Bus Route Span of Service Changes: Ridership Impacts on Unaltered Hours

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A Thesis Quality Research Project Submitted in Partial Fulfillment of the Requirements for the Masters of Science in Transportation Management

2014

Abstract

The ridership response to bus route span of service changes –the start time of the first trip to the end time of the last trip each day –is examined specifically during hours that were not altered by a span of service change. Nine western United States transit agencies provided usable data on 39 bus routes that experienced span of service changes without any other types of changes, enabling the largest known analysis of such data from American transit systems. Results demonstrate that bus routes that received a span of service increase experienced a 12.4% increase in ridership during unaltered hours, or a 3.4% increase in ridership during unaltered hours after adjusting for systemwide ridership changes. Bus routes that received a span of service decrease experienced a 0.1% decrease in ridership during unaltered hours or a 1.5% decrease in ridership during unaltered hours after adjusting for systemwide ridership changes. Possible reasons for ridership increases following a span decrease are explored. The agency that implemented the largest collection of span increases simultaneously also experienced the largest percent increase in ridership during unaltered hours, exhibiting signs of similarity to another large span increase outside of the United States, indicating a potential synergistic effect that warrants additional research. Other factors present in routes that experienced relatively strong ridership responses during unaltered hours are also presented for agencies to consider when evaluating possible service span changes.

Keywords: transportation, urban bus, suburban bus, span of service, service span, ridership, ridership response

Acknowledgments

The author would like to sincerely thank the agencies and individuals that successfully provided data for this research effort, specifically Britt Card at Foothill Transit, Martin M. Barna at Valley Transportation Authority, Ted Day at King County Metro, Tim Simon and Ken Augustson at Lane Transit District, Michael Seden-Hansen at City of Paso Robles, James Drake and Jessica Sandoval at Regional Transit, Joel Soden at Spokane Transit, and Joshua Palazzo at Riverside Transit Agency; without the significant time these individuals dedicated to providing data, this research would not have been possible. Other individuals that also spent time providing data or assisting with contacts are appreciated, including Angélica Bryant at Sun Metro, Howard Der at AC Transit, Don Varley of San Diego Metropolitan Transit System, Vanessa Rauschenberger of Gold Coast Transit, Jim Archer of Houston Metro, Jarrett Walker of Jarrett Walker and Associates, and Michael Roschlau of the Canadian Urban Transit Association. The instructors and staff of the Mineta Transportation Institute were also instrumental in providing guidance throughout the Masters of Science in Transportation Management Program, which provided the foundation for this research. Lastly, the author would like to thank his wife for her love and patience throughout this long research process, and his mother for her lifetime of loving support and encouragement.

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Along with frequency, bus route span of service –also known as service span, hours of operation, or operating hours –determines the *when* in the question of *when and where* does transit service operate[1]. Regardless of how well-planned or useful a transit route may be, it is of no use when it does not operate –before the first trip and after the last trip of each service day. As acknowledged by the Transportation Research Board's TCRP Report 165 (2013), a bus route with a longer span of service will generally be able to accommodate a wider variety of users and trip purposes than a route with a shorter span of service. However, span of service also has a direct cost impact, as most costs associated with bus service are on a per-unit basis; each hour of service generally has an incremental cost. Therefore, transit agencies must give careful consideration to determining the most appropriate span of service for each bus route, based on the needs of the customers and communities the route serves, within the context of available funding.

The economic recession of the late 2000s brought about a number of bus service reductions; often, this affected the span of service for bus routes in many cities. Phoenix, Arizona eliminated all bus service after 10 p.m. amid a broad policy decision (Newton, 2008). Orange County, California eliminated overnight (2 a.m. & 3 a.m.) service on four bus routes in 2010 after a detailed analysis (Molina, 2010). Las Vegas, Nevada, decreased the span of service on a number of bus routes by one hour or more amid a package of service cuts enacted between 2009 and 2011 (Hanson, 2011). In each of these cases, these changes represent the loss of transit service for customers that used the bus routes during the eliminated hours. Similarly, span of service increases, such as those enacted in the Las Vegas area on many routes during the late

[1] Span of service is sometimes discussed in terms of how many hours in a 24-hour period that a bus route operates. For example, a route that operates from 5 a.m. to midnight could be said to have a 20 hour span of service each day.

1990s and the mid 2000s, provide existing customers with additional mobility options and potentially attract new customers that want or must travel during hours in which service was previously unavailable. The elimination of bus service during certain hours forces affected patrons to either make potentially major life changes –in the form of a new job, new work schedule, or new residence –or switch modes, which may not necessarily be practical for some affected persons. Similarly, a span of service increase that makes bus service available during hours in which it previously was not offered creates entirely new options for existing transit users, especially transit-depending customers –in ways that could significantly increase a customer's quality of life, such as being able to work more hours or accept a new job working a shift that was previously inaccessible -and potentially attracts new customers that were previously unable to utilize bus service.

Ridership lost during eliminated hours, or gained during added hours, represent direct impacts of a span of service change. When a span of service decrease is considered, it is generally only these customers that are considered affected; comments by the Phoenix City Council regarding Valley Metro span of service cuts reported by Newton (2008) serve as an example. However, there may also be indirect impacts from such changes that are less obvious and less understood. For example, will afternoon ridership be affected if late night bus service is eliminated, as riders working swing shifts in restaurants, grocery stores, customer service call centers, or other non-traditional employment venues are no longer able to make their return trip via bus service? Will fewer trips be made on buses in the early evening if late evening service is eliminated? Similarly, will ridership in the early afternoon increase if bus service starts an hour or two earlier in the morning because those that must be at work at 5 a.m. or 6 a.m. are now able to make use of bus service and therefore will complete a return trip during afternoon hours, a

time when service had previously been offered? Does overall ridership on a bus route increase by more than the additional ridership gained during new hours of service if the span of service is increased, and if so, to what extent? In a related but slightly different scenario, if a bus route that previously operated until midnight is reduced to ending at 10 p.m., what type of change in ridership will be experienced during 9 p.m. and 10 p.m. trips? Will ridership during these hours increase -because customers that were previously using the service at 11 p.m. and midnight are able to adjust their schedules and now use the service at 10 p.m. instead -or will it decrease because of newly-added anxiety amongst customers traveling on what now became the last trip of the night, leading those customers to seek another mode due to the lost assurances of later "lifeline" service in case of delays or changes in their schedules? How will ridership earlier in the evening be affected, when the outgoing portion of some trips are taking place?

These types of potential indirect ridership impacts due to a span of service change are the focus of this research paper. The outcome of these questions has a substantial impact on how transit agencies should approach the possibility of span of service changes, which often occur either amid other service cuts designed to address budgetary shortfalls or in the larger context of improving service for customers, whether specifically requested by customers or merely assumed as part of a strategic effort. An agency forced to cut service for budgetary reasons seeks to have the best possible information on the likely impacts and outcomes of various ways of cutting service. If research finds that there is a noticeable decline in ridership during unaltered hours due to span of service reductions enacted in similar agencies, such information would be important for the agency to consider when evaluating how to reduce service, and could result in another, less impactful option being chosen. Alternatively, if research shows little to no impact on ridership during unaltered hours, the agency can perhaps feel more confident in reducing a

bus route span of service when confronting a budgetary shortfall. An agency given the opportunity to invest in improving bus service faces similar questions about how best to allocate resources; knowing the potential full benefits of a possible span of service increase –if there are any other than the new riders served during the added hours of operation -would be very useful in making such decisions.

Whether unaltered hours experience a change in ridership is an important question to agencies operating bus service, but it is even more important to bus riders. If a span of service change can be shown to significantly affect ridership during unaltered hours, it may result in fewer span of service cuts and more span of service increases. However, this too would have an impact on bus riders in the form of potentially other types of service cuts or the opportunity cost of other types of service improvements to the extent that resources are expended to increase the span of service, respectively. If span of service changes generally have minimal impact on unaltered hours, riders may experience a greater likelihood of span of service cuts during budgetary challenges or a reduced likelihood of earlier or later hours of operation when service is being improved, though both situations would result in service being decreased in fewer other ways or increased more in other ways, respectively. Among the many alternatives to span of service reductions or increases, bus agencies may instead choose to change headways during peak or non-peak hours; extend or truncate routes; or introduce new or eliminate underperforming routes. All of these inter-related outcomes could be affected by knowing more about the ridership impacts of span of service changes.

Existing research on the broader topic of bus route span of service features several limitations that hinder the applicability of the body of knowledge to contemporary western and southwestern United States bus systems. Much of the existing knowledge on the subject relies

on examples or case studies that are now several decades old; from older, more established parts of the United States or from countries other than the United States; contain span of service changes mixed with other types of service enhancements or reductions; or not focused specifically on bus service. Often, these studies analyzed only to what extent total ridership on a bus route had increased, not specifically whether the increases in ridership were occurring during hours of service that had been added or during time periods that were not directly affected – unaltered- by a span increase. Some of the most notable publications regarding span of service, including the Transportation Research Board's Transit Capacity and Quality of Service Manual, 3rd Edition (2013), offer quality of service indicators based on the number of hours that service operates each day and note that a longer span of service allows a larger range of trip purposes to be served, but do not discuss potential ridership impacts that changes in span of service may have on unaltered hours. As the Literature Review section will demonstrate, there have been precious few studies addressing the question of the ridership impacts that span of service changes have on unaltered hours, and none that are exclusive to span of service ridership impacts have focused on cities in the United States. As noted, to make the best possible decisions, bus agencies need to know how span of service changes impact ridership. This research project therefore attempts to provide more information on this scarcely-researched but vital topic.

This research effort will be conducted under certain parameters designed to maximize the applicability for a targeted set of potential client agencies. In terms of nations and regions surveyed, this research will focus exclusively on the western and southwestern (including Texas) United States. This concentration lies in the possibility of differences in the market response in the newer and fast-growing cities of the southwest and western U.S. compared to the much older and more slowly changing cities of the northeast or 'Rust Belt'. This research will also focus

exclusively on relatively recent occurrences of span of service changes; all data analyzed will be from 1997 to 2014 (past 17 years). While the most recent examples possible would be preferable, this date range is being selected to ensure that a few economic cycles are captured; reliant in large part on non-farebox revenues, agencies tend to reduce service during and in the few years after an economic recession, then increase service during times of economic growth. Finally, due to the possible difference in the market response to rail and other transit modes, this research will focus exclusively on bus span of service changes[2].

These parameters will help ensure that the research findings are applicable and useful to planners and managers in contemporary bus transit agencies in the western and southwestern United States. It is the goal of this research that bus systems given the opportunity or forced to make the types of decisions outlined in the opening of this paper are able to do so with an enhanced understanding about how such decisions may affect overall ridership. In addition to concise, summarized information designed for planners and managers, the body of this report attempts to explain the context of span of service changes when the results produced deviate significantly from the averages, to the maximum extent possible, and to note any other factors that may have influenced the ridership response to the adjustment that took place.

Literature Review

The topic of span of service in the broader public transportation context is widely discussed. Prominent publications cite the role that span of service plays in determining whether transit service is available (TCRP Report 95, 2004). Research from the Florida Department of

[2] For the purposes of this research paper, Bus Rapid Transit is also being treated as a distinct mode and will not be included, except for portions of contribution to the literature review section.

Transportation calculates transit Level of Service (LOS) using span of service and frequency (Guttenplan, Davis, Steiner, & Miller, 2003). Similarly, the Transit Capacity and Quality of Service Manual (2003) also provides guidance for span of service LOS calculations, where LOS F equates to just zero to three hours of service per day –"very limited or no service," LOS C equates to 14 to 16 hours of service per day –"early evening service provided," and LOS A equates to 19 to 24 hours of service per day –"night or 'owl' service provided." Crockett (2002) emphasizes that span of service also determines transfer availability; even where many routes operate a long service span, if one route in a transit customer's commute is not operating at a given time, the customer will either choose not to board any of the transit routes needed to complete that trip or will otherwise be stranded at a transfer point. Each of these publications demonstrate that span of service is the temporal equivalent to service coverage.

While intended for Bus Rapid Transit (BRT) application, span of service guidelines provided by the American Public Transportation Association ([APTA], 2010) describe features that many traditional local bus services may seek to emulate. The guidelines note that the vast majority of BRT systems in the United States and Canada operate seven days a week, with the most common and preferred approach to operate service 18 to 20 hours per day. These design features are intended to capture most or all potential ridership demand and maximize the level of public confidence in the service. As noted, while these guidelines are intended for BRT application, it stands to reason that transit agencies that desire for certain local bus routes to achieve similar goals may consider a similar service design.

The process that transit agencies use to determine span of service for each route has also been discussed in various industry literature. Approaches used vary widely by agency. TCRP Report 111 (2007), an exploration of the elements needed to create high-ridership transit service,

provides a brief, fairly generic discussion regarding potential span of service changes. The report suggests analyzing ridership in the time period nearest to a potential span of service increase to estimate possible ridership. Similarly, the Center for Urban Transportation Research (2009) provides two examples of approaches used to determine whether a span of service increase is justified. The first example, employed by Palm Tran (Palm Beach County, Florida), considers an earlier or later trip if the first or last trip of the existing service is performing better than 50% of the system average in passengers per revenue hour. The second example, used by the Chicago Transit Authority, considers a span of service increase when the first or last hour of existing service exhibits productivity greater than the average system productivity for that hour. For a wider perspective, TCRP Synthesis 10 (1995) contains survey results from dozens of transit agencies regarding the presence and content of agency guidelines pertaining to span of service. The report found that about 20% of responding agencies had no such guidelines in place; a similar number operated all, or virtually all, routes with a similar span of service. Among the remaining 60%, 17% reported route level considerations, 14% suggested that a daytime grid might become an overnight grid with greater parallel spacing between routes, and the remaining 29% reported both route level considerations and potentially greater spacing between parallel routes.

In many situations, there is evidence that customers are not satisfied with the span of service decisions being made by transit agencies, in terms of how accessibility is impacted. A study of customer satisfaction with transit systems in Florida identified span of service as one of the top importance factors where improvement was needed for several transit agencies (CUTR, 2000). In particular, ending times for both weekday and weekend service were the overall lowest rated factor amongst respondents, receiving lower scores than frequency, timeliness,

ability to access desired destinations, and all other factors. A later study assessing the barriers to transit use for major activity centers in Florida found that the span of service, particularly ending times, was inadequate to fully serve many major activity centers, such as shopping malls (CUTR, 2001). One of five recommendations from the study was for systems to consider increasing evening span of service. Similarly, a survey of transit planners and providers in Connecticut ranked 'more frequent service and better service span' as the most important feature for assessing transit accessibility (Mamun, 2011). TCRP Report 111 (2007) also notes that a mismatch between services provided and those desired by customers, such as a mismatched span of service, can be amongst the reasons for lower-than-expected transit usage. Still, despite some documented dissatisfaction and demand from customers and the recognized role that span of service plays in transit accessibility, of 86 operating or service adjustment projects identified by TCRP Report 111 (2007) designed to improve ridership, only four involved an increased span of service. More popular types of service improvements included increased route coverage, route restructuring, and passenger facility improvements.

Considering the recognized importance of span of service in terms of accessibility, the ridership response to span of service changes has received little empirical research, especially if the context is limited to bus service in the United States in the past twenty years (Currie & Loader, 2009). The only identified relatively recent and detailed examination of the ridership response to span of service changes in a western or southwestern United States location came from Santa Clarita, California. Santa Clarita Transit instituted significant service increases between 1992 and 1998, including doubling frequency on many routes and increasing the span of service. The increased span of service extended transit service two additional hours on Weekdays, three additional hours on Saturdays, and launched Sunday service on most routes.

Minor routing changes and a 33% increase in fares also occurred. In total, ridership exhibited an elasticity of +1.55 compared to service hours and an elasticity of +1.14 compared to service miles –both indicating that ridership increased by more than the increase in bus service operated (TCRP Report 95, 2004). However, as noted, this case included other significant service improvements; a major challenge in determining the specific ridership response to span of service changes is that the effect is often not identified separately from other types of changes, especially frequency changes (TCRP Report 95, 2004). Two additional examples of a 'significant' ridership increase during unaltered hours due to the introduction of evening or weekend service are also provided from the Bellingham, Washington and Dallas, Texas areas, but no specific figures or percentages are provided (TCRP Report 95, 2004).

To attempt to more fully examine the existing documented ridership impacts of span of service changes, the context must be broadened to include examples from elsewhere in the United States, as well as to include transit modes other than exclusively bus, and to allow older case studies to be considered. Permitting a wider search, a few other examples are also provided by TCRP Report 95. New Jersey Transit (NJT) restored Sunday bus service on Route 59 in 1994-95, which had been eliminated over two decades prior. The service, which operated between 8 a.m. and 6 p.m., averaged about 45 passengers per Sunday one-way trip. The study also notes that NJT experienced successful ridership with additional commuter rail train trips that were added on Saturdays and especially Sunday, where a farebox recovery ratio of 52% was achieved. However, no discussion is provided about ridership impacts, if any, during unaltered hours. An even older example (from 1970) is provided where Reston, Virginia added a single additional trip slightly later in the evening (between 7:00 p.m. and 7:26 p.m.); only 15 to 20 additional riders used that particular trip, but more than 80 new riders were attracted to the

system overall, an indication that the riders needed the assurances against being stranded that a longer span of service –even only slightly –would provide (TCRP Report 95, 2004). Some potentially conflicting evidence of a span of service change making a much smaller contribution to ridership increases is offered by a case study from the Washington Metropolitan Area Transit Authority (WMATA) that estimated span of service extensions as providing only a 4% contribution towards a 20-year improvement goal of doubling ridership (TCRP Report 111, 2007). However, a possible explanation for the fairly small contribution could be that WMATA was already operating a fairly suitable span of service relative to other types of service needs, meaning this case is not necessarily in conflict with other studies.

