads are an interesting case in this regard. A road can be ‘consumed’ by many people at the same time and has a degree of ‘publicness’ to it. After a certain point, however, congestion sets in and motorists cannot travel as fast or as reliably as they did when there was little or no congestion. Before that point roads are similar to pure private good with complete rivalness and excludability in consumption. Once congestion occurs rivalness suffers as one person’s consumption of the road degrades another’s. Hence roads are a ‘club good’ (Buchanan, 1965).

Because of this, roads will generally have some sort of public policy dimension, even if, as is often the case, the road itself is privately owned and/or operated. Moreover, in cases where roads connect key points and there are few or no feasible alternative routes, there is a situation of natural monopoly. This potential for market failure is also a reason why equity can be a concern in the provision of roads, especially toll-roads.

There are two standard dimensions of equity: horizontal and vertical. Vertical equity is defined as fairness in the treatment of people in differing social position (usually different levels of income or consumption). Horizontal equity is defined as fairness in the treatment of people at the same levels.

A standard measure of equity (or more properly speaking relative equality) is the Lorenz Curve in which the proportion of population is matched against the proportion of a metric of some benefit or cost. A perfectly equal distribution of income across a population would produce a linear Lorenz curve in which the proportion of the population exactly matched the proportion of available income.

With transport facilities and services a metric of such equality would be access or mobility. In this case there might be a Lorenz Curve mapping total travel-time to and from work, or, for more detailed network analyses a network matrix showing relative differences in travel time between specific origins and destinations (Levinson, 2002). Other metrics, such as who bears external environmental costs are also possible, the latter being specially important in the environmental justice literature (Bullard and Johnson, 1997).

Finally, gross equity would be a measure of distribution of some quantity across a population, ignoring distribution of other quantities across that same population. Net equity would account for the distribution of all relevant quantities across a given population. Of course, by a gross measure, a given set of persons might be worse off while the net measure might show them to be better off, as might be the case for distributions of before- and after-tax income.

These concepts refer to actual distribution of resources. But which is the 'right' or 'fair' distribution of resources? Economic theory offers no definite answer to this question (Arrow, 1950). Nonetheless, there is still a need for public policy concerns to make some sort of judgment.

The analysis that follows is a first-order analysis. When speaking of 'burden' we mean 'gross burden' not 'net burden' and the metrics used consist of average toll revenues measured across different population measures. Net advantages, such as bearing a toll but having lower-priced housing as a trade-off, are not considered here. Moreover a benchmark for fairness is not used or defined and consequently judgments about preferred distributions are not made. While crude, the analysis nonetheless does begin the process of measuring equity in toll roads, which is something that has largely not been done thus far.

2 Data and Methods

The New Jersey Turnpike Authority manages both the 148-mile New Jersey Turnpike and the 173-mile Garden State Parkway (though before 2003 a separate Garden State Parkway Authority operated the latter road). The Authority is an independent governmental agency. Most of the tolls on both roads are collected electronically by means of 'E–ZPass', an electronic toll system that collects data and payment each time a user goes through an electronic toll gate. Most drivers use this system.

TABLE 1
DATA COVERAGE

Road	**NJ Turnpike**	**Garden State Parkway**
Gannett Data (Dollars)	$132,412,487	$88,332,576
Total Tolls in 2006 (Dollars)	$533,399,014	$203,879,971
Percentage of Tolls (Dollars)	24.8%	43.3%

A detailed analysis of existing tolls in New Jersey has been conducted using toll-collection data proved by the Gannett New Jersey Organization from the New Jersey Turnpike Authority. The data analysed do not include the relatively small percentage of drivers who pay in cash, most of whom are out-of-state residents who, for obvious reasons, have not invested in the E–ZPass technology. The data-base provides (at a Zip Code level) combined Business and Residential toll-data for the electronic toll collection users on both the New Jersey Turnpike and the Garden State Parkway. These toll accounts for the two roads are classified according to the billing addresses on the accounts. A summary of the dollar value of these accounts is provided in Table 1.

Under a Freedom of Information Act request from Gannett New Jersey, the New Jersey Turnpike Authority, provided E–ZPass toll collection data from the period July 2006 to June 2007. The data were supplied to the authors by Gannett New Jersey and provide information concerning 262,177,285 transactions, representing $220,745,063 in tolls.

