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A time series analysis of passenger rail demand in major Australian cities

Albert Wijeweera *, Hong To, Michael B. Charles, Keith Sloan

Southern Cross Business School, Southern Cross University, Australia

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ABSTRACT

The paper uses cointegration and error correction approach to examine train passenger boardings in four major Australian cities. It suggests that demand is highly price inelastic, thereby implying that a decrease in fare would not lead to a rise in total revenue, although it could lead to a rise in patronage to some extent. City population and number of kilometres run are the most influential determinants. This is both encouraging and challenging, especially because the Australian urban population is steadily rising and the system is already supply-constrained, particularly in peak periods. The study also suggests that private vehicle and rail travel are at best weak substitutes and, in some cases, are possibly complements. Passengers have fewer options in the short run, while, in the long run, they may respond more comprehensively to changes by changing their personal circumstances.

1. Introduction

Recently unexpected growth in passenger rail demand in major cities in Australia has posed several challenges to state rail authorities and planning agencies. While an increase in urban rail demand might appear welcome, government transport agencies must choose to invest, to varying degrees, in a variety of transport options, including urban rail, with increasingly constrained resources (Wijeweera and Charles, 2013b). Providing over capacity in an urban rail network is also not an attractive outcome, since funds directed to this infrastructure provision or augmentation could have been better directed to other projects across a variety of sectors, including health, education, energy and sanitation. Hence, a clear understanding of the factors affecting urban rail passenger demand is crucial for infrastructure planning and service delivery.

Among the existing models used to analyse transport demand, the sequential four-step model comprising of (i) trip generation, (ii) trip distribution, (iii) modal choice, and (iv) route assignment remains the most widely used in the transport industry (Goulias et al., 1990; Wardman, 1997). This model, however, has proved to be somewhat deficient, especially with respect to predicting the spikes in urban rail demand experienced in Australian capital cities and their peripheries in recent years, as pointed out recently by Wijeweera and Charles (2013a). Indeed, a failure to predict recent demand growth has resulted in considerable pressure on existing rail infrastructure (Gaymer, 2010). Given the seeming inadequacies of the demand estimation methods currently in use, it will be worthwhile to ascertain which factors have contributed to fluctuations in urban rail patronage from other approaches. Wijeweera and Charles (2013a,b) have looked at this issue in their recent separate studies of Melbourne and Perth. But the present study builds upon these earlier

* Corresponding author. Tel.: +61 7 5589 3211.
E-mail address: albert.wijeweera@scu.edu.au (A. Wijeweera).

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investigations by comparing the travel demand function in these two cities, and adding results derived from time-series data relating to Adelaide and Sydney. As a result, a more holistic understanding of rail travel demand in Australia is achievable.

Time series estimation, which analyses historical data to observe what has happened in the past when variables change, is obviously not new. For our purposes, the method can be used with profit to gain inferences about the interrelationships between these variables. In other words, time series analysis seeks to identify patterns in relationships between the variables in a time series data set, with the intention of explaining past behaviour and forecasting future values of the variables of interest. Time series studies allow for robust statistics, can better determine changes in behaviours, and can detect behaviour trends over time. This is because the research analysis responses to the same questions from the same respondents at a different point in time (Spitz et al., 2006).

In studying travel behaviour, time series data can yield insights into lagged adjustments in behaviour, time trends, and asymmetries between the effects of improvements and deteriorations in travel attributes. These attributes of time series analysis confirmed its applicability to the current study. Most of the existing time series studies on passenger rail demand have been conducted for rail networks in the United Kingdom or the United States, where there is often a much denser urban structure than is found in Australian cities, where urban rail covers much less of the urban fabric (see, e.g., Fowkes et al., 1985; Chen, 2007; Voith, 1991). In contrast, there are very few studies based on Australian data. To our knowledge, aside from the aforementioned work of Wijeweera and Charles (2013a,b) dealing with Melbourne and Perth, there have been only two published studies on the passenger rail demand in Australia using a time series approach, these being: (i) a study using a 38-year data set from 1969 to 2008 conducted by Douglas and Karpouzis (2009) for the case of Sydney; and (ii) a study by Odgers and Schijndel (2011) for the Melbourne metropolitan area over a twenty-seven year period from 1983–1984 to 2009–2010. As found by Wardman (1997), who employed a pooled data set of 764 observations of changes of demand on 160 non-London flows from 1985/86 to 1990/91, estimation results do vary significantly.