Another study of relatively recent bus route span of service changes in the United States comes from Montgomery County, Maryland (Washington, D.C. metropolitan area). In 1998, Montgomery County transit (Ride On) extended the span of service on eight bus routes to match the operating hours of the connecting metro rail system (Bravman, Dunn, & Linderman, 2005). Both the previous service span and the new service span varied by route; increases varied from just a few minutes on some routes on weekdays (particularly with start times) to several hours of increases in the evening on other routes, particularly on weekends. The increases were implemented under the rationale of providing better aid to the working population of the County. According to an on-board customer survey conducted in 2005 on the trips that had received a span of service increase years earlier, approximately 83% of the riders were primarily engaged in a work trip. Approximately 35% of respondents using the extended evening service stated they would not have their present job without the late evening Ride On trips. A significant percentage of riders also responded that the extended span of service allowed them to obtain their current job, keep a previous job, work more hours, or work a better schedule of hours. Unfortunately, no

analysis is provided of the ridership impact of this span of service increase on the unextended, unaltered hours of service.

More generally, Walker (2014) argues that a transit network designed for all-day use, rather than peak-centric, is vital to "permanently successful service, the kind of service you can build a city around". Walker notes the interrelatedness of ridership at various times of day and alludes to the possibility that an extended span of service can help increase ridership during core, peak hours, noting that customers will not use transit without an assurance that they can complete a return trip. However, Walker (2008) previously acknowledges that more research is needed to determine the extent to which evening bus service contributes to successful ridership during daytime hours. In a related article to Walker (2014), Jaffe (2014) recounts the experience of a New Jersey Transit commuter rail line that introduced off-peak service for the first time in 2007. Survey results found that 5% of riders started using more peak train service due to the addition of off-peak service, and that 60% of riders who reported they would return to driving if off-peak service was cancelled were peak riders. The original research study on this subject recommends, on the basis of the empirical data, that the effect on peak ridership be considered when making adjustments to off-peak trains, since the off-peak trains made the transit service more attractive to customers overall (Deka, 2011).

For more evidence of the impact of span of service changes on ridership during unaltered hours, a few examples from around the world must be considered. In early 2008, Athens, Greece extended metro train service by two hours (from 12:30 to 2:30 a.m.) on Friday and Saturday nights as part of a two month pilot program. In a study of the ridership response, Veliou, Kepaptsoglou, & Karlaftis (2010) note that in addition to ridership added during the extended hours, ridership also increased during unaltered hours prior to the extended service. Ridership

increased by approximately 15% between 8 and 10 p.m. and by approximately 45% between 10 p.m. and midnight –time periods that were unaltered, experiencing no change in service.

Two closely related case studies from Melbourne, Australia (an urbanized area with approximately 3.6 million inhabitants) provide some of the best and most detailed examinations of span of service changes affecting bus ridership during unaltered hours. Service cuts in the 1990s significantly reduced evening and weekend bus service in Melbourne; as of 2003, the average evening finishing time for bus services was 6:53 p.m., and only about 20% of bus services operated on Sundays (Currie & Loader, 2009). In response to comparatively low levels of service, a funded, ten year program to substantially improve bus service to at least a new 'social safety net' minimum standard was launched in 2006 (Currie & Loader, 2009; Loader & Stanley, 2009). By 2007, 72 bus routes operated until at least 9 p.m., seven days a week; by 2008, 111 bus routes met this standard.

Currie & Loader (2009) selected 22 bus routes that received no improvements other than an extended service span for further study. Of the 22 routes, two previously had no Saturday service and 18 previously had no Sunday service; all received seven day a week service as part of the improvements. Additionally, the span of service on the average route in the study group increased by approximately two and a half hours in the evening on weekdays; by approximately three hours and fifteen minutes on Saturdays; and by approximately three and a half hours on Sundays. On average, the 22 routes exhibited a ridership elasticity of 0.35 on weekdays, 0.84 on Saturdays, and 0.83 on Sundays. Perhaps most importantly, ridership grew substantially during both evening (recently extended) and daytime (unaltered) hours. Weekday ridership increased by a total of about 3.3% on the studied routes, and about 47% of the weekday ridership increase occurred before 5 p.m., during which time all routes were previously in operation and were

unaltered by the implemented service improvements. Daytime ridership growth was particularly strong on Saturday afternoons and throughout the day on Sundays. The report noted that state travel survey data indicated that 27% of outbound daytime trips on weekdays that start before 5 p.m. return after 7 p.m., whereas 39% of outbound Saturday and Sunday daytime trips that start before 5 p.m. return after 7 p.m.; 13% of trips started on weekends before 5 p.m. return after 10 p.m.. Using this data and the ridership growth percentages by hour for each day type, the study authors conclude with the strengthened hypothesis that extending the evening service span on bus routes increased ridership by encouraging more daytime outbound trips using the bus, since return evening trips could be captured by the later span of service.

Loader & Stanley (2009) selected a slightly different approach in analyzing similar data from the same region, choosing to analyze routes as a group based on their previous ending times on Saturdays. Of the 26 routes in the study of Saturday ending times, two previously ended between 4 and 5 p.m.; perhaps unsurprisingly, these routes experienced "striking" ridership growth –more than doubling boardings during the 2 and 3 p.m. hours, which were not directly affected by the span increases that extended service until 9 p.m. Amongst the seven routes that previously ended between 5 and 6 p.m., there was ridership growth in the unaltered afternoon hours of approximately 20%. Nine routes that previously ended between 6 and 7 p.m. displayed more modest growth during afternoon hours (around 10%), while two routes that previously ended during the 7 p.m. hour in one direction and the 8 p.m. hour in the other direction experienced only nominal growth during afternoon hours but slightly higher growth in the early evening. The report concludes the Saturday ridership analysis by noting that the data suggests many passengers making trips during the day require service until at least 7 p.m. for a return trip, while routes operating beyond 7 p.m. are growing demand for evening service but having no

effect on daytime travel. Overall weekday ridership increases were much smaller, but the extent of the extended service was also much less, since more routes previously operated longer spans on weekdays than on Saturdays. A relatively small (n = 101) survey was conducted of evening riders on one of the bus routes that had received a span of service increase. Highlights of the results include findings that work trips were the plurality trip purpose for users of the new evening trips; that greater access to social activities was the number one response to the question of what activities were now made easier for existing users due to the extended operating hours; and that the majority of respondents who used the route before the hours were extended previously received a car ride from others when the service was not available. The report concludes by noting that despite conditions favoring increased public transit usage, ridership did not rise –actually declined –on routes with poor service levels, suggesting minimum service levels need to be met before a transit route can rise to the threshold of basic mobility (Loader & Stanley, 2009).

A more recent study by Wallis (2013) evaluated primarily off-peak frequency increases that occurred in several Australian cities since the mid 2000s, generally finding that evening and weekend service elasticities are significantly greater than peak hour elasticities. While some of these off-peak frequency increases may have also affected span of service, no analysis was provided to determine the elasticities of span of service changes as separated from frequency changes.

Literature Review –Summary and Implications for Research

While there appears to be widespread recognition that span of service impacts ridership in some way, few studies have been conducted that actually measure ridership changes during

unaltered hours due to a span of service change; most studies are not specifically searching for evidence of such a phenomenon. It appears that no studies meet the exact parameters of the intended research for this paper –to focus on the ridership impacts during unaltered hours from bus route span of service changes in the western or southwestern (including Texas) United States within the past 20 years, as independent from other types of service adjustments (such as frequency increases). Several case studies provide information that fulfills many of these conditions, but none meet the exact parameters. Additionally, to the extent that a ridership response to span of service changes has been measured, none of the studies identified examined the ridership implications of span of service decreases –only increases were explored. Research is needed to determine whether the limited findings of ridership increases during unaltered hours due to span of service increases also translate to ridership decreases during unaltered hours due to span of service decreases. The overall relative lack of comparable studies weighted against the potential importance of this topic confirms the need for this research project.

Unfortunately, the lack of existing research on the ridership impact during unaltered hours due to bus route span of service changes limits the comparability of findings produced by this research project. Rather than being able to offer an update or comparison to prior research, the results from this research project will need to be evaluated primarily as new information, at least in the context of the target research audience. Further, there is little prior guidance or direction regarding how best to conduct such a comparative ridership by hour analysis, and certainly nothing resembling an accepted standard for doing so. Few conventions exist in terms of how to analyze the data that will be featured in this report, although the approach employed by Currie & Loader (2009) and Veliou, Kepaptsoglou, & Karlaftis (2010) that utilizes graphs and charts to compare the ridership by hour or by multi-hour time periods both before and after a

span of service change will be borrowed to present the data and analyze the findings. While the lack of many similar studies perhaps increases the challenge of conducting this research and creates a burden of contributing to the establishment of a standardized framework for evaluation, it also provides an opportunity to make a significant contribution to this under-researched but important topic.

Methodology

To determine the extent of any impacts to ridership during unaltered hours due to a span of service change, detailed ridership by route is necessary from both before and after a candidate span of service change. The source of this data could theoretically include bus fareboxes, Automatic Passenger Counters (APCs), manual counts by operators, or an agency's smart card system; in practice, data from the first three of these sources was obtained for this research. Data was obtained in spreadsheet format (Excel) for all analyzed span changes, although in many cases significant manipulation of the data was required to produce the necessary comparisons using a mostly standardized and uniform template.

Data in the form of either ridership by hour (by route) or ridership by trip is required, and must be available for some time period both before and after a span of service change. Ideally, data would be available by month for multiple months before and after an applicable span change; in practice, data for multiple months or by season was obtained from some agencies, but many others were only able to provide one month's worth of data from prior to a span change and one month's worth of data from after a span change. To avoid seasonal fluctuations in ridership, obtaining data from the same calendar month(s) or season prior to and following a

span change was considered important; such data was successfully obtained for all analyzed agencies.

Theoretically, it was seen as optimal to obtain ridership data from about two to four months prior to a span change being implemented, with the data from after the span change therefore being about eight to ten months after implementation. These date ranges were considered optimal because using data from two to four months prior to a span change being implemented would generally ensure that any awareness or publicity about the upcoming span changes was minimized, and therefore that customers had not yet made any changes to travel habits; using data from eight to ten months after implementation would provide a reasonable amount of time for the span changes to mature, particularly in allowing potential customers to become aware of recent span increases. In practice, the data obtained from most agencies often met these parameters. Instances of analyzed data not meeting these ideal date range parameters were generally due to changes being implemented very recently; subsequent changes interfering with the analysis if such date ranges had been utilized (for example, a frequency increase being implemented nine months after a span increase); or such data simply not being available or accessible.

An approach was necessary to control for factors unrelated to the span of service change that may have affected ridership on a route being analyzed. Other types of changes, such as routing changes, fare changes, frequency changes, and significant rescheduling to improve on-time performance, may also affect ridership on a route that experienced a span of service change. Isolating the effects of the impact to ridership caused by one variable can be a very difficult endeavor. Complex, statistical-heavy approaches such as regression analyses are outside of the scope of this report, and may only offer limited value by making the research more esoteric and

difficult to understand for busy transit agency management and staff. Instead, a more basic approach of prevention was seen as the most effective means of minimizing the pollution associated with different types of service changes being evaluated together. Special effort was made to ensure that routes selected for analysis were as unaffected by non-span of service changes as possible; many routes that experienced span of service changes for which data was provided or could have been provided were rejected due to frequency, routing, or major scheduling changes that occurred simultaneously. Evaluating exclusively span changes was a top priority.

Still, to somewhat control for broader ridership trends, patronage on routes affected by a span of service change was compared to the ridership on all bus routes in a transit system to help determine the extent to which changes to span of service caused a greater ridership response (positive or negative) than was experienced on other routes. This approach, which produces *adjusted ridership* figures, helps determine whether a route that experienced a span of service change overperformed or underperformed in terms of ridership when compared to the bus system average during the measured time period. An example finding would be three routes that experienced a span of service increase that resulted in an average ridership increase of ten percent during unaltered hours compared to all other bus routes in a transit system that experienced a ridership increase of three percent during the same time period –routes with a span of service increase experienced ridership growth during unaltered hours of seven percent more than routes without a span of service increase, or an adjusted ridership increase of seven percent.

Transit agencies operating bus service in the western or southwestern (including Texas) United States in urban areas with a population of 250,000 or more and have implemented span of service changes without other types of accompanying changes were considered the targeted

agencies for this research effort. Specifically, an agency needed to have at least one bus route that experienced a span of service change of one hour or greater in the past twenty years to be eligible for further consideration in the study[3]. While some brief news searches were conducted, the effort to identify whether an agency had any bus routes that had experienced such span of service changes relied mostly on the historical knowledge of contacted agency staff.

Data Collection

The data collection process began by attempting to email all transit planners and transit agencies operating bus service in the western or southwestern (including Texas) United States in an urban area with a population of 250,000 or more. Email contacts were obtained through a variety of means; in some cases, the author used personal contacts or references, but in many cases the initial contact was made by sending a message through an agency's website or directly to general email addresses provided on such sites. In all cases, initial emails included a brief description of the research being conducted and a request to forward the message to agency staff that would be aware of past span of service changes and best able to provide applicable data relating to such changes. The initial email emphasized that the researcher is aware that agency staff may have limited time and resources and therefore intends to request only the data that is necessary for the research effort, as well as to be as flexible as possible in the timing and format of any data received. Follow-up, reminder emails were sent at least once, and in some cases multiple times through different communication channels (website comment system instead of direct emails, for example), to ensure maximum response. Phone calls were also made when

[3] Span of service changes that are as recent as possible were viewed as ideal for research. While it was expected that fairly recent examples of span of service reductions would be available, difficulty was anticipated in finding instances of span of service increases in the past several years due to budget cuts that affected many transit agencies in the late 2000s and early 2010s. As the Findings & Results section will demonstrate, there have actually been a considerable number of span increases since 2011, although data from prior periods is still considered relevant.

proper contact information through an agency's website could not be found, or when requested or preferred by agency staff.

While a large number of samples for analysis were welcomed, as it generally allows for greater confidence in the applicability of the findings to various transit agencies and operating environments, a majority response rate was not expected or required. As noted in the Literature Review, the few previous empirical studies that have been identified on this subject relied on just a single transit agency for analysis, so any contribution to the body of knowledge on this topic – especially with relatively recent examples from bus systems in the western and southwestern United States –was viewed as useful information to contemporary transit agencies and transit planners in the region. A full explanation of the responses received is provided in Findings & Results section.

Findings & Results

Multiple attempts were made to contact the 65 identified transit agencies that met the criteria outlined in the Methodology section. Of these 65 agencies, 45 responded with a minimum of an acknowledgement of the data request; 20 of the agencies did not respond in any way. Amongst the 45 responding agencies, a total of 16 agencies were able to provide data generally resembling what had been requested; reasons for close to two-third of responding agencies not being able to successfully provide data for this research are as follows:

- Four agencies had not implemented a span of service change of greater than one hour on any routes in the past twenty years, or were otherwise unaware of what past spans of service were for various routes.

- Nine agencies did not have sufficiently detailed ridership by hour or by trip data available from both before and after a bus route experienced a span of service change.
- Eleven agencies were simply too busy to provide necessary data, in many cases citing a time-consuming process being required to assemble such data, or were unable to provide the necessary data by the required deadlines.
- Two agencies required an onerous process to obtain data or were concerned about data becoming publicized, and therefore could not be of use.
- Remaining agencies were unable to provide data for at least two of the reasons listed above.

Data from 7 of the 16 agencies that attempted to provide data was either insufficient to conduct a proper analysis or the actual span changes did not qualify as good candidates for this research, generally due to accompanying frequency or routing changes. Thus, in total, nine agencies successfully provided data on 39 eligible span changes that form the basis of the remainder of this research.

Raw data received from agencies was, in some cases, edited to correct clear errors or to otherwise facilitate a proper analysis. For example, the raw hourly ridership data obtained from the Regional Transportation Commission occasionally contains some ridership from hours in which a route did not operate; this is presumed to be caused by operator error in logging on to the incorrect route through the vehicle farebox. Data from Spokane Transit Authority, also from a farebox ridership program, exhibited similar issues. Any such ridership from the routes analyzed during hours in which they could not possibly have been operating was deleted to avoid misleading results; at most, the ridership deleted averaged only a few riders per hour, a very small percentage. As another example, data from Valley Transportation Authority included

ridership on a few trips primarily designed to serve school students; these trips, while open to everyone, often fluctuated wildly in ridership before and after implementation of span changes. Susceptible to such variation and not likely to be affected in any way by span changes, data from such trips was not considered in the analysis.

Borrowing an approach utilized by Currie & Loader (2009) and Veliou, Kepaptsoglou, & Karlaftis (2010), detailed ridership by hour or by day information obtained from transit agencies was inputted into spreadsheets to produce two graphs for each span change analyzed. The first graph shows the percent change in ridership of unaltered hours after a span of service change. The second graph for each span change analyzed shows the total ridership by hour on the selected route from before and after a span change. These graphs, which follow a consistent composition, provide the full perspective of ridership changes for each hour of the service day for every analyzed change. However, perhaps as could be expected, there is a significant amount of variation in ridership and trends from one hour to the next. Therefore, in order to focus on larger patterns and trends rather than individual data points or experiences, these graphs have been placed in the appendix of this research paper. To view the full detail of each change analyzed, please see the Appendix.

The following nine tables summarize the full results for each span of service change from each agency analyzed. A variety of information needed to help understand the context of each span change is included. The right-most column, "adjusted route percent change during unaltered hours", is the most critical measurement of ridership response during unaltered hours to the span change enacted, although the adjacent "route percent change during unaltered hours" column provides a perspective on the raw, unadjusted results. A full analysis of these results by varying categories follows after the series of tables.