The New Jersey Turnpike Authority data are provided for 704 zip codes across the State in an E–ZPass account file. The data were then summarised to match with the data from the 2000 U.S. Census. The U.S. Census Bureau provides data at various levels of aggregation, including state, county and Census Tract and Block. None of these summaries are exactly convertible to match with zip code-level data though the Bureau does provide data in a standardised form of zip code summary: the ZCTA code data. These files contain data from the U.S. Census summarised to reflect the 'primary' zip code for a particular region. With 580 separate municipalities and twenty-one counties, New Jersey has a significant level of governmental fragmentation since the U.S. Postal Service does not plan zip codes on the basis of municipal boundaries.

We therefore had to perform some adjustments to the zip coding of the toll data to achieve a good fit with the ZCTA data. We then summarised the 704 reported zip codes from the toll data into the 580 ZCTA codes and merged the two data sources. We have performed an extensive review of the zip codes in the data-base to provide the best match of zip codes and demographic data. We are able to assign $217,387,759 of the $220,745,063 in tolls, or 98.47% of the toll data to a ZCTA code area. The remaining tolls of $3,357,304.00 will be further analysed to find the best possible match in the ZCTA data. As a small portion of the toll data is still unassigned, the reported results may slightly understate the true burden at the town level. Any unassigned tolls are placed in a general county category and arbitrarily allocated the zip code 99999.

At the county level, the ZCTA codes allow us to summarise the data at the County Post Office level. The County Post Office summary does not match the true county level data exactly, as some post office boundaries cross county boundaries. However, the overall fit is generally good and the regional population summaries vary by a relatively small percentage. For ease of discussion, we shall consider ZCTA and Zip Codes to be the same for the rest of this report.

3 Results

With these raw data, it remained to developed metrics of the equity burden of the GSP and NJTPK tolls by zip code.

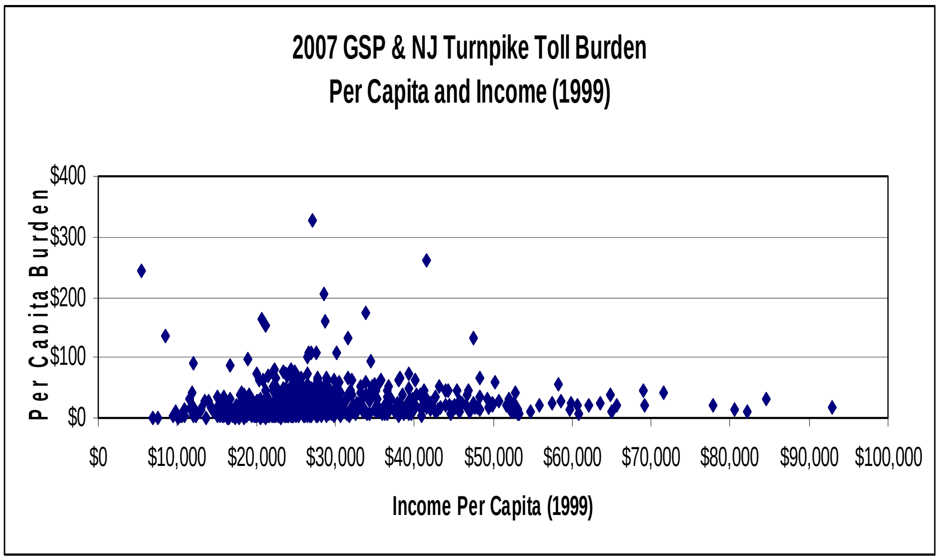
Metric I: *Per Capita* Burden

The first metric used was the burden *per capita*, i.e. the total tolls collected in a region divided by the population in a particular ZCTA code area.

There are some limitations in this method, as we have both business and residential toll collection data for a particular area. However, the concept of *per capita* burden does have some value as it gives weight to both the residential as well as the commercial activity of a region. In this form of analysis, the heaviest burdens by ZCTA code are carried in areas that appear to have high levels of commercial activity. Certain ZCTA codes in areas such as Trenton, Teterboro and Hainesport exhibit extremely high toll burdens *per capita* and our expectation is that these areas are localised zip codes that serve high concentrations of business. These extreme values are omitted from the data.