The variation in the results of previous research suggests that determinants of ridership may vary by location, i.e., from city to city, and from country to country. For example, Voith (1991) found that the primary measurable determinants of passenger rail ridership on the Southeastern Pennsylvania Transportation Authority commuter system are related to transportation policy rather than to the ancillary effects of changing demographics. Yet, in a more recent study for the case of London, Chen (2007) suggested that employment in central London is the main factor affecting demand. That said, it is not possible to apply existing estimation results in the context of other countries to Australia for infrastructure planning and service delivery. More so, it is also difficult to apply results found in the context of one city to the other city, even within Australia, where there are many ostensible commonalities between capital cities.

In addition, previous studies, aside from the recent investigations of Wijeweera and Charles (2013a,b) into the travel demand function in Melbourne and Perth, have not utilized modern time series techniques—another reason for revisiting this problem in an Australian context and undertaking a multi-city comparative analysis. In particular, the traditional time series estimation methods of passenger rail demand are often associated with empirical problems such as the non-stationarity of the variables (Odgers and Schijndel, 2011). This is especially the case given that the most time series data are non-stationary. If this fails to be taken into account, spurious results and invalid inferences may result (Granger and Newbold, 1974). For example, Jones and Nichols (1983) used four-weekly UK data from the beginning of 1969 to the middle of 1977 and applied an ordinary least squares method to estimate the passenger rail demand function for seventeen London-based routes. Although the Jones and Nichols study has its own merits, it did not account for non-stationary data. Their results also suffer from some serious statistical problems. As Fowkes and Nash (1991) showed, the Durbin Watson statistics reported by Jones and Nichols are significantly low, which may indicate the presence of serial correlation and potential statistical problems with the findings.

The issues associated with traditional time series techniques have also been largely neglected in previous Australian studies, aside from those conducted by Wijeweera and Charles (2013a,b), who only look at single cities in isolation from each other. In particular, the time series study of Sydney's passenger rail demand conducted by Douglas and Karpouzis (2009) does not perform a satisfactory overall goodness of fit, with only 35% of the variation in passenger trip rates being explained by the estimated model. Furthermore, none of the parameters is significant at a 5% level of significance, although all of them have the expected signs. Only the constant term is significant. This suggests that the model might have been specified incorrectly and/or suffered from non-stationary data. It also seems to suffer from omitted variable bias. Previous studies, mainly in the UK context, have found that many other variables, including seasonality and petrol price, exert an impact on passenger rail demand.

Another issue of concern is that previous Australian studies, aside from the limited single-city studies of Wijeweera and Charles (2013a,b), have also ignored the separation between short-run and long-run passenger rail demand responses. Without doing this, there is the danger of serious statistical problems and confusing short-run impacts with those that will occur in the long-run if the relationship between key variables changes. The international time series studies on passenger rail demand have suggested that demand responses are not instantaneous and that the long-run responses are considerably different to those of the short run (Owen and Phillips, 1987; Voith, 1991). This issue is also important for rail authorities and planning agencies. In particular, the smaller impacts of changes in fares and service levels on rail patronage in the short-run compared to those in the long-run found (i) by Owen and Phillips (1987) for inter-city rail demand in the United Kingdom and (ii) by Voith (1991) for US networks imply that there is a potential for an increase in revenue by increasing fare in the short run. Yet this policy might not be successful in the long-run because consumers can change their behaviour as a result of