Table 1

Regional Transportation Commission of Southern Nevada (RTC; Las Vegas, NV) Span of Service Changes

Route/ line #	Span change type	Hours / trips directly affected	Span change duration (approx. h:mm)	Days affected	Implemented date	Before data range / after data range	Route % change	System % change	Adjusted route % change	Route % change during unaltered hours	Adjusted route % change during unaltered hours
101	Increase	01:00 - 04:00	+4:00	Everyday	22-May-2005	Feb. & Mar. 2005 / Feb. & Mar. 2006	13.9%	11.1%	2.8%	10.3%	-0.8%
106	Decrease	01:55 & 02:55 SB / 02:52 & 03:52 NB	-2:45	Everyday	28-Jun-2009	Sep. - Nov. 2008 / Sep. - Nov. 2009	-20.8%	-18.2%	-2.6%	-19.8%	-1.6%
107	Increase	02:20, 03:20, 04:20, & 05:20 SB / 02:04, 03:04, 04:04, & 05:04 NB	+4:00	Everyday	27-Apr-1997	Jan. - Mar. 1997 / Jan. - Mar. 1998	8.4%	17.6%	-9.2%	5.0%	-12.6%
207	Decrease	05:00 & 20:00 - 22:00 weekday / 06:00 & 20:00	-3:45	Everyday	20-May-2012	Jan. - Mar. 2012 / Jan. - Mar. 2013	-24.6%	1.8%	-26.4%	-16.4%	-18.2%
211	Decrease	22:00 & 23:00	-2:00	Everyday	3-Jun-2007	Feb. - Apr. 2007 / Feb. - Apr. 2008	1.1%	3.1%	-2.0%	6.1%	3.0%
211	Decrease	20:00 & 21:00	-2:00	Everyday	7-Nov-2010	Jul. - Sep. 2010 / Jul. - Sep. 2011	-4.0%	5.2%	-9.2%	3.5%	-1.7%

Note: All RTC ridership data provided is based on farebox counts by hour.

Table 2

Foothill Transit (San Gabriel Valley, CA) Span of Service Changes

Route/ line #	Span change type	Hours / trips directly affected	Span change duration (approx. h:mm)	Days affected	Implemented date	Before data range / after data range	Route % change	System % change	Adjusted route % change	Route % change during unaltered hours	Adjusted route % change during unaltered hours
178	Increase	20:00 - 22:00	+3:00	Weekends	24-Nov-2013	Jan. & Feb. 2013 / Jan. & Feb. 2014	15.8%	22.2%	-6.4%	10.7%	-11.5%
195	Increase	10:35 - 12:45	+3:00	Weekdays	24-Nov-2013	Jan. & Feb. 2013 / Jan. & Feb. 2014	69.1%	22.2%	46.9%	32.2%	10.0%
285	Increase	10:45, 11:45, & 20:45	+3:00	Weekdays	24-Nov-2013	Jan. & Feb. 2013 / Jan. & Feb. 2014	63.7%	22.2%	41.5%	47.9%	25.7%
286	Increase	20:00 - 22:00	+3:00	Weekdays	24-Nov-2013	Jan. & Feb. 2013 / Jan. & Feb. 2014	27.2%	22.2%	5.0%	21.4%	-0.8%
289	Increase	10:15, 11:15, 12:15, & 19:15	+4:00	Weekdays	24-Nov-2013	Jan. & Feb. 2013 / Jan. & Feb. 2014	109.5%	22.2%	87.3%	52.6%	30.4%
291	Increase	19:30 - 21:30	+2:30	Weekends	24-Nov-2013	Jan. & Feb. 2013 / Jan. & Feb. 2014	12.2%	22.2%	-10.0%	2.6%	-19.6%
488	Increase	19:30 - 21:30 WB / 20:00 - 22:00 EB	+3:00	Weekends	24-Nov-2013	Jan. & Feb. 2013 / Jan. & Feb. 2014	33.0%	22.2%	10.8%	26.6%	4.4%
492	Increase	19:00 - 21:00	+2:40	Weekends	24-Nov-2013	Jan. & Feb. 2013 / Jan. & Feb. 2014	46.5%	22.2%	24.3%	37.0%	14.8%

Note: All Foothill Transit ridership data provided is based on farebox counts by hour.

Table 3

Valley Transportation Authority (VTA; San Jose, CA) Span of Service Changes

Route/ line #	Span change type	Hours / trips directly affected	Span change duration (approx. h:mm)	Days affected	Implemented date	Before data range / after data range	Route % change	System % change	Adjusted route % change	Route % change during unaltered hours	Adjusted route % change during unaltered hours
16	Decrease	09:00 - 13:00	-4:12	Weekdays	9-Jan-2012	October 2011 / October 2012	-28.0%	4.9%	-32.9%	-20.3%	-25.2%
37[a]	Increase	Saturday (entire day)	All Day	Saturdays	11-Jul-2011	April 2011 / April 2012	-2.9%	-3.2%	0.3%	-2.9%	0.3%
45	Decrease	18:40 - 19:40 & Saturdays (entire day)	-1:00 / All Day	Weekdays / Sat.	9-Jan-2012	October 2011 / October 2012	2.9%	4.9%	-2.0%	7.4%	2.5%
81[b]	Decrease	Sunday (entire day)	All Day	Sundays	9-Jan-2012	October 2011 / October 2012	-5.7%	4.9%	-10.6%	-5.7%	-10.6%
201	Increase	19:15 - 21:15	+2:05	Weekdays	8-Jul-2013	October 2012 / October 2013	4.0%	-1.1%	5.1%	-0.4%	0.7%

[a]Span change involved the addition of Saturday service; changes to weekday ridership are shown.

[b]Span change involved the elimination of Sunday service; changes to weekday ridership are shown.

Note: All VTA ridership data provided is based on Automated Passenger Counters (APCs) by trip.

Table 4

King County Metro (Seattle, WA) Span of Service Changes

Route/ line #	Span change type	Hours / trips directly affected	Span change duration (approx. h:mm)	Days affected	Implemented date	Before data range / after data range	Route % change	System % change	Adjusted route % change	Route % change during unaltered hours	Adjusted route % change during unaltered hours
101 Inbnd	Increase	19:59, 20:29, & 20:59	+1:30	Weekdays	16-Feb-2002	Fall 2001 / Fall 2002	-1.0%	-4.3%	3.3%	-3.1%	1.2%
101 Outbnd	Increase	05:45, 06:02, 06:30, 21:03, 21:33, & 22:03	+2:31	Weekdays	16-Feb-2002	Fall 2001 / Fall 2002	5.2%	-4.3%	9.5%	-0.9%	3.4%
139	Decrease	04:52, 21:45, 22:15, & 22:45	-2:15	Weekdays	13-Feb-2010	Fall 2009 / Fall 2010	0.0%	0.3%	-0.3%	0.7%	0.4%
139	Decrease	20:18, 20:47, & 21:15	-1:24	Weekdays	2-Jun-2012	Fall 2011 / Fall 2012	18.3%	6.3%	12.0%	20.1%	13.8%
234	Increase	18:48, 19:51, & 20:51 Inbound / 19:24, 19:54, & 20:54 Outbound	+2:30	Weekdays	17-Feb-2007	Fall 2006 / Fall 2007	16.1%	6.2%	9.9%	10.1%	3.9%

Note: All King County Metro ridership data provided is based on Automated Passenger Counters (APCs) by trip.

Table 5

Lane Transit District (LTD; Eugene / Springfield, OR) Span of Service Change

Route/ line #	Span change type	Hours / trips directly affected	Span change duration (approx. h:mm)	Days affected	Implemented date	Before data range / after data range	Route % change	System % change	Adjusted route % change	Route % change during unaltered hours	Adjusted route % change during unaltered hours
33	Decrease	20:45 & 21:45	-2:00	Weekdays	19-Sep-2010	October 2009 / October 2011	3.4%	1.5%	1.9%	7.3%	5.8%

Note: All LTD ridership data provided is based on Automated Passenger Counters (APCs) by trip.

Table 6

Paso Express (Paso Robles, CA) Span of Service Changes

Route/ line #	Span change type	Hours / trips directly affected	Span change duration (approx. h:mm)	Days affected	Implemented date	Before data range / after data range	Route % change	System % change	Adjusted route % change	Route % change during unaltered hours	Adjusted route % change during unaltered hours
A	Decrease	07:00 & 18:00	-2:00	Saturdays	18-Aug-2012	July 2012 / July 2013	0.5%	25.6%	-25.1%	11.6%	-14.0%
B	Decrease	07:00 & 18:00	-2:00	Saturdays	18-Aug-2012	July 2012 / July 2013	-10.1%	25.6%	-35.7%	0.2%	-25.4%

Note: All Paso Express ridership data provided is based on manual operator counts by hour.

Table 7

Regional Transit (Sacramento, CA) Span of Service Changes

Route/ line #	Span change type	Hours / trips directly affected	Span change duration (approx. h:mm)	Days affected	Implemented date	Before data range / after data range	Route % change	System % change	Adjusted route % change	Route % change during unaltered hours	Adjusted route % change during unaltered hours
11	Increase	18:00	+1:00	Weekdays	2-Sep-2012	Feb. - July 2012 / Feb. - July 2013	12.6%	1.4%	11.2%	6.9%	5.5%
21	Decrease	21:00 & 22:00	-1:20	Weekdays	20-Jun-2010	Nov. 2009 - April 2010 / Nov. 2010 - April 2011	-1.9%	-14.9%	13.0%	-0.1%	14.8%
21	Increase	21:00 & 22:00	+1:05	Weekdays	2-Sep-2012	Feb. - July 2012 / Feb. - July 2013	2.1%	1.4%	0.7%	-0.3%	-1.7%
24	Increase	06:00, 06:50, 18:14, & 19:10 Inbound / 06:21, 17:45, & 18:41 Outbnd	+3:40	Weekdays	6-Jan-2013	July - Dec. 2012 / July - Dec. 2013	23.6%	4.6%	19.0%	3.6%	-1.0%
80	Increase	21:00	+1:00	Weekdays	2-Sep-2012	Feb. - July 2012 / Feb. - July 2013	7.1%	1.4%	5.7%	3.9%	2.5%
81	Decrease	21:00 & 22:00	-1:30	Weekdays	20-Jun-2010	Nov. 2009 - April 2010 / Nov. 2010 - April 2011	-1.4%	-14.9%	13.5%	0.9%	15.8%
81	Increase	21:00	+1:00	Weekdays	2-Sep-2012	May - July 2012 / May - July 2013	6.8%	1.1%	5.7%	5.0%	3.9%
82 Outbnd	Decrease	21:00	-1:00	Weekdays	20-Jun-2010	Nov. 2009 - April 2010 / Nov. 2010 - April 2011	0.7%	-14.9%	15.6%	3.5%	18.4%

Note: All Regional Transit ridership data provided is based on Automated Passenger Counters (APCs) by trip.

Table 8

Spokane Transit Authority (Spokane, WA) Span of Service Changes

Route/ line #	Span change type	Hours / trips directly affected	Span change duration (approx. h:mm)	Days affected	Implemented date	Before data range / after data range	Route % change	System % change	Adjusted route % change	Route % change during unaltered hours	Adjusted route % change during unaltered hours
2[a]	Increase	19:00 - 22:00 & Weekends (All Day)	+4:10 / All Day	Weekdays / Weekends	18-Sep-2011	July & August 2011 / July & August 2012	-1.3%	3.2%	-4.5%	-6.1%	-9.3%
32	Increase	20:00 & 21:00	+2:00	Saturdays	15-Jan-2012	Nov. - Dec. 2011 / Nov. - Dec. 2012	23.6%	2.2%	21.4%	19.9%	17.7%
98	Increase	21:00	+1:00	Saturdays	15-Jan-2012	Nov. - Dec. 2011 / Nov. - Dec. 2012	15.8%	2.2%	13.6%	13.4%	11.2%

[a]Span change involved the addition of Saturday & Sunday service; changes to weekday ridership are shown.

Note: All Spokane Transit Authority ridership data provided is based on farebox counts by hour.

Table 9

Riverside Transit Agency (RTA; Riverside County, CA) Span of Service Change

Route/ line #	Span change type	Hours / trips directly affected	Span change duration (approx. h:mm)	Days affected	Implemented date	Before data range / after data range	Route % change	System % change	Adjusted route % change	Route % change during unaltered hours	Adjusted route % change during unaltered hours
15 WB	Increase	19:00 - 21:00	+2:30	Weekdays	8-Sep-2013	Oct. - Dec. 2012 / Oct. - Dec. 2013	9.2%	0.2%	9.0%	3.1%	2.9%

Note: All RTA ridership data provided is based on Automated Passenger Counters (APCs) by trip.

Results by Span Change Type

As Tables 1 through 9 indicate, a total of 24 span increases and 15 span decreases were analyzed. Of the 24 span increases, ridership increased by an average of 12.4% during unaltered hours; 18 of the 24 samples experienced ridership increases during unaltered hours while six samples actually posted a decrease, although the decrease in three of those six samples was negligible (less than one percent). When adjusted to account for systemwide ridership changes, the percent increase during unaltered hours drops to 3.4%; adjusted ridership during unaltered hours increased in 16 of the 24 samples while decreasing in the other eight cases, although the decrease in three of the cases and the increase in two of the cases was one percent or less.

Of the 15 span decreases that were analyzed, ridership (unadjusted) during unaltered hours was essentially unchanged on average, decreasing by just 0.1%; 10 of the 15 samples experienced ridership increases during unaltered hours while five samples posted a decrease, although three of the increases and one of the decreases were less than one percent. When adjusted to account for systemwide ridership changes, the percent change during unaltered hours becomes -1.5%; adjusted

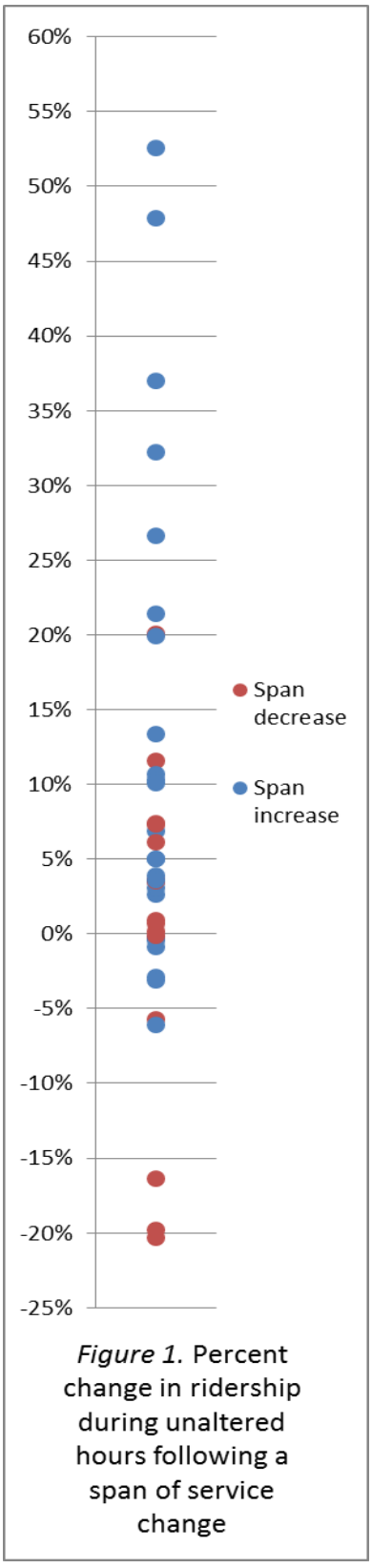

Figure 1. Percent change in ridership during unaltered hours following a span of service change

ridership during unaltered hours increased in eight while decreasing in seven of the 15 analyzed cases (one of those increases was less than one percent).

Within both categories, however, individual samples exhibited a wide range of results; this is illustrated by Figures 1 and 2, which show the distribution of percent changes in ridership (unadjusted and adjusted) following a span change. While the average span increase resulted in adjusted ridership increases during unaltered hours of 3.4%, this average was comprised of experiences ranging from a 30.4% increase for Foothill Transit Route 289 to a 19.6% decrease for Foothill Transit Route 291. As noted above, while adjusted unaltered ridership increased amongst two-thirds of the samples analyzed, 8 of the 24 span increase actually experienced a ridership decline during unaltered hours when adjusted for systemwide ridership changes; in 5 of these 24 instances, the decline was more than 1%. These five instances of an adjusted ridership decline during unaltered hours after a span of service increase could be considered counter-intuitive results, as the expectation would be that adjusted ridership during unaltered hours would at least remain neutral (if not increase) when a span change takes place. Similarly, although the average was a fairly small 1.5% decrease, span decreases resulted in adjusted ridership changes during unaltered hours ranging from a 25.4%

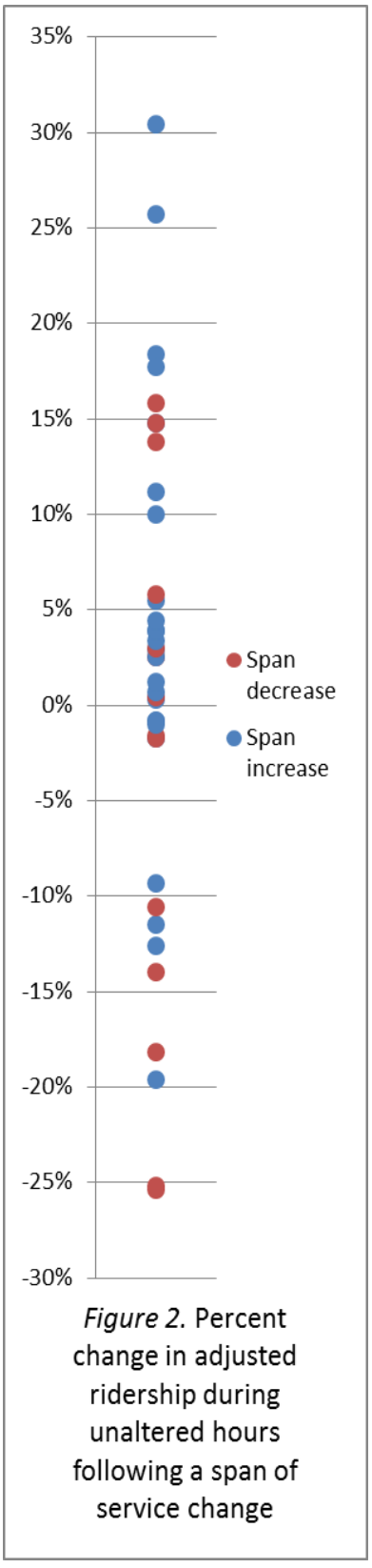

Figure 2. Percent change in adjusted ridership during unaltered hours following a span of service change

decline for Paso Express Route B to an 18.4% increase for Regional Transit Route 82 outbound. Adjusted ridership during unaltered hours decreased by more than one percent in 7 of the 15 span decrease samples analyzed, but also increased by more than one percent in seven other span decrease samples (the last remaining sample experienced a negligible increase). Thus, it could be said that seven instances (47%) of the span decreases analyzed exhibited counter-intuitive results by actually demonstrating a ridership increase during unaltered hours, once adjusted for systemwide ridership changes.