As is shown in Chart 1, the general relationship between income and *per capita* toll burden for the majority of zip codes (two observations being omitted—Hanesport (08036) and Teterboro (07608)) is quite variable. There is a significant amount of variation in terms of burden as related to the income *per capita* though generally a significant number of towns with relatively low incomes have very high burdens under existing tolls.

CHART 1
PER CAPITA BURDEN AND INCOME



In addition, the wealthiest zip codes in New Jersey all have relatively low burdens *per capita.* Of the thirty-four zip codes that had *per capita* incomes greater than $50,000, all had burdens less than $60 *per capita* ($58.40 dollars maximum in Sea Girt (08750)). As a group, these thirty-four towns had an average burden of $23.10 per person.

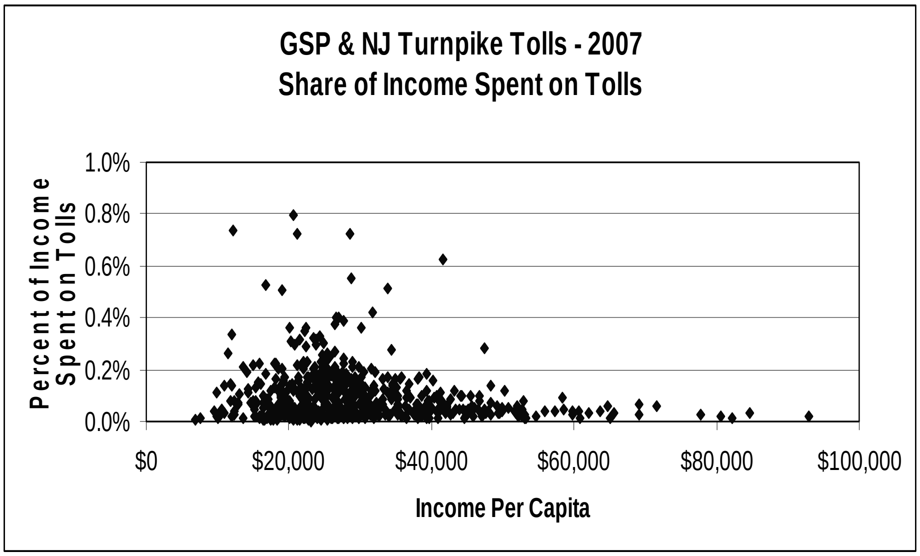
In contrast, the thirty-one lowest income zip codes in New Jersey, towns with income *per capita less* than $15,000 per person, report an average burden of $17.60 per person in 2007. This result probably significantly under-reports the true impact in these communities due to the use of E–ZPass only data. Lower income individuals are less likely to have some of the necessary financial and social infrastructure needed to utilise electronic toll collection than higher income groups. The items needed to establish and maintain electronic tolling accounts, such as stable mailing addresses, credit or debit cards, and cheque accounts are much less prevalent in low income communities.

We excluded Trenton (08625) the lowest income zip code with a *per capita* income of $5,458 and a burden of $244.20 *per capita* in the low income analysis because it is located in the centre of the State capital. State Government activity has created a concentration of special services such as legal and consulting services as well as elected officials and State agency employment surrounding the capital complex. As such, any inference that we would seek on household or business behaviour from this zip code would be distorted by the overwhelming effect of being the state capital. If this zip code was included the implication of 'regressivity' would be strengthened.

Metric II: Share of Income Spent on Tolls

The second metric developed was the percentage of income spent on tolls. While *per capita* burden is a crude measure of horizontal equity, the percentage of income burden is a crude measure of vertical equity.