Results by Agency

Many agencies were only able to provide data on one or a few span of service increases or decreases, making it especially difficult to ascribe much of an agency-level trend to the results, so findings in this section are necessarily limited. In general, agencies varied significantly in the response observed to span of service changes, based on these very limited samples.

On average, Foothill Transit, which operates in the San Gabriel Valley of eastern Los Angeles County, experienced the greatest increase in ridership during unaltered hours following a span of service increase. For Foothill Transit, these span increases occurred at a time when systemwide ridership was also experiencing strong increases –overall system ridership increased by 22.2% in the one year period between January and February 2013 to January and February 2014. On average, the eight Foothill Transit routes that received a span increase during the study period experienced a 28.9% increase in ridership during unaltered hours, meaning the adjusted increase for routes experiencing a span of service improvement was 6.7%. It is worth noting that Foothill Transit implemented the largest set of span of service improvements on a single date of

any transit agency that was able to successfully provide data for this research. Foothill Transit was also the only agency studied to implement a span of service increase during mid-day hours, with weekday mid-day service added on three routes. Still, not all eight of the span increases implemented by Foothill Transit resulted in ridership increases during unaltered hours after adjusting for the large gains in systemwide ridership –two of the six routes actually experienced a decrease in ridership during unaltered hours after adjusting for the 22.2% systemwide ridership gains, while a third route was essentially unchanged. These results may change, however, as more time after implementation has passed; in contrast to most agencies, data used to evaluate ridership after the span change was from just one and a half to three and a half months after implementation, meaning the increases had little time to mature and potentially attract more ridership. This limitation of the Foothill Transit data, which was simply due to the relatively recent implementation of these changes, means that the strong increases should be regarded as particularly impressive. A follow-up study would be necessary to determine the full extent of ridership increases that these routes will experience.

After the eight span increases for which Foothill Transit provided data, the next agency able to provide the greatest number of samples from exclusively span increases or span decreases was Regional Transit in Sacramento, California. Regional Transit provided data for five span increases, four of which occurred in September 2012 while the fifth occurred in January 2013. All of these increases affected weekday evening service, and three of the five involved a partial or full restoration of a span of service that was reduced just over two years prior –a condition that was unique amongst the studied span changes. On average, ridership on the five routes during unaltered hours increased by 3.8%, or 1.8% after adjusting for an average 2% systemwide ridership increase. Still, while most routes experienced modest increases during unaltered hours,

one of the five routes actually experienced a ridership decrease during unaltered hours after accounting for systemwide ridership changes. Overall though, it can be said that Regional Transit routes that experienced a span increase also recorded noticeable ridership increases during unaltered hours.

The agency that provided the largest number of samples of span decreases was the Regional Transportation Commission of Southern Nevada (RTC). Of the four samples provided, ridership decreased by an average of 4.6% during unaltered hours after adjusting for systemwide ridership changes. However, similar to the increases implemented by other agencies, results varied significantly, with adjusted route ridership on one route actually increasing by 3.0% during unaltered hours while another route experienced an 18.2% decline. The other two routes experienced very modest declines of 1.6% and 1.7% during unaltered hours after adjusting for systemwide ridership changes.

Paso Express service, located in the city of Paso Robles, California (near San Luis Obispo) experienced a sharp decline of 19.7% in adjusted ridership during unaltered Saturday hours after eliminating service during the 7 a.m. and 6 p.m. hours on Saturdays. However, the comparative decline is due to systemwide ridership increasing by 25.6% during the date range studied; unadjusted for the systemwide ridership increase, ridership during unaltered hours actually increased by 5.9%. This data means ridership during unaltered hours on Saturdays simply did not increase by nearly as much as ridership on Weekdays during the studied date range.

The remaining agencies were able to provide no more than three instances of span increases or span decreases, meaning analysis is best focused on reviewing results by other categories combined with data from other agencies.

Results by Time of Day Affected

The span changes enacted can be divided into six logical categories based on the time periods affected. These six categories are listed below, along with the quantity of samples from each time period, although note that individual samples can belong to multiple affected time periods:

- Start of the service day (first trips): two increases, four decreases
- End of the service day (last trips): 18 increases, 12 decreases
- Middle of the service day (trips between traditional morning and afternoon peak hours): three increases, one decrease
- Overnight service (new/former 24-hour service): two increases, one decrease
- Saturday service (entire day): two increases, one decrease
- Sunday service (entire day): one increase, one decrease

As the above list demonstrates, span changes that affected the end of the service day (last trips) were by far the most common amongst the analyzed samples. Due to the dominating prevalence of span changes affecting the end of the service day, the trends amongst this group largely mirror those discussed by span change type (span increase or span decrease). Span changes affecting the end of the service day actually demonstrated slightly stronger counter-intuitive results than span increases or span decreases as a whole; on average, adjusted ridership increased by 1.6% during unaltered hours (or an 8.5% unadjusted increase during unaltered

hours) in the 18 span increases affecting the end of the service day, but adjusted ridership also increased by 1.3% during unaltered hours (or a 3.7% unadjusted increase during unaltered hours) in the 12 span decreases that affected the end of the service day.

Perhaps the most notable results regarding a particular time period come from samples analyzed during the middle of the service day. While the sample is very small (just three increases and one decrease), all three of the span increases that involved launching mid-day service and thereby eliminating gaps in service between morning and afternoon peak hours experienced a large increase in adjusted ridership during unaltered hours, averaging a 22% increase, or a dramatic 44.2% increase during unaltered hours without adjusting for systemwide ridership changes. Similarly, the one available sample of a span decrease during mid-day hours (eliminating service between the traditional morning and afternoon peak) experienced a 25.2% decline in adjusted ridership during unaltered hours (20.3% unadjusted decrease during unaltered hours).

Results by other time periods affected generally offered mixed or conflicting results, likely due to the very small sample sizes. Additionally, span changes during certain times of day, particularly those affecting the start of the service day, often or exclusively occurred along with span changes during other times of day as well, making it difficult or impossible to isolate the effects of the changes to these specific time periods.

Results by Span Change Duration

The magnitude of change to the span duration could theoretically affect the ridership response during unaltered hours; it is perhaps logical to expect that a span increase or decrease of several hours may have more of an effect on ridership during unaltered hours than a span

increase or decrease of just one hour (the minimum for inclusion in this research). The actual results seem to perhaps support this theory.

To examine this issue, span increases and span decreases were separated. Span increases were then divided into halves, based on the span change duration. Of the 24 span increases analyzed, the half (12) that received the greatest span increases (more than two and a half hours) experienced the greatest increase in adjusted ridership during unaltered hours, increasing by an average of 4.1% (19.9% unadjusted increase during unaltered hours). By comparison, the other half of span increase samples that received smaller span increases (two and a half hours or less) experienced smaller increases in adjusted ridership during unaltered hours, increasing by an average of 2.6% (5.0% unadjusted increase during unaltered hours). Thus, larger span of service increases experienced significantly larger increases in ridership during unaltered hours than smaller span of service increases.

Regarding span decreases, the difference in ridership response between the most affected versus the least affected routes was much more vivid. Of the 15 span decreases analyzed, the one-third (five) that received the greatest span decreases (more than 2 hours and 15 minutes) experienced a sharp 11.0% decline in adjusted ridership during unaltered hours (12.3% unadjusted decrease during unaltered hours). By contrast, the one-third (five) smallest span of service decreases (one and a half hours or less) actually experienced a 13.1% increase in adjusted ridership during unaltered hours (6.4% unadjusted increase during unaltered hours). The middle one-third of span decreases (those that experienced a span decrease of two hours) when arranged in order of span change duration experienced a 6.5% decline in adjusted ridership during unaltered hours (but a 5.7% unadjusted increase during unaltered hours), which is in between the results of the highest and lowest one-thirds of samples. Thus, the largest span of service

decreases experienced significantly greater adjusted ridership loss during unaltered hours than smaller span decreases.

Results for Last Unaltered Hour of Service for Each Change

Thus far, the results discussed have pertained to all unaltered hours for the entire service day. However, it could be reasoned that the experiences of ridership during the last hour of unaltered service prior to an evening span increase or span decrease may produce different results than other unaltered hours of the day. As discussed on Page 9, logical arguments could be made that ridership may increase in the last unaltered hour of the service day prior to a span change, but other logical arguments could suggest a ridership decrease during such hours. The data collected as part of this research allows the first known attempt to be made to answer this question.

Data from the 12 analyzed span decreases that partially or exclusively involved evening service shows an average adjusted increase in ridership of 3.4% during the last hour of unaltered service after adjusting for systemwide ridership changes, or a 5.8% increase without such adjustments. However, the variation amongst the 12 changes that meet this criterion is very high; changes in adjusted ridership during the last unaltered hour ranged from a 54.6% decrease for Paso Express Route A to a 63.7% increase for Lane Transit District Route 33. The standard deviation of these 12 decreases was 30.4% based on adjusted ridership, or 26.2% based on unadjusted ridership, representative of the wide range of experiences recorded.

Ridership during the last unaltered hour of evening service prior to a span of service increase experienced a similarly wide range of results, but was much higher overall. Of the 18 analyzed span increases that partially or exclusively involved evening service, adjusted ridership

during the last unaltered hour experienced an average ridership increase of 12.7%; unadjusted ridership during the last unaltered hour increased by 19.6%. Again though, individual results varied wildly, ranging from a 43% adjusted decrease for Foothill Transit Route 291 to a 124.8% adjusted increase for Spokane Transit Route 32. The standard deviation of these 18 increases was 35.6% based on adjusted ridership, or 36.3% based on unadjusted ridership.

Difference between Adjusted and Unadjusted Ridership

It is extremely important to stress the difference between adjusted and unadjusted increases during unaltered hours. The results that have been discussed above are based on adjusted ridership, which in many cases significantly reduces the change in ridership on the routes analyzed. As noted above, the actual increase in ridership during unaltered hours for routes that experienced a span increase was a strong 12.4%; this is what customers and operators on unaltered trips would have observed. However, systemwide ridership increased by an average of 9.1% between the same dates, thus the adjusted increase during unaltered hours was a much more modest 3.4%.

While adjusting for systemwide ridership changes helps avoid overstating the change in ridership that routes experiencing a span change may have encountered, it also introduces some new potential complications. The reasons for overall systemwide ridership changes were outside the scope of this research. If a bus system had implemented significant service increases, such as higher frequencies or new routes, between the date ranges studied, the increase in systemwide ridership would be partially related to those increases in service. The span changes studied, then, would be adjusted based on systemwide changes that themselves included increased service. However, even in such a scenario, it would not be reasonable to compare routes that experienced

span changes to routes that had experienced no changes, as even routes that experienced no direct changes could have likely benefitted from network improvements to other routes (for example, if frequency on one route is increased, it may somewhat increase ridership on an intersecting route, as more customers attracted to use the first route also make use of the second route). It is therefore possible that the process of adjusting the ridership on routes that underwent a span change by accounting for systemwide ridership changes may somewhat understate the increase or decrease in ridership that routes undergoing a span change experienced. It is partially due to this possibility that the results of the span changes analyzed as part of this research have included both adjusted and unadjusted ridership changes during unaltered hours.

Analysis and Conclusion

Regarding the central question of this research –to what extent bus route span of service changes affect ridership during unaltered hours –the considerable evidence presented in this paper suggests that ridership does, on average, increase during unaltered hours when span of service is increased. As noted, routes that experienced a span increase recorded a 3.4% increase in adjusted ridership during unaltered hours, based on an average of the 24 samples collected, or a 12.4% increase in ridership during unaltered hours if the results are not adjusted to account for systemwide ridership changes. However, the evidence demonstrates that routes experiencing a span of service decrease encountered much more modest ridership changes. Routes that experienced a span decrease recorded a fairly small 1.5% decrease in adjusted ridership during unaltered hours, based on an average of the 15 samples collected, or almost no change (-0.1%) if the results are not adjusted for systemwide ridership changes. Thus, while there was a

considerable degree of variation amongst the 15 span decreases analyzed, it would be fair to conclude that on average, there was little to no change in ridership during unaltered hours on most routes when spans of service was decreased.

There are several possible explanations for why ridership during unaltered hours might actually increase when the span of service on a route is reduced. One seemingly plausible and simple explanation may be that riders that previously used the route during hours that were eliminated –in most cases, a small percentage of the total ridership on the route - were now instead using the service during hours that were unaltered. In such a case, ridership increases during unaltered hours because riders just shift to those trips when service is eliminated. Such a scenario may be possible or amenable for some customers, but others may not have a choice or may be unwilling to shift their travel patterns.

Another explanation may be that other changes implemented throughout the transit system during the date ranges studied caused a small percentage of riders from other transit lines to shift to the analyzed routes. This certainly seems plausible when agencies are making significant service cuts, as such reductions often affect a wide range of routes offered by a transit provider. For example, if an agency significantly reduced the frequency on a nearby parallel route to a route that experienced a span decrease that was part of this analysis, it would likely result in some riders from the parallel line shifting to the route that had experienced a span decrease. In a more extreme example, a nearby parallel line or a line that serves the same key destinations as a route that experienced a span decrease could be eliminated, in which case ridership would logically increase during unaltered hours on a route that experienced a span decrease.

A third explanation could be that the attention and publicity associated with a service reduction or package of service reductions actually helped increase interest, and ultimately ridership, on routes that experienced a span decrease. This phenomenon was actually observed by Houston Metro, where it was repeatedly found that ridership often increased noticeably following a publicized service cut, especially on routes anchored by a park and ride (J. Archer, personal communication, April 17, 2014). This theory for ridership increase, however, requires that a service cut receive substantial attention and publicity; logically, it also requires that the service cut not be too severe so as to make the service unattractive to new customers.

Finally, perhaps the simplest explanation is that natural variations in ridership or days sampled (in the case of APC-based data where only a portion of the fleet is equipped with the devices) produced the appearance of a response that was never truly present. Average daily ridership often varies by a few percent from day to day, as many riders do not use the same routes or trips every weekday (or every Saturday or Sunday). Additionally, some agencies that supplied data originating from APCs do not have devices installed on all vehicles, meaning trips may have only been sampled for a portion of the date ranges for which data was provided; this is known to have been the case with King County Metro, which reported that only about 15% of the vehicles in the fleet were APC-equipped at the time (T. Day, personal communication, May 12, 2014). Natural variation generally is most likely to affect routes with lower overall ridership, as the presence or absence of just a handful of riders could potentially create the false appearance of a particular ridership response. However, more significant ridership changes likely cannot be explained away by natural variation.

Agency staff responses regarding why routes that experienced span decreases instead recorded ridership increases varied. Martin Barna, Transit Service Development Specialist at

VTA, where Route 45 experienced a 2.5% increase in adjusted ridership during unaltered hours, or a 7.4% increase in unadjusted ridership during unaltered hours, after the elimination of Saturday service and one hour of evening weekday service, offered a different explanation for ridership changes observed: routes that connect with Route 45 had received notable improvements between the date ranges studied, thereby making Route 45 more attractive in the process. A small percentage of ridership attracted to other improvements in the VTA system would also now make increased use of Route 45 as well (personal communication, May 15, 2014).

Kenneth Augustson, Transit Planner at LTD, where Route 33 experienced a 5.8% increase in adjusted ridership during unaltered hours, or a 7.3% increase in unadjusted ridership during unaltered hours, after the elimination of two hours of evening service, speculated that many of the riders on Route 33 likely just shifted onto what now became the last trip of the evening, two hours earlier (personal communication, May 14, 2014). Indeed, the ridership by trip data seems to support this theory, as ridership on what would become the last trip after the span reductions took place increased from 11 to 18 daily riders, which represented the largest percent increase during the last unaltered hour of the 12 analyzed span decreases that involved evening service. Mr. Augustson noted that although there was some media attention as part of the public outreach process, Route 33 is a small neighborhood circulator route with a limited ridership base, and thus the increased attention was likely not a factor contributing to the ridership increase (personal communication, May 14, 2014).

Ted Day, Transportation Planner III at King County Metro, where Route 139 experienced a 13.8% increase in adjusted ridership during unaltered hours, or a 20.1% increase in unadjusted ridership during unaltered hours, after elimination of one and a half hours of evening service,

suggested that the ridership increase may have just been due to random sampling variation, as only about 15% of King County Metro buses featured the devices at the time (personal communication, May 12, 2014). Similar to LTD Route 33, King County Metro Route 139 is a short, low ridership neighborhood loop route with only a few dozen trips per day, making it especially susceptible to natural variations in ridership, as a change in a dozen or so riders represents a significant percentage of total boardings.

James Drake, Service Planner at Regional Transit in Sacramento, California, where Route 82 outbound experienced an 18.4% increase in adjusted ridership during unaltered hours, or a 3.5% increase in unadjusted ridership during unaltered hours, after elimination of one hour of evening service, noted that a change implemented simultaneously on nearby Route 34 may have increased ridership on Route 82 throughout the day, especially when college students were commuting (personal communication, May 27, 2014). Regional Transit's other two routes that experienced an evening span decrease at the same time as Route 82 also experienced similar results; in those cases, adjusted ridership during unaltered hours still increased by about 15%, but unadjusted ridership during unaltered hours experienced little change. Thus, in Regional Transit's case, the appearance of strong adjusted ridership increases during unaltered hours following a span decrease is heavily influenced by the magnitude of the ridership decline that the overall Regional Transit system experienced during the date ranges studied.

These responses indicate that no one single explanation is universally applicable when ridership increases during unaltered hours following a span decrease, although most agency respondents did not feel that the publicity factor of additional attention was a significant contributor in their particular span decreases. It is also important to remember that while some

agencies encountered ridership increases during unaltered hours after span decreases, several others did experience significant ridership loss.

The fact that ridership increased slightly on the last unaltered trips prior to an evening span of service decrease suggests that at least some customers do in fact simply shift to an earlier trip when their preferred trip is eliminated. However, the modest increase in ridership on such trips is not nearly enough to compensate for the loss of ridership from all of the riders that previously used trips that were eliminated; adjusted ridership increased by 3.4% on the last unaltered trips of the evening following an evening span decrease, but overall adjusted ridership (including both altered and unaltered hours) on the same routes decreased by 3.7%. Additionally, agencies must still recognize that such a modification in riding behavior, to the extent that it occurs, is by definition not the preferred choice of customers.

Notably, the observed ridership growth on the last unaltered trips prior to a span increase was actually much higher than in instances of span decreases. This indicates that when span of service is extended, many of the customers traveling on the newly added hours of service are making trips that previously did not occur on transit; ridership was added, rather than just shifting away from what were previously the last trips of the evening. Again, this is consistent with the results observed from the Athens, Greece and Melbourne, Australia cases discussed in the Literature Review. These results, combined with the overall adjusted increase in ridership during all unaltered hours of 3.4%, or 12.4% without adjusting for systemwide ridership changes, suggests that span of service increases are a reasonably effective means of growing overall transit ridership.

The implementation of a dramatic bus service investment initiative with a major focus on increasing service span, as was implemented by Melbourne, Australia and analyzed by Currie & Loader (2009) and Loader & Stanley (2009), has been quite rare in the western and southwestern United States in the past twenty years (at least to the extent that detailed before and after data is available). The largest set of service span increases without other accompanying types of changes that any single agency that responded was able to provide data for was the eight routes improved by Foothill Transit in November 2013. No data within the regional and time filters applied to this research was found of any comparability to the Melbourne experience of dramatically increasing the service span on dozens of routes; indeed, it perhaps the rarity of such experiences that contributes to the relative dearth of information on this subject. Still, while a larger sample size would be helpful, especially when attempting to filter by various categories of span changes (by span change type, time of day affected, etc.), the scope of data successfully gathered for this research represents the largest known collection of exclusively bus route span of service changes –without other types of changes – for transit systems in the United States.

Interestingly, of the agencies studied, the agency that implemented the greatest number of span increases, with the greatest duration of hours added, is also the agency that experienced the greatest overall ridership response to span increases: Foothill Transit. A key question for potential future research is whether implementation of a package of span improvements of several hours on multiple routes produces some type of synergistic effect that results in greater ridership gains than would have occurred if the changes were implemented individually; is the whole greater than the sum of its parts? Unfortunately, due to the rarity of data (and experiences) of such large scale span increases without other accompanying types of changes, a broader search of agencies –likely including at least the entire United States, if not

internationally –would be necessary to better investigate this hypothesis. Still, considering that the closest example of a package of improvements resembling the Melbourne experience produced similarly impressive ridership increase results, it seems there is reason to suspect a strong ridership response from a large package of span of service increases.

How should agencies for which this research is intended view the potential ridership impacts of span of service changes? As discussed, this research demonstrates that on average, ridership during unaltered hours increases noticeably following a span of service increase but decreases very modestly, if at all, following a span of service decrease. However, it is very important to recognize that this research examined specifically the ridership impacts on unaltered hours; total ridership on affected routes –meaning ridership that includes the altered hours for which service was added or eliminated –changes by much more than unaltered hours. Overall adjusted ridership on routes that experienced a span decrease declined by 6.1%, whereas overall adjusted ridership on routes that experienced a span increase saw growth of 12.6%. Indeed, it is the hours that are directly affected by span changes –when customers either lose or gain service – that have an obvious and critical effect on riders, and are the traditional focus of study regarding span of service changes; this research regarding ridership impacts on unaltered hours in no way seeks to diminish or distract from the importance of that topic. Rather, this research simply attempted to determine if there is another factor to consider –ridership impacts to unaltered hours, instead of just hours directly altered –when evaluating a potential span of service change. When evaluating potential span changes, agencies should primarily consider the direct impacts to customers, either in the form of reduced or enhanced mobility, and then consider the potential changes to ridership during unaltered hours explored in this research as a form of secondary guidance.

The research results outlined in this paper provide guidance on some factors that may help increase the ridership response during unaltered hours following a span of service change. Span of service changes where mid-day service is introduced or eliminated exhibited the greatest changes in ridership during unaltered hours; this suggests agencies should prioritize mid-day span increases, or the preservation of mid-day service when considering span decreases, to achieve the largest possible ridership gains (or avoid the largest ridership reductions) during unaltered hours. It also appears that large packages of span increases produce the strongest possible ridership response; agencies should perhaps consider bundling several span of service increases into a marketable package for which some positive publicity can be gained. Furthermore, span of service changes of a greater duration experienced larger ridership changes during unaltered hours, therefore agencies should consider significant span of service increases – by more than two hours –whenever the opportunity is available, although it is recognized that larger span increases will also involve larger increases in operating costs. Such significant improvements could also contribute to the marketability of the changes, as alluded to above. It must be emphasized that these are all factors that routes experiencing the largest ridership increases following span of service increases all had in common; it is in no way a statement of direct cause and effect.

In conclusion, transit agencies must closely consider the specifics of any potential span of service change to determine how ridership might be affected. As noted, the potential ridership impacts during unaltered hours that have been explored in this research should be considered secondary to the primary impacts of customers affected by span reductions or benefitting from span increases. The transit needs of each community differ; varying economies and lifestyles

necessitate varying spans of service. However, this research, if used properly, can help aid agencies considering span of service changes.

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Appendix

The graphs in this Appendix illustrate ridership change by hour during unaltered hours and total ridership by hour for each of the 39 span changes that are analyzed as part of this research effort. Summarized information about each of these changes can be found in Tables 1 through 9 in the Findings & Results section of this paper.

The first graph for each span change illustrates the actual percent change in ridership along with an *adjusted* percent change in ridership, which is the percent change in ridership during the hour listed plus the percent change in overall bus ridership for the transit system for which the route belongs. For example, if a given hour on a route experiences a 4% increase in ridership following a span of service change but the systemwide bus ridership for that agency increased 1.5% between the before and after measurements, the adjusted percent change would be a 2.5% increase; it could be said that the route outperformed the systemwide average change in ridership by 2.5% in that time period. Likewise, if ridership during a certain hour on a route experiences a 6% decrease after a span of service change while the systemwide bus ridership for that agency decreased by 2% between the before and after measurements, the adjusted percent change would be -4%; it could be said that the route underperformed the systemwide average bus route by 4% in that time period. Note that the change in systemwide bus ridership used to calculate the adjusted percentages reflects the change in total monthly (or multi-month) ridership for all hours –it does not reflect the percent change in average system ridership during just the single hour being analyzed; it is the same value for all hours.

The second graph for each span change analyzed shows the total ridership by hour on the selected route from before and after a span change. Its purpose is to provide context of the scale of overall ridership and the hourly ridership patterns on the route being analyzed.

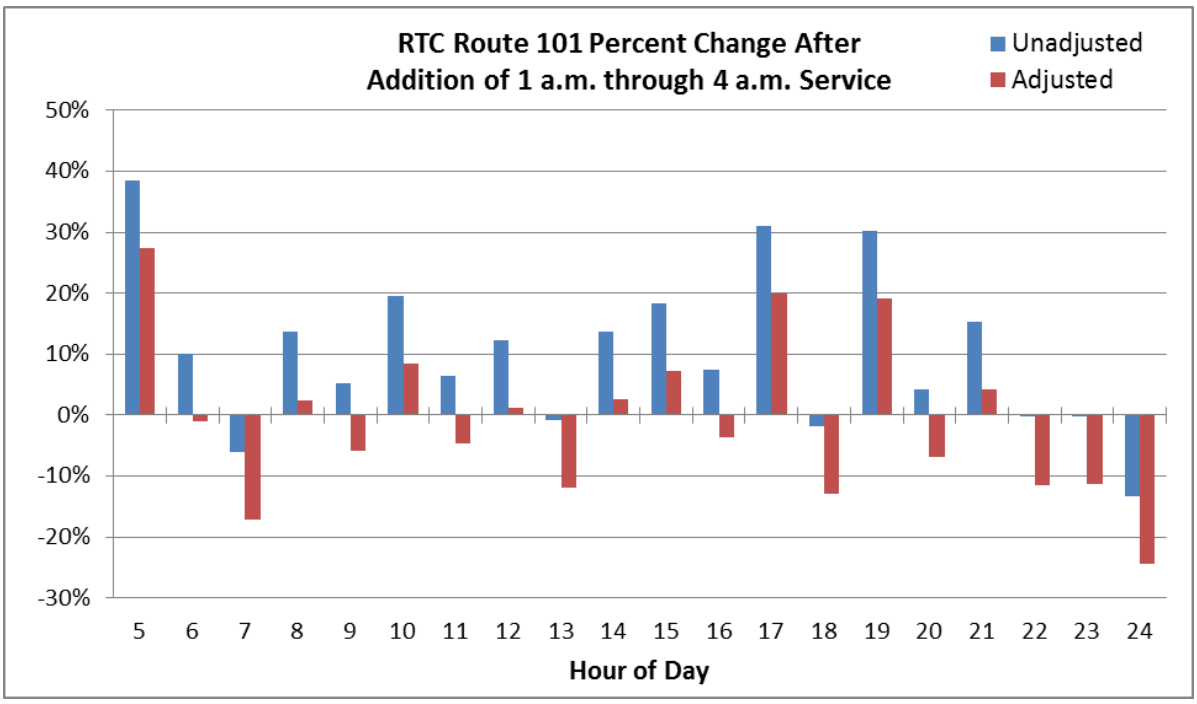

Figure 3. RTC Route 101 percent change in ridership after addition of 1 a.m. through 4 a.m. daily service in May 2005.

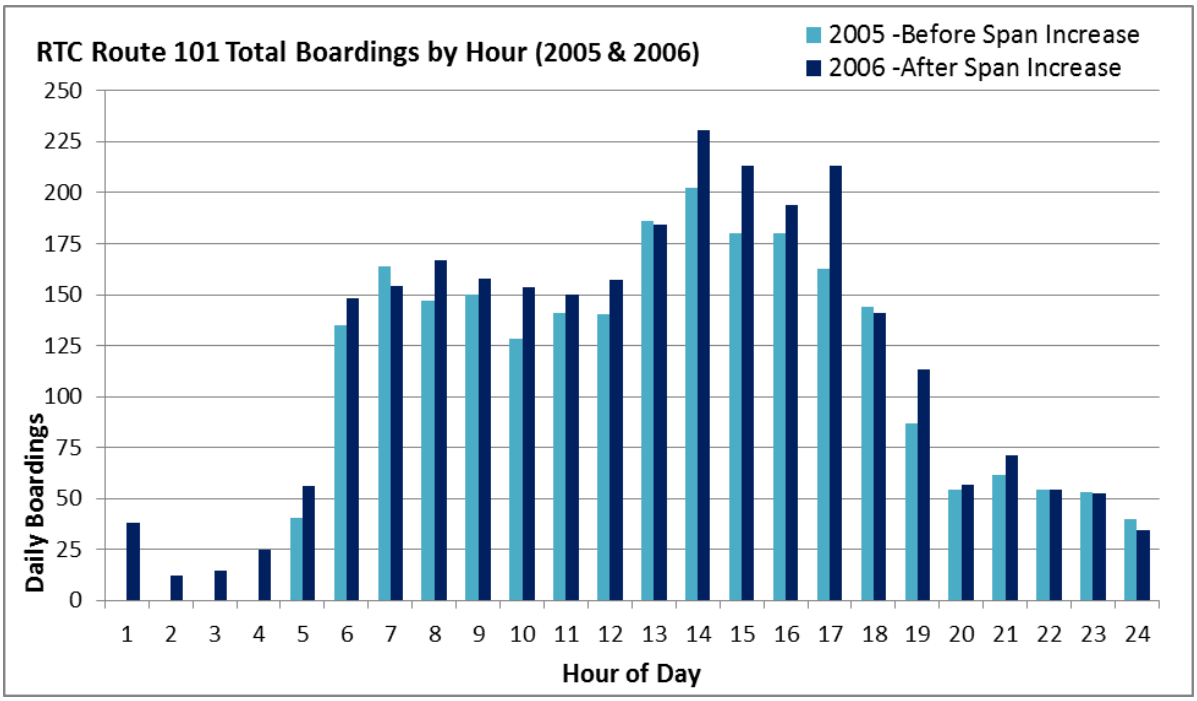

Figure 4. RTC Route 101 total boardings by hour before and after May 2005 addition of 1 a.m. through 4 a.m. daily service.

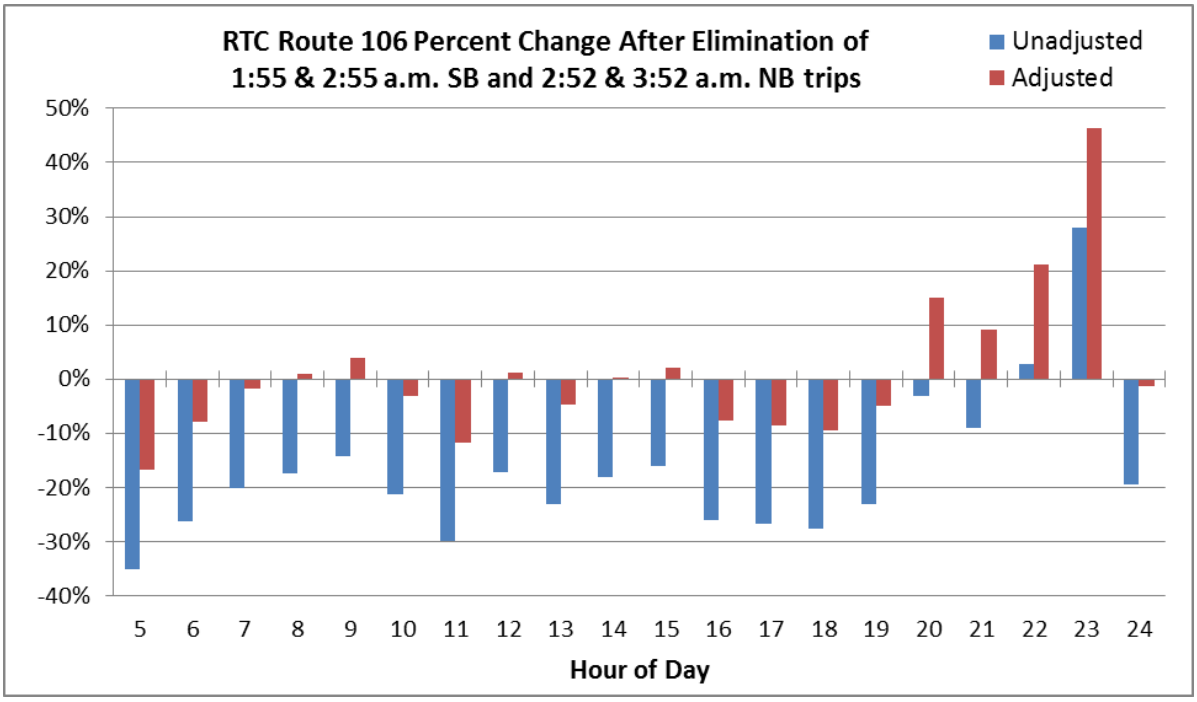

Figure 5. RTC Route 106 percent change in ridership after elimination of 1:55 & 2:55 a.m. southbound and 2:52 & 3:52 a.m. northbound daily trips in June 2009.

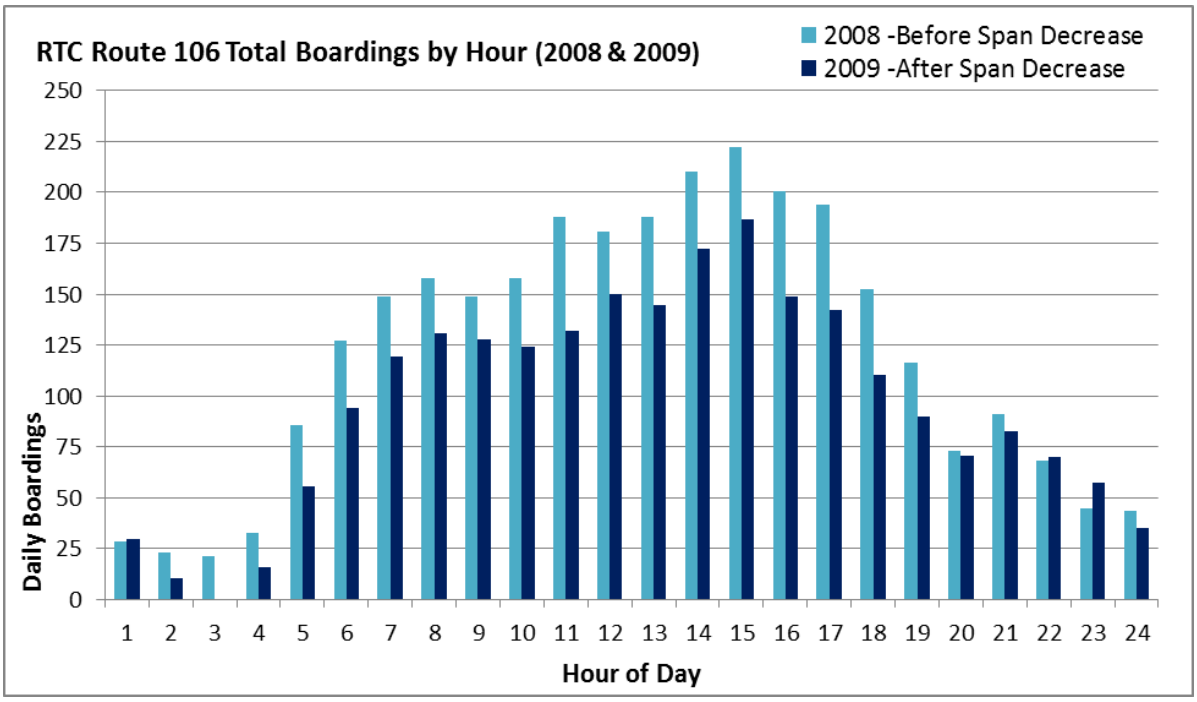

Figure 6. RTC Route 106 total boardings by hour before and after June 2009 elimination of 1:55 & 2:55 a.m. southbound and 2:52 & 3:52 a.m. northbound daily trips.