CHART 2
INCOME PER CAPITA *AND PERCENT OF INCOME SPENT ON TOLLS*



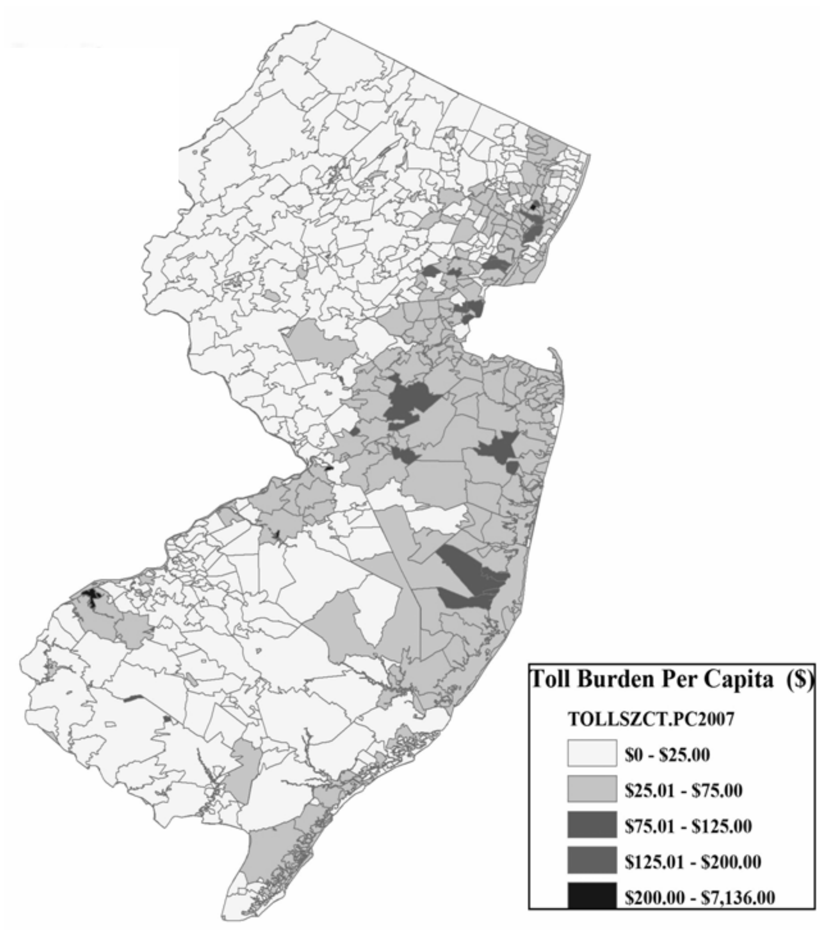
As can be seen from Chart 2, the share of income spent on tolls varies widely among the towns, with some low-income towns already spending almost 1% of their income on GSP & NJTPK tolls. No higher income zip-code communities spend anywhere near that proportion. Interestingly, normalising for income does not alter the basic pattern greatly, with a general pattern remaining of higher percentage of income being spent on tolls in lower income zip codes, with the reverse pattern holding in higher income zip codes.

Metric III: Locational Equity—Maps

To further explore the 'locational equity' of New Jersey toll roads, we developed maps using ARCView software to study the regional equity of the proposal. In addition, data by postal county were summarised to observe the variation by region.