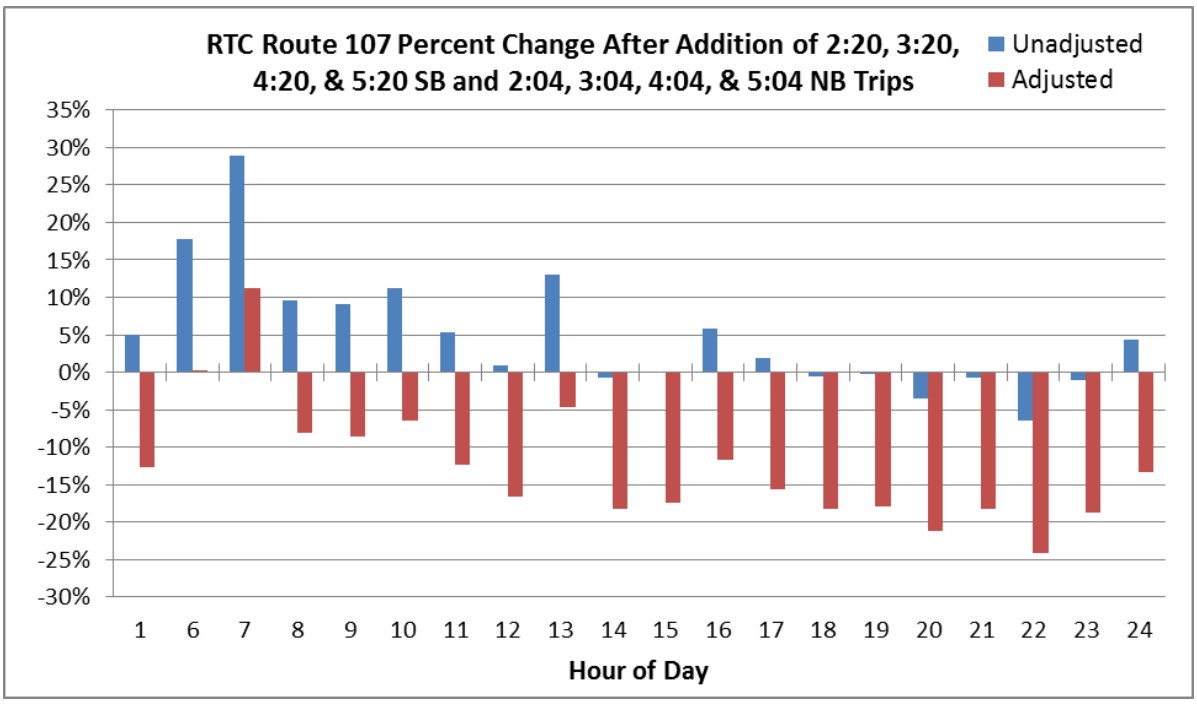

Figure 7. RTC Route 107 percent change in ridership after addition of 2:20, 3:20, 4:20, & 5:20 a.m. southbound and 2:04, 3:04, 4:04, & 5:04 a.m. northbound daily trips in April 1997.

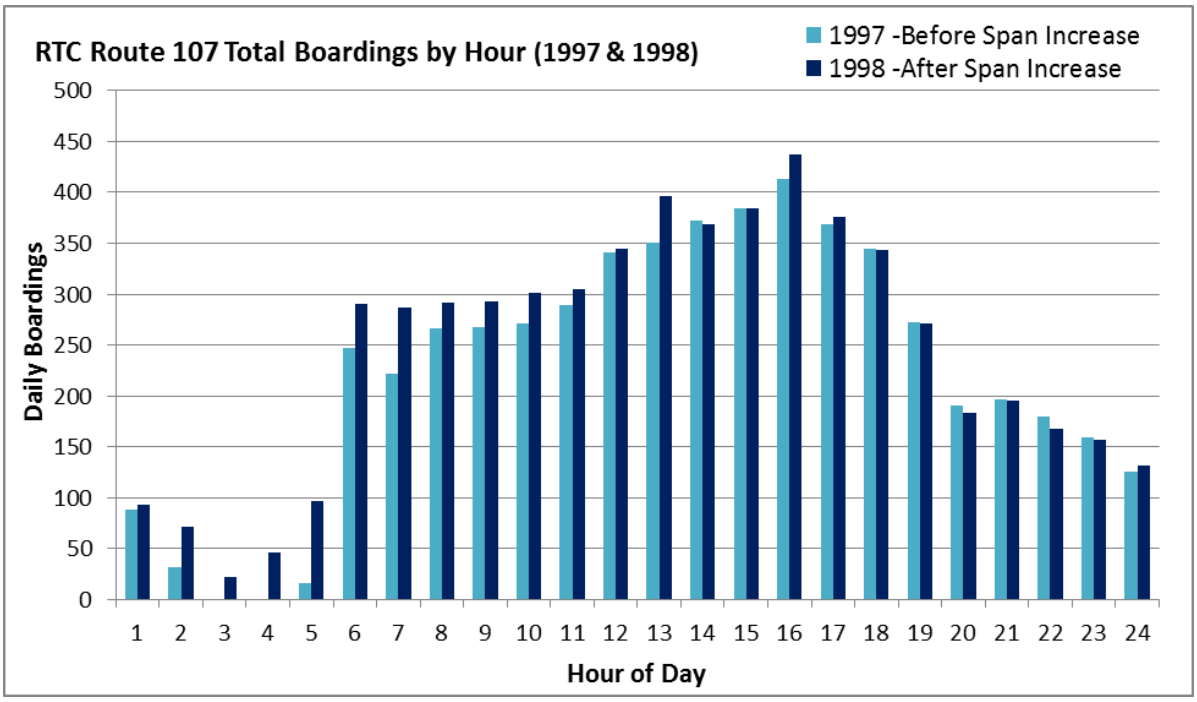

Figure 8. RTC Route 107 total boardings by hour before and after April 1997 addition of 2:20, 3:20, 4:20, & 5:20 a.m. southbound and 2:04, 3:04, 4:04, & 5:04 a.m. northbound daily trips.

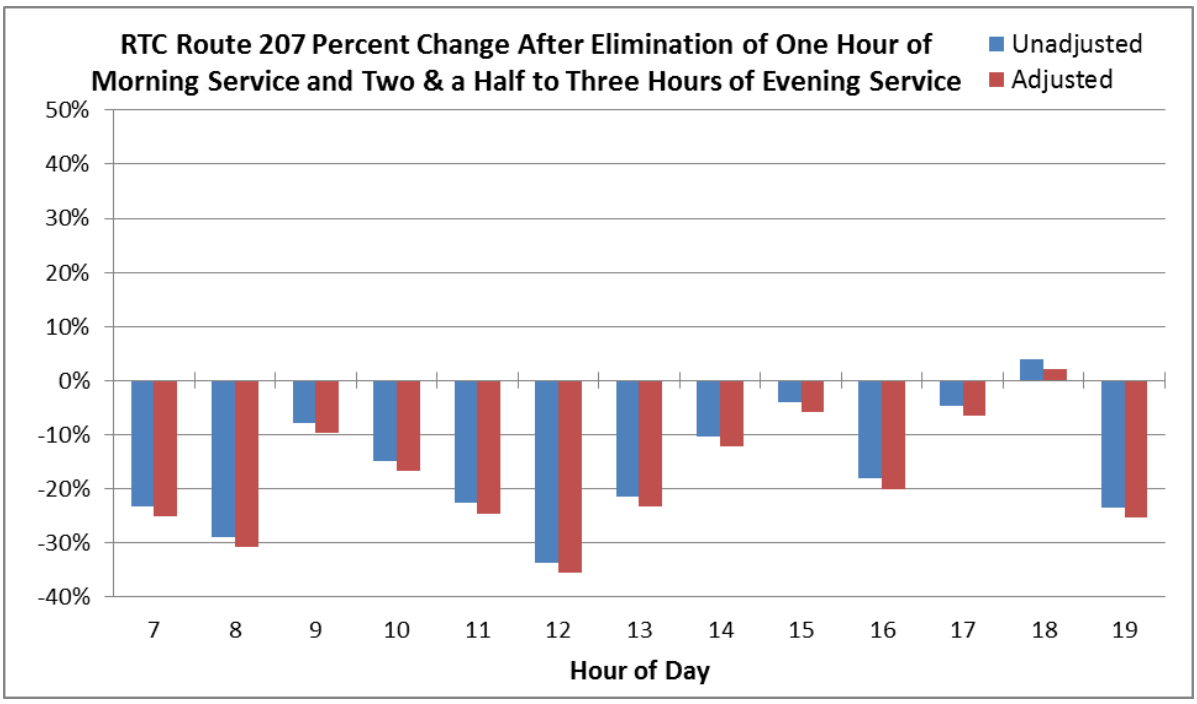

Figure 9. RTC Route 207 percent change in ridership after elimination of one hour of morning service and two and a half to three hours of daily evening service in May 2012.

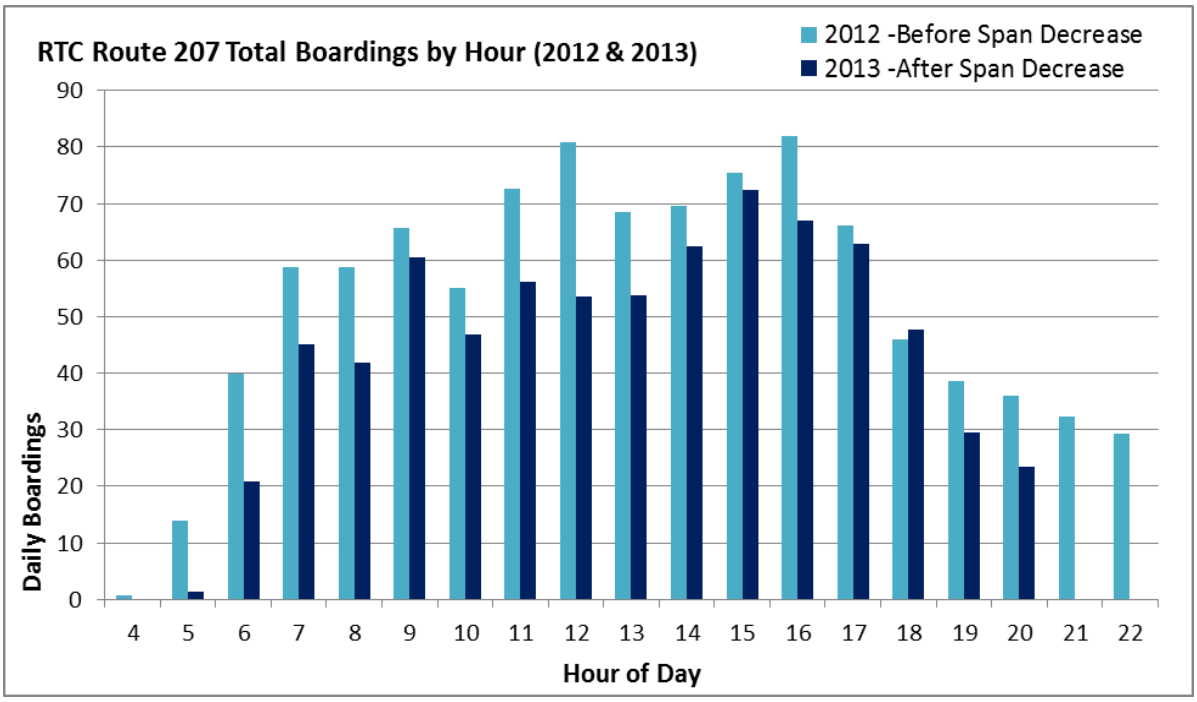

Figure 10. RTC Route 207 total boardings by hour before and after May 2012 elimination of one hour of morning service and two and a half to three hours of daily evening service.

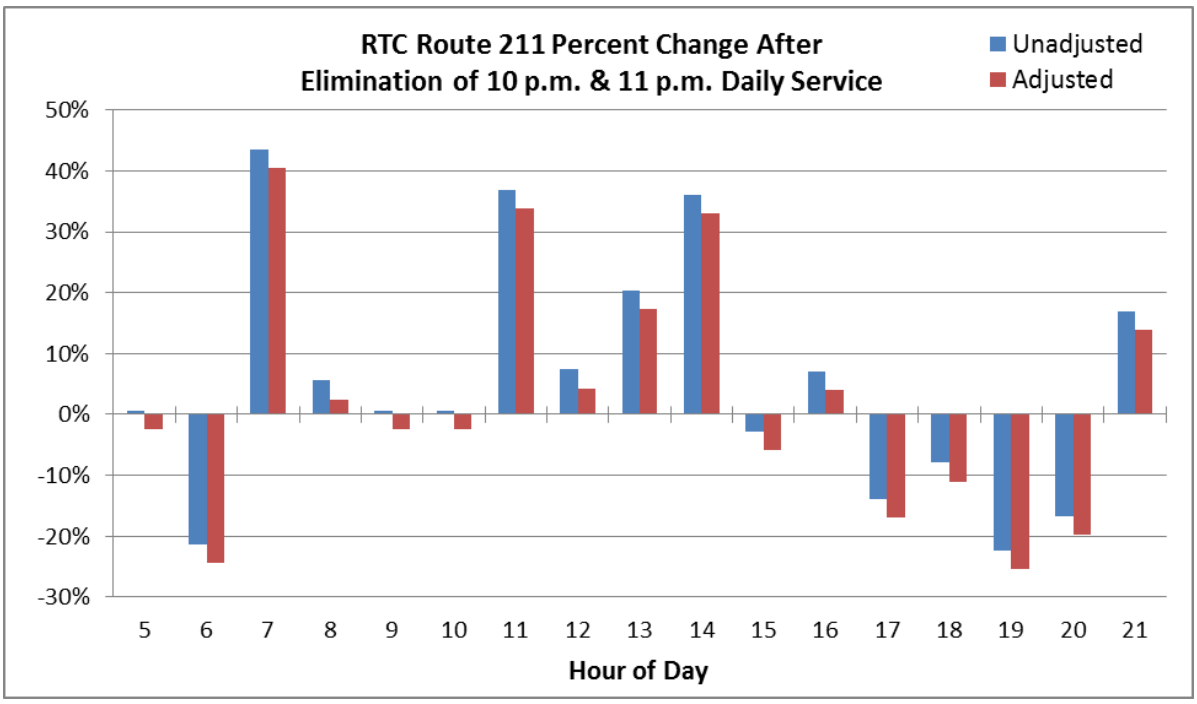

Figure 11. RTC Route 211 percent change in ridership after elimination of 10 p.m. & 11 p.m. daily service in June 2007.

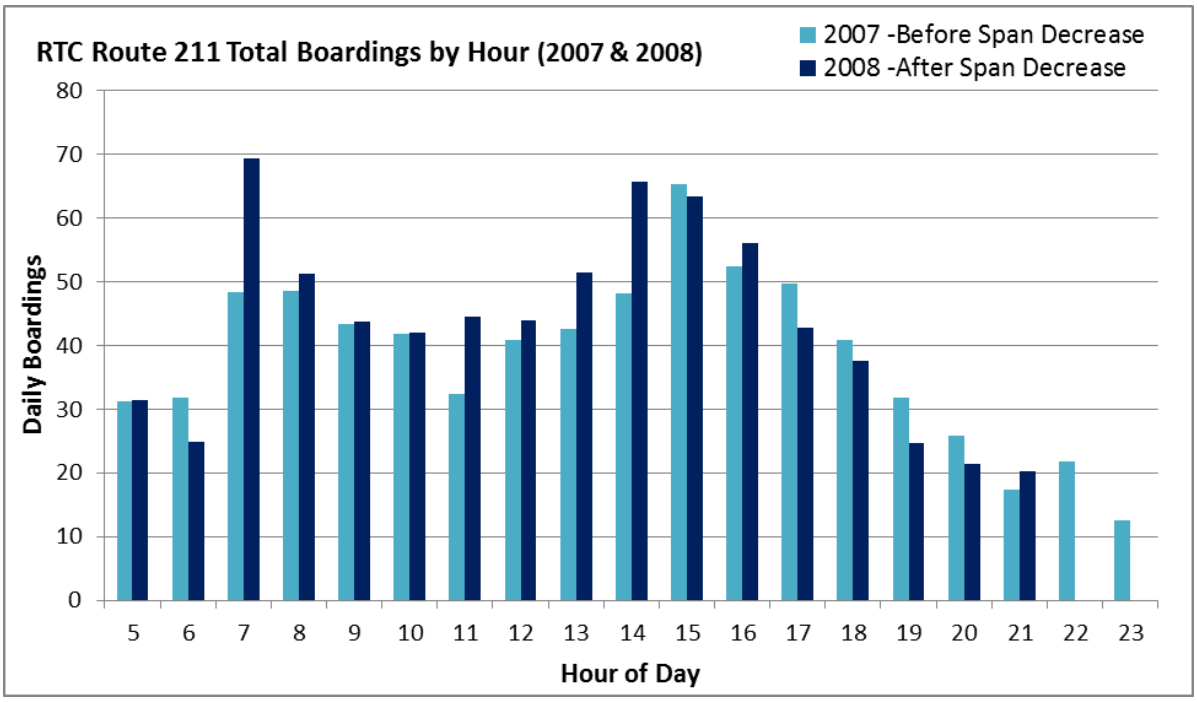

Figure 12. RTC Route 211 total boardings by hour before and after the June 2007 elimination of 10 p.m. & 11 p.m. daily service.

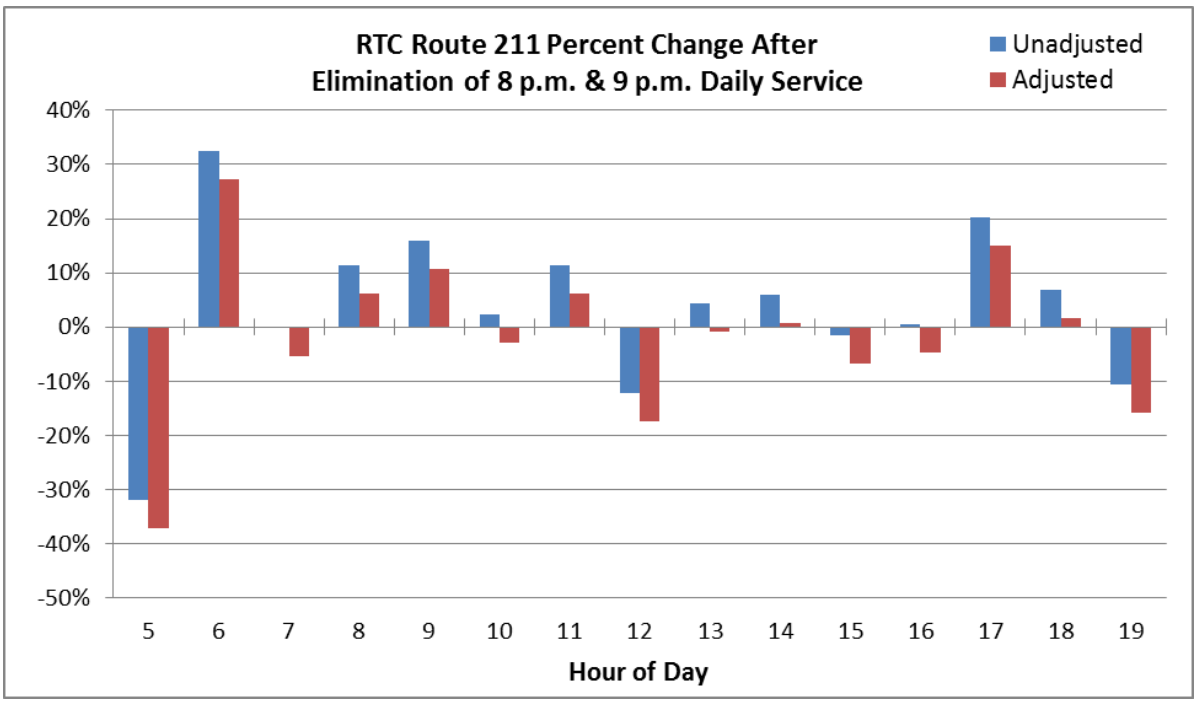

Figure 13. RTC Route 211 percent change in ridership after elimination of 8 p.m. & 9 p.m. daily service in November 2010.

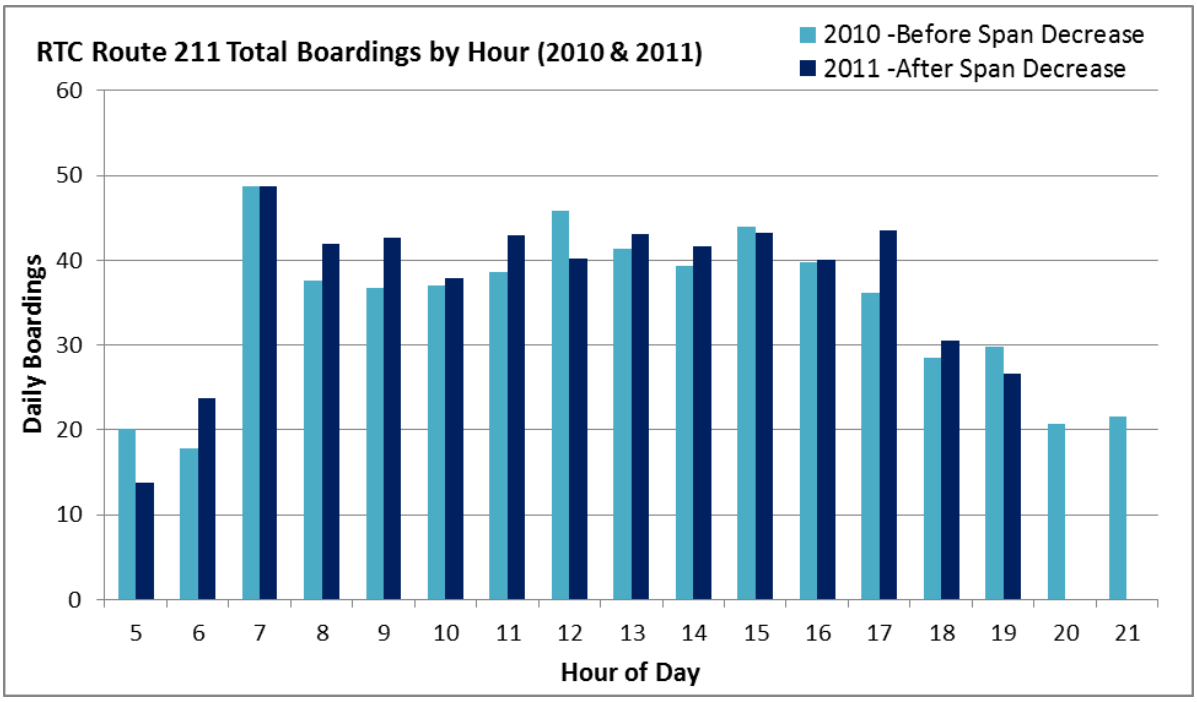

Figure 14. RTC Route 211 total boardings by hour before and after November 2010 elimination of 8 p.m. & 9 p.m. daily service.

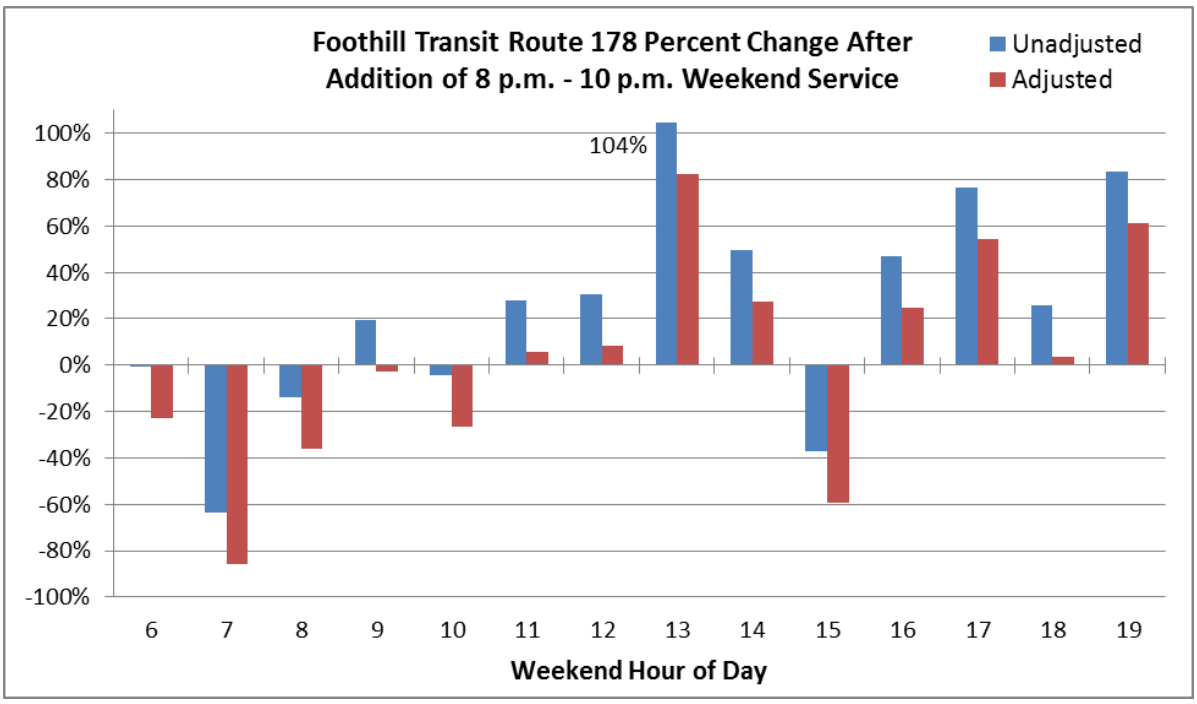

Figure 15. Foothill Transit Route 178 percent change in weekend ridership after addition of 8 p.m. through 10 p.m. weekend service in November 2013.

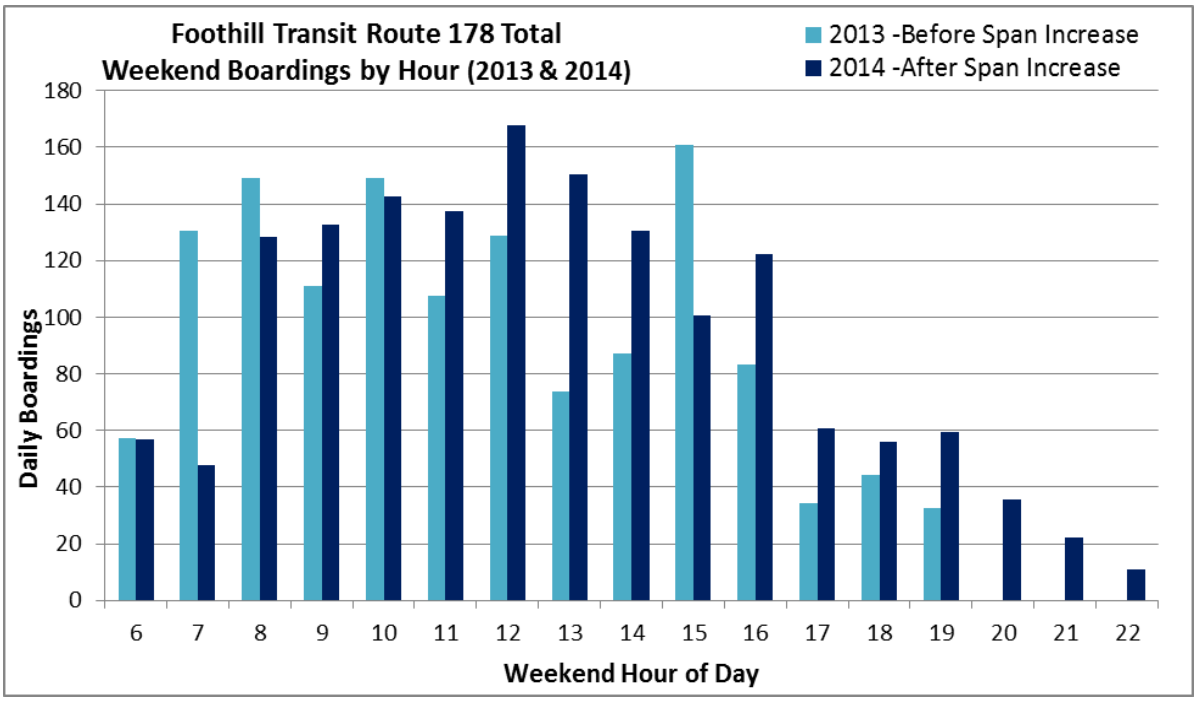

Figure 16. Foothill Transit Route 178 total weekend boardings by hour before and after November 2013 addition of 8 p.m. through 10 p.m. weekend service.

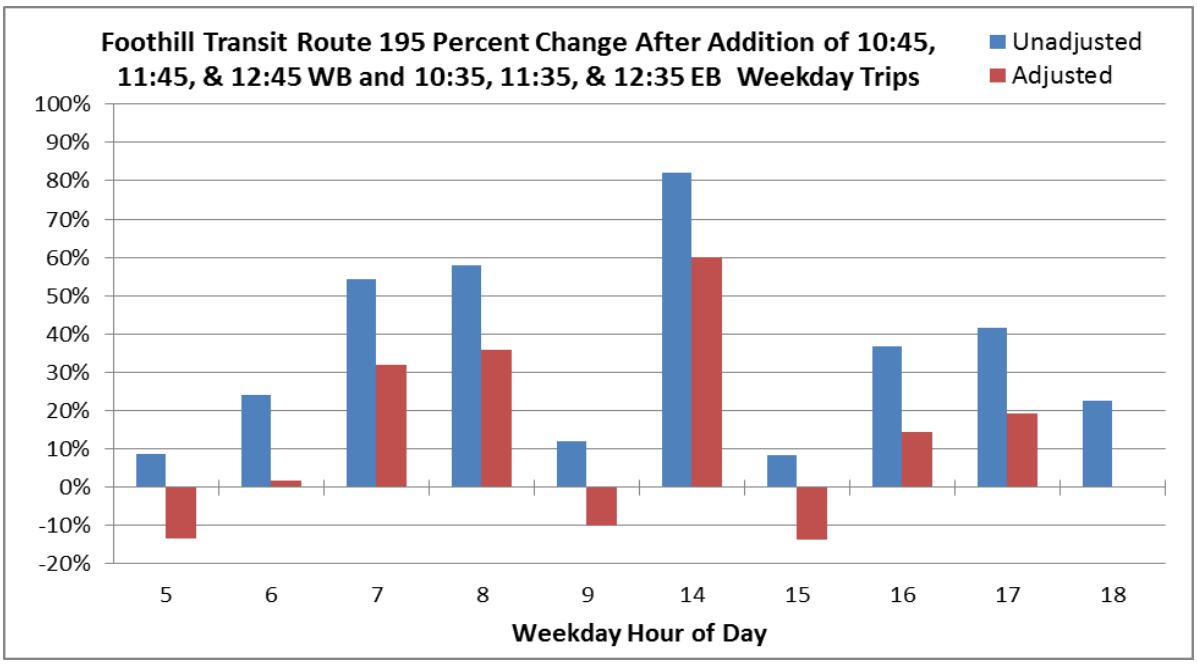

Figure 17. Foothill Transit Route 195 percent change in weekday ridership after addition of 10:45 a.m. – 12:45 p.m. westbound & 10:35 a.m. – 12:35 p.m. eastbound weekday trips in November 2013.

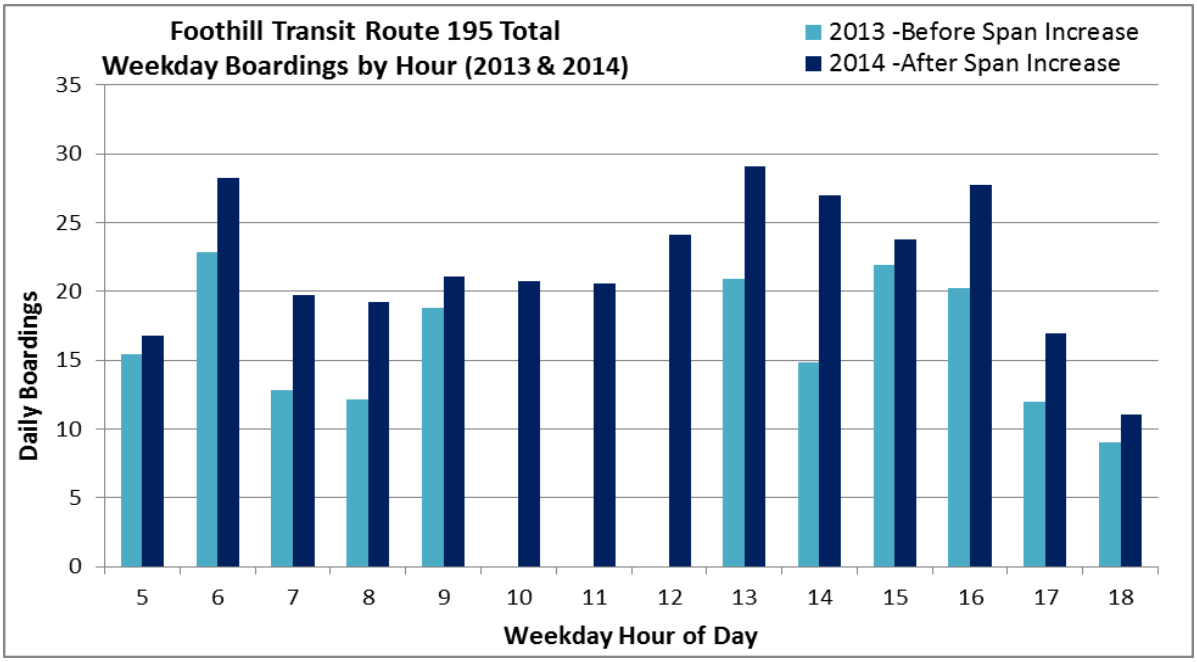

Figure 18. Foothill Transit Route 195 total weekday ridership by hour before and after November 2013 addition of 10:45 a.m. – 12:45 p.m. westbound &10:35 a.m. – 12:35 p.m. eastbound weekday trips.

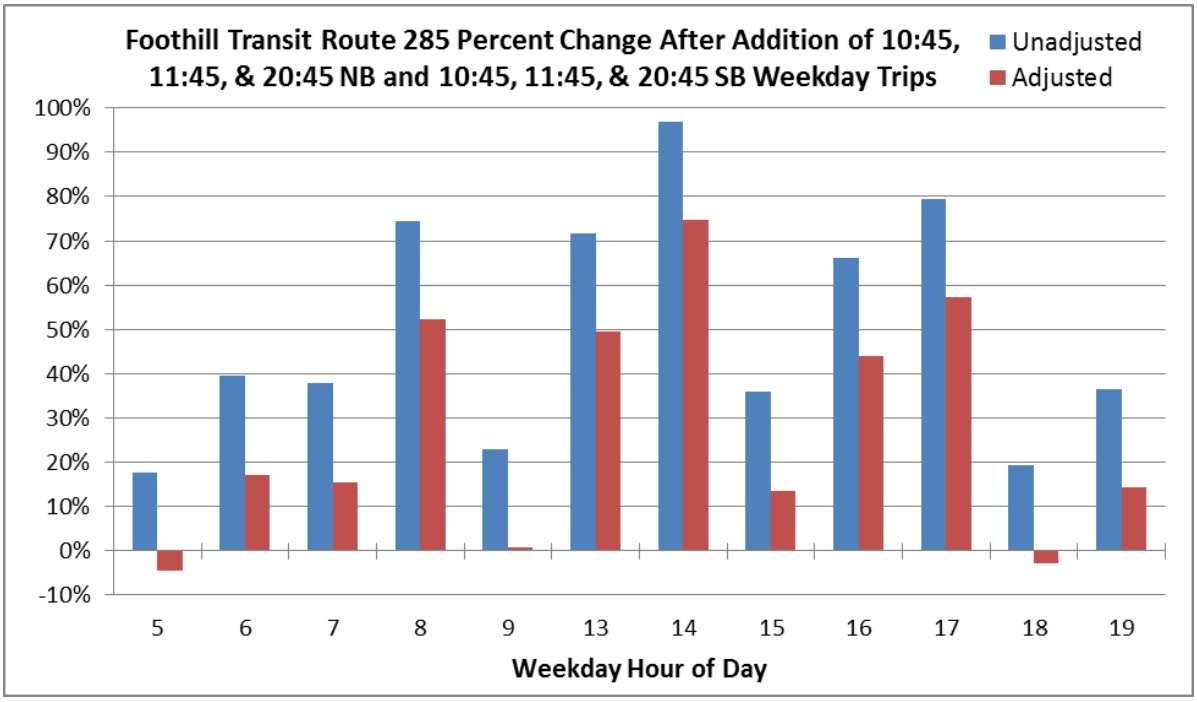

Figure 19. Foothill Transit Route 285 percent change in weekday ridership after addition of 10:45 a.m., 11:45 a.m., and 8:45 p.m. weekday trips in November 2013.