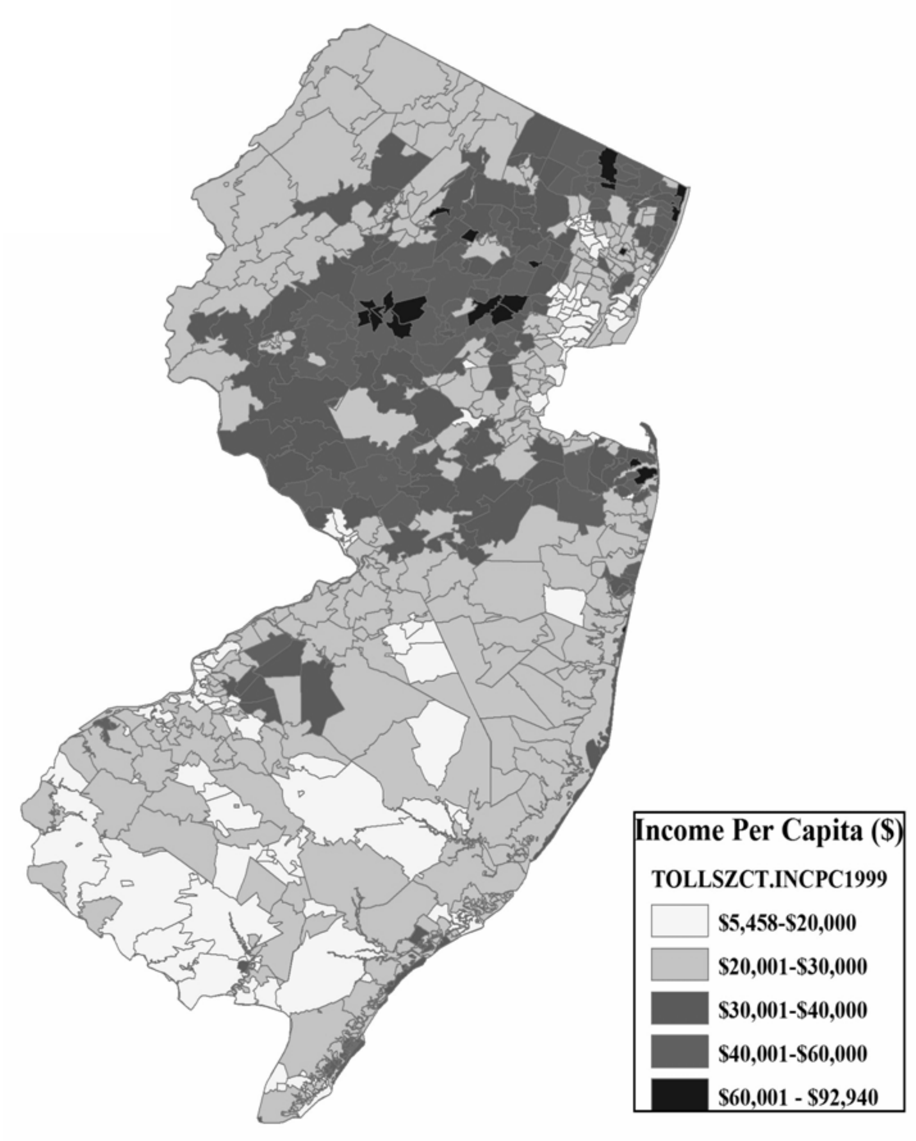
Map 1 illustrates the *per capita* burden at a zip-code level. As is clearly observable, the regions with limited access to alternative highway services are most impacted by tolls. Counties such as Middlesex, Monmouth, Ocean as well as Essex and Union counties which mostly ring the New York Harbour around New York City have a disproportionate burden per person Counties such as Warren, Sussex, Somerset and Hunterdon to the east and south have relatively low burdens currently.

MAP 1
GSP & NJ TURNPIKE TOLLS (E-Z PASS DATA ONLY)
PER CAPITA *TOLL BURDEN BY ZIP CODE*



In comparison, income *per capita* is illustrated in Map 2. Clearly the high income areas of North Central New Jersey exhibit relatively lower levels of toll burden as compared to lower income areas of Middlesex, Ocean and others. Map 3 shows the location of the two roads being studied, i.e. the New Jersey Turnpike and the Garden State Parkway.

MAP 2
INCOME PER CAPITA *FROM 2000 CENSUS*



One supplementary metric of locational equity is to show burden over some common geographic or regional unit. The zip code data are doing this already but this is not

MAP 3
GARDEN STATE PARKWAY (GSP) AND NEW JERSEY TURNPIKE (NJTPK) ROUTES

(note: white line indicates GSP; black line NJTPK)

One limitation of using zip codes is that they are not policymaking units. As an alternative total tolls collected within the counties of New Jersey and the percentage distribution of tolls collected across those counties were calculated. The other metrics referred to above were also calculated by county. The county is a common jurisdiction across all US States and also an important governmental unit in many States, including

New Jersey (although townships are generally more powerful there). Table 4 provides an overview of the impact by county.

TABLE 2
GSP & NJTP TOLLS AND BURDEN BY COUNTY

Postal County	Total Accounts	NJTP & GSP Total Tolls	Total Popula-tion	Housing Units	Per Capita Burden	Average Toll	Percent Total Tolls Collect-ed	Percent Total State Popula-ion
							%	%
Atlantic	42,221	$3,080,226	252,646	113,841	$12.19	$0.74	1.4	3.0
Bergen	148,993	$25,422,590	884,118	339,820	$28.75	$0.85	11.5	10.5
Burlington	60,950	$8,387,403	413,750	159,067	$20.27	$1.72	3.8	4.9
Camden	68,133	$4,370,652	524,368	205,385	$8.34	$1.49	2.0	6.2
Cape May	18,645	$2,603,155	102,949	91,308	$25.29	$0.70	1.2	1.2
Cumberland	6,489	$1,134,459	148,172	53,622	$7.66	$3.26	0.5	1.8
Essex	111,138	$22,378,805	858,914	324,071	$26.05	$0.71	10.1	10.2
Gloucester	35,505	$3,433,367	238,390	89,104	$14.40	$1.98	1.6	2.8
Hudson	81,347	$21,229,350	608,975	240,618	$34.86	$1.25	9.6	7.2
Hunterdon	14,459	$1,015,243	124,707	45,690	$8.14	$0.86	0.5	1.5
Mercer	36,967	$5,707,284	360,704	136,538	$15.82	$1.15	2.6	4.3
Middlesex	130,753	$35,395,840	742,865	271,362	$47.65	$1.16	16.0	8.8
Monmouth	119,126	$29,177,825	627,911	245,461	$46.47	$0.70	13.2	7.5
Morris	69,211	$5,914,215	453,104	168,036	$13.05	$0.76	2.7	5.4
Ocean	102,124	$22,659512	510,746	248,614	$44.37	$0.53	10.3	6.1
Passaic	61,589	$8,515,850	500,035	174,209	$17.03	$0.73	3.9	5.9
Salem	3,579	$435,519	65,226	26,528	$6.68	$2.30	0.2	0.8
Somerset	41,101	$3,215,586	260,979	98,756	$12.32	$0.83	1.5	3.1
Sussex	13,663	$590,420	145,363	56,951	$4.06	$0.65	0.3	1.7
Union	79,540	$15,616,427	486,201	179,555	$32.12	$0.81	7.1	5.8
Warren	8,334	$461,335	103,867	41,661	$4.44	$0.79	0.2	1.2
TOTAL	1,253,867	$220,745,063	8,413,990	3,310,197			100.0	100.0

The county level of *per capita* burden varies from $4.06 per person in Sussex County to $47.65 per person in Middlesex County. The trends in county data are more mixed than those presented for ZCTA. Some wealthy counties, such as Monmouth County, have amongst the highest *per capita* toll burdens, while others, such as Morris County, have the lowest. A similar range is present for low-income counties such as Hudson and Camden. This suggests some sensitivity of equity measures to jurisdictional boundaries.

Some of these variations are certainly due to the presence of transit alternatives within counties taken as a whole. There seems to be a broad association between counties well served by commuter rail and low burdens and those not well-served and high burdens. Where transit alternatives are available there are opportunities to shift from roads to other modes of travel. Far Hills, New Jersey has a 6.1% mass transit usage to work and an income *per capita* of $81,535. The high-income areas in North Central New Jersey are currently served by non-tolled interstate highways I–78 and I–80. High-income zip codes in areas that are located in areas that are served only by toll roads for interstate highway services exhibit high levels of burden *per capita.* For example, Monmouth County exhibits a burden of $46.47 *per capita* while Morris County is $13.05 *per capita*. But the data here are not entirely consistent: areas such as moderate income Bergen County with high *per capita* toll burdens also have higher mass transit usage (11% in 2000) versus low toll burden areas in the wealthiest sections of Morris County (with 4.2% mass transit usage in 2000).

4 Conclusions and Suggestions for Further Research

A few conclusions may be drawn about the equity implications of New Jersey's toll roads.

When measured by zip code, the gross burden of toll roads in New Jersey seems to fall disproportionately on lower income communities. This seems consistent with respect to locational, vertical, and horizontal measures of equity as calculated here. These measures are fairly crude and the geographic areas relatively broad. Nonetheless, the pattern is clear. County measures, while exhibiting a similar pattern, are not so consistently regressive, suggesting a sensitivity of the equity measures to the boundaries of the analytical units. It is conceivable that some of the impact of mass transit usage may lower the burden of tolls in high-income areas and perhaps in some low-income areas as well.

It should be noted that the Garden State Parkway tolls are not variable, being fixed over all periods of the day and for every day of the week. New Jersey Turnpike tolls have a mild variation in price during the peak period. As such, the predominant effect in any zip code is frequency of usage and distance travelled—not time of day. Thus the proximity of these communities to toll facilities seems to be the predominant effect. Variable congestion pricing would certainly alter the equity impacts of the tolls, though it is not entirely clear in what direction.

Would a net measure, taking into account things such as housing price and modal choice, sustain this impression? Our existing data do not allow us to answer these questions. Other aspects, such as modal choice, might be measured to a greater or lesser extent, and joining the current analysis with such data is an appropriate next step. In general it would be expected that the presence of alternative non-tolled roads or alternative modes of travel such as transit should allow users to evade the burden of tolling by shifting to alternatives. The county data may suggest that this is occurring, though as noted above other factors also seem to be at play.

There are several possibilities for fruitful further research on the equity of public services. With respect to toll roads with electronic toll collections, in the US these are in general nominally public authorities and presumably they collect similar data to that of the New Jersey toll authorities. Thus similar equity analysis of other toll roads should be possible. The problem, however, is that the US authorities generally choose not to make such data public. This should be a surmountable obstacle, though if data have to be obtained through Freedom of Information Act (FOIA) requests this could take a considerable amount of time.

There are further refinements that need to be made to this line of inquiry, both on the revenue burden and receipt of services by specific classes of people. For example, only the equity of toll revenues is considered here, not the distribution of burden from other cross-subsidies such as the gasoline tax and general revenues.

Additionally, while the users of toll roads are fairly straightforward to identify, it may be harder to pinpoint users of other services such as police protection. An extension of this type of analysis into other areas could face some challenges that would require new primary source data or 'creativity' with the existing secondary data. The same could be said of services where a discrete fee, analogous to a toll, is collected. Finally this analysis has only used crude and broad measures of equity. More refined measures, such as those developed in the tax analysis literature. are called for.

REFERENCES

Arrow, K. J. (1950) "A Difficulty in the Concept of Social Welfare", *Journal of Political Economy*, 58, pp. 328–346.

Brueckner, Jack (1982) "A Test for Allocative Efficiency in the Local Public Sector", *Journal of Public Economics*, 19, pp. 311–331.

Buchanan, James M. (1965) "An Economic Theory of Clubs", *Economica*, new series, 32, pp. 1–14.

Bullard, R. D. and G. S. Johnson (eds) (1997) *Just Transportation: Dismantling Race and Class Barriers to Mobility* (Gabriola Island, Canada: New Society Publishers).

Fried, Harold O., C. A. Knox Lovell and Shelton S. Schmidt (eds) (1993) *The Measurement of Productive Efficiency: Techniques and Applications* **(**Oxford: Oxford University Press).

New Jersey Turnpike Authority (2008) "E–Z Pass Toll Use for the New Jersey Turnpike and the Garden State Parkway 2006-2007" (Woodbridge, New Jersey: New Jersey Turnpike Authority).

Levinson, David (2002) "Identifying Winners and Losers in Transportation", *Transportation Research Record*, Vol. 1812, pp. 179–185.

Litman, Todd (1996) "Using Road Pricing Revenue: Economic Efficiency and Equity Considerations", *Transportation Research Record*, Vol. 1558, pp. 24–28.

New Jersey Turnpike Authority (2006) "Annual Report 2006" (New Brunswick, New Jersey: New Jersey Turnpike Authority) http://www.state.nj.us/turnpike/2006-NJTA-Annual-Report.pdf.

North Jersey Transportation Planning Authority (2007) "Environmental Justice Regional Analysis: Baseline and Time Series Data" (Newark, NJ: North Jersey Transportation Planning Authority) http://www.njtpa.org/Plan/Element/EJ/documents/EJ_REPORT_II_Exec_Sum.pdf.

Sørensen, P. B. (ed.) (2004) *Measuring the Tax Burden on Capital and Labor* (Cambridge: MIT Press).

U.S. Census Bureau (2000) *Census 2000 Gazetteer Database for New Jersey* (Washington, DC: U.S. Census Bureau).