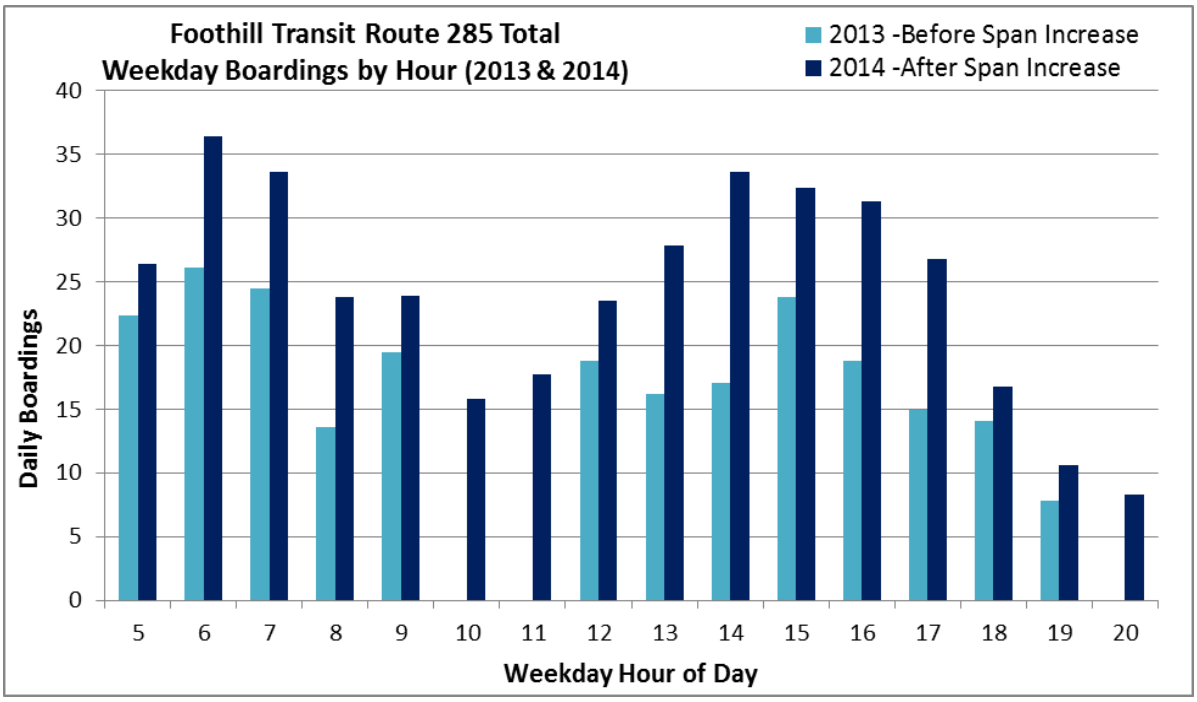

Figure 20. Foothill Transit Route 285 total weekday ridership by hour before and after November 2013 addition of 10:45 a.m., 11:45 a.m., and 8:45 p.m. weekday trips.

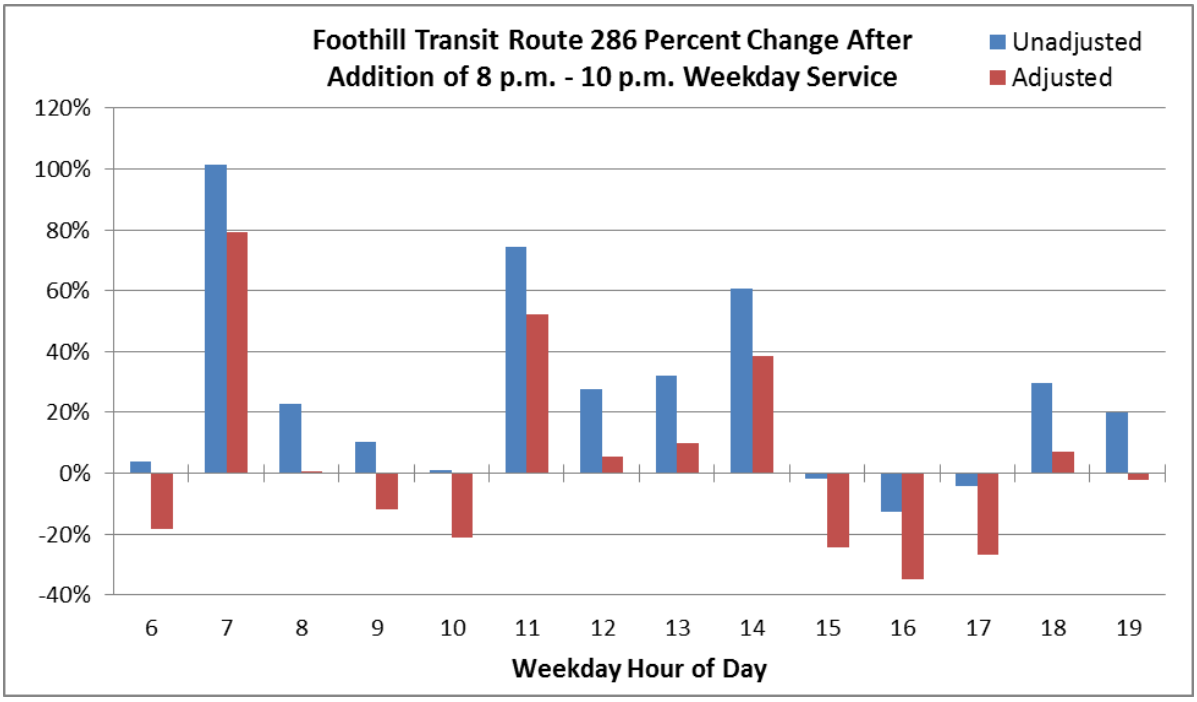

Figure 21. Foothill Transit Route 286 percent change in weekday ridership after addition of 8 p.m. through 10 p.m. weekday service in November 2013.

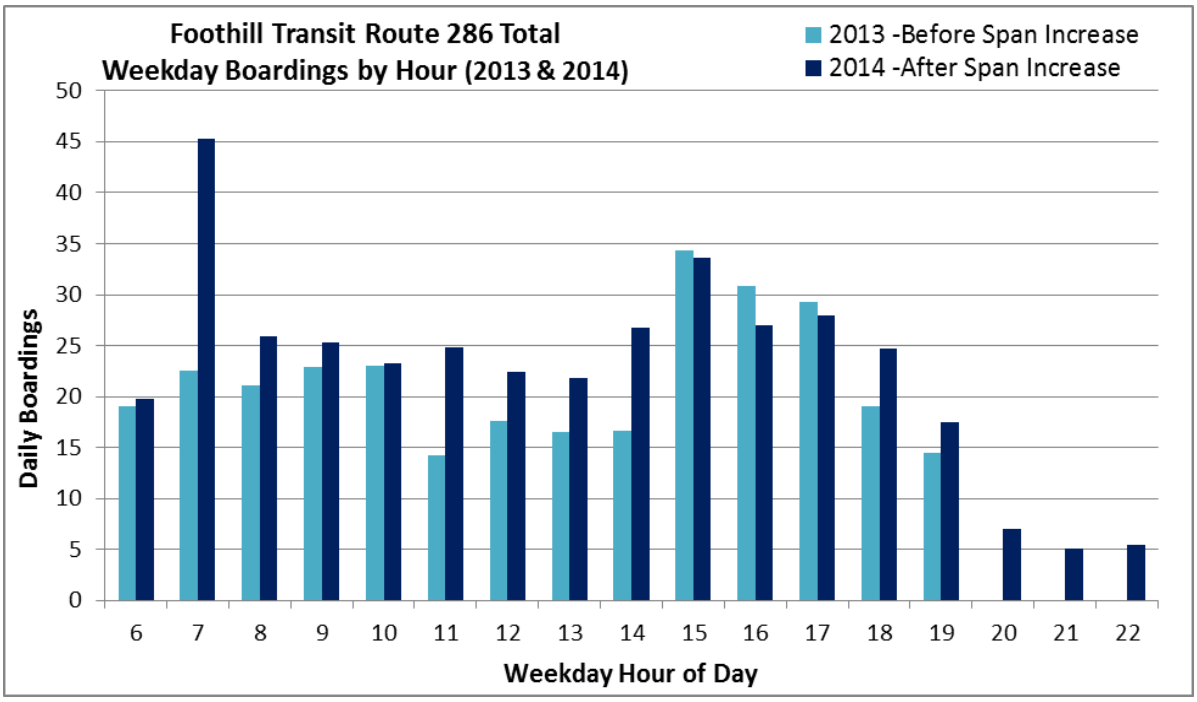

Figure 22. Foothill Transit Route 286 total weekday boardings by hour before and after November 2013 addition of 8 p.m. through 10 p.m. weekday service.

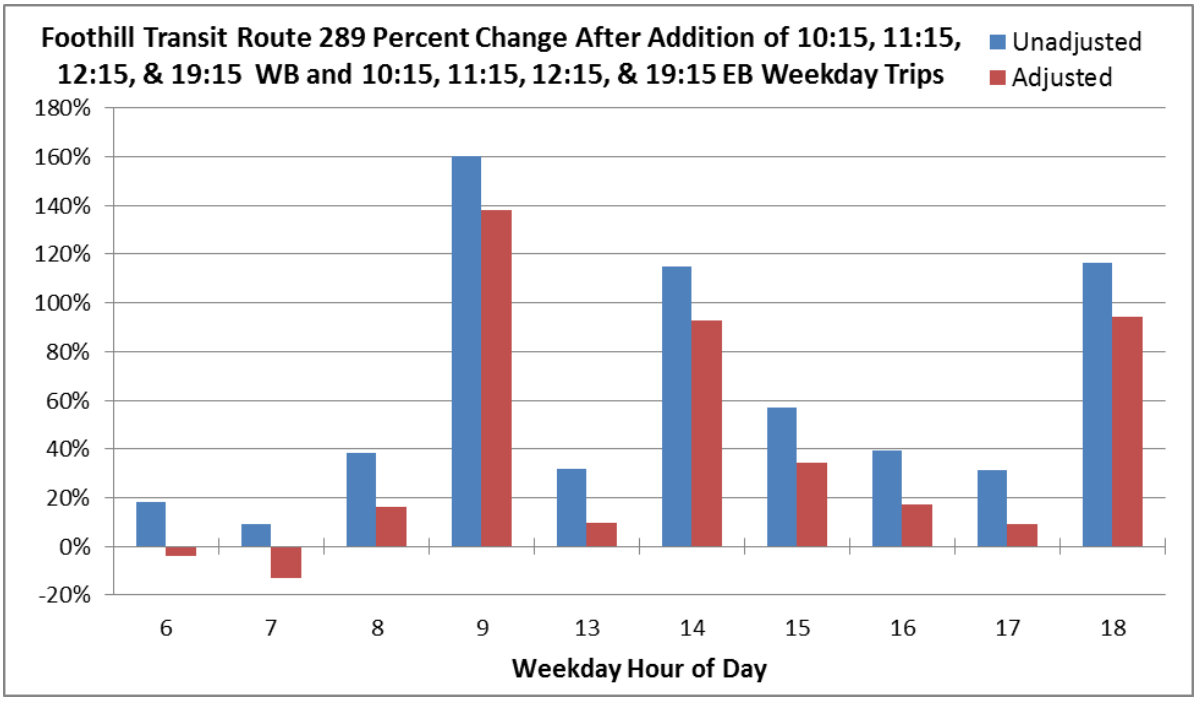

Figure 23. Foothill Transit Route 289 percent change in weekday ridership after addition of 10:15 a.m., 11:15 a.m., 12:15 p.m., and 7:15 p.m. weekday trips in November 2013.

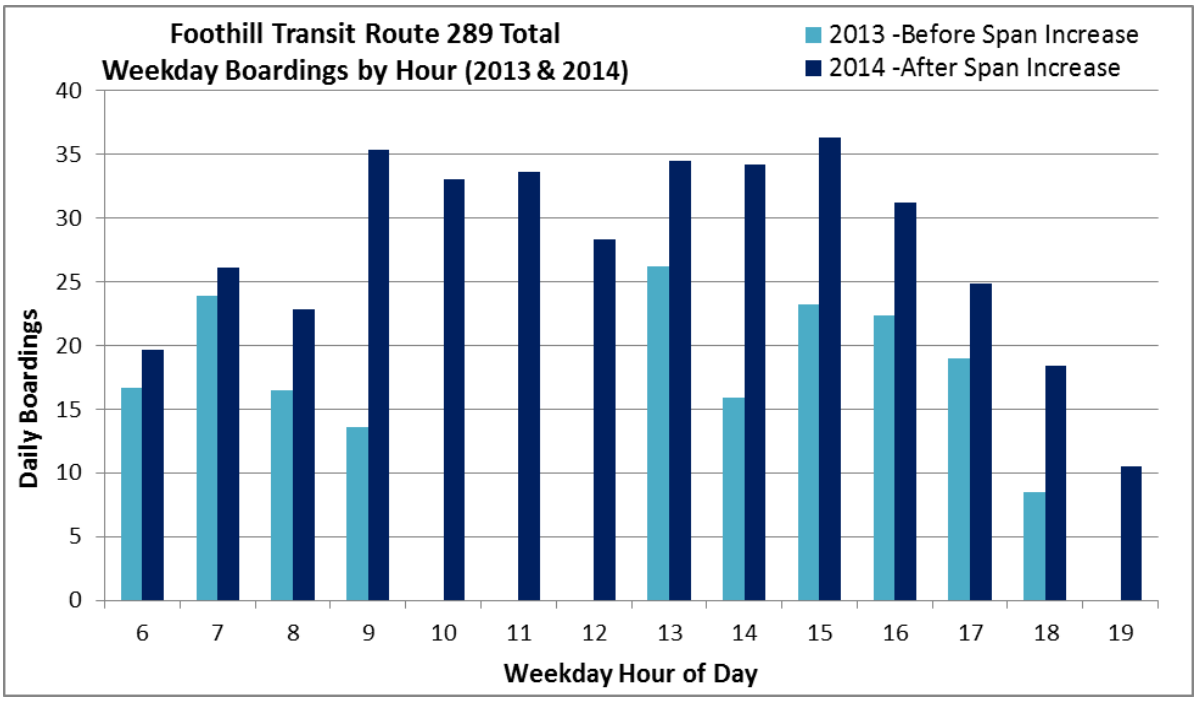

Figure 24. Foothill Transit Route 289 total weekday ridership by hour before and after November 2013 addition of 10:15 a.m., 11:15 a.m., 12:15 p.m., and 7:15 p.m. weekday trips.

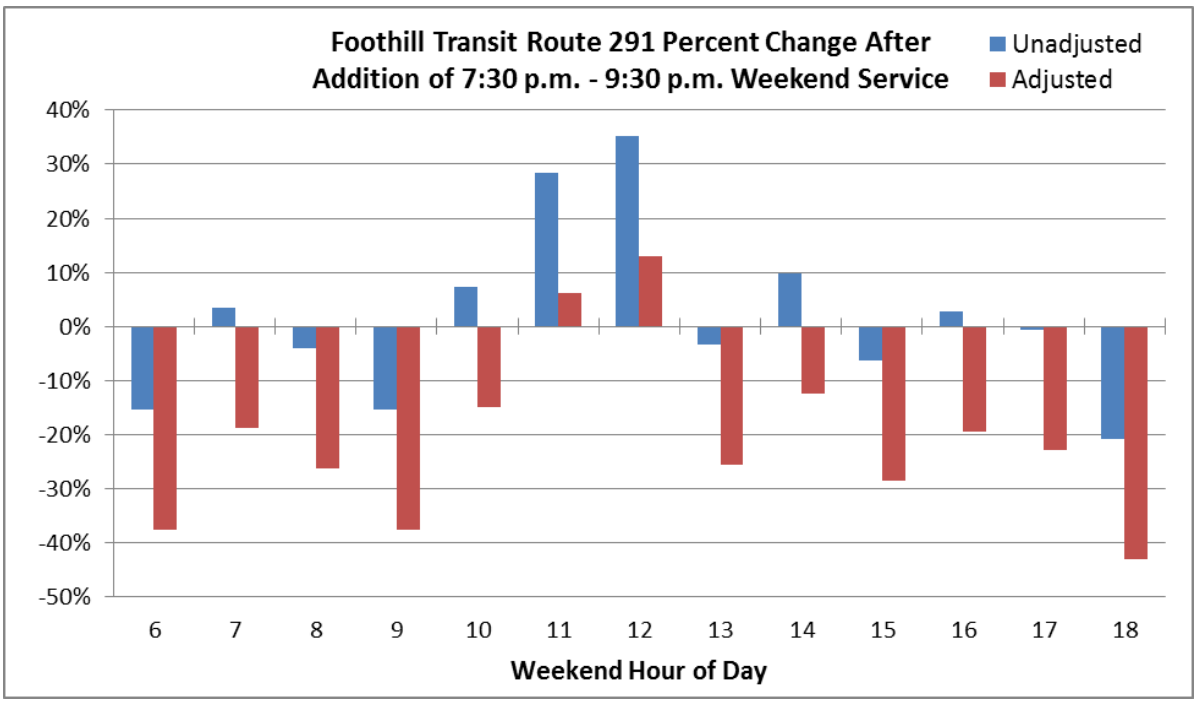

Figure 25. Foothill Transit Route 291 percent change in weekend ridership after addition of 7:30 p.m. through 9:30 p.m. weekend service in November 2013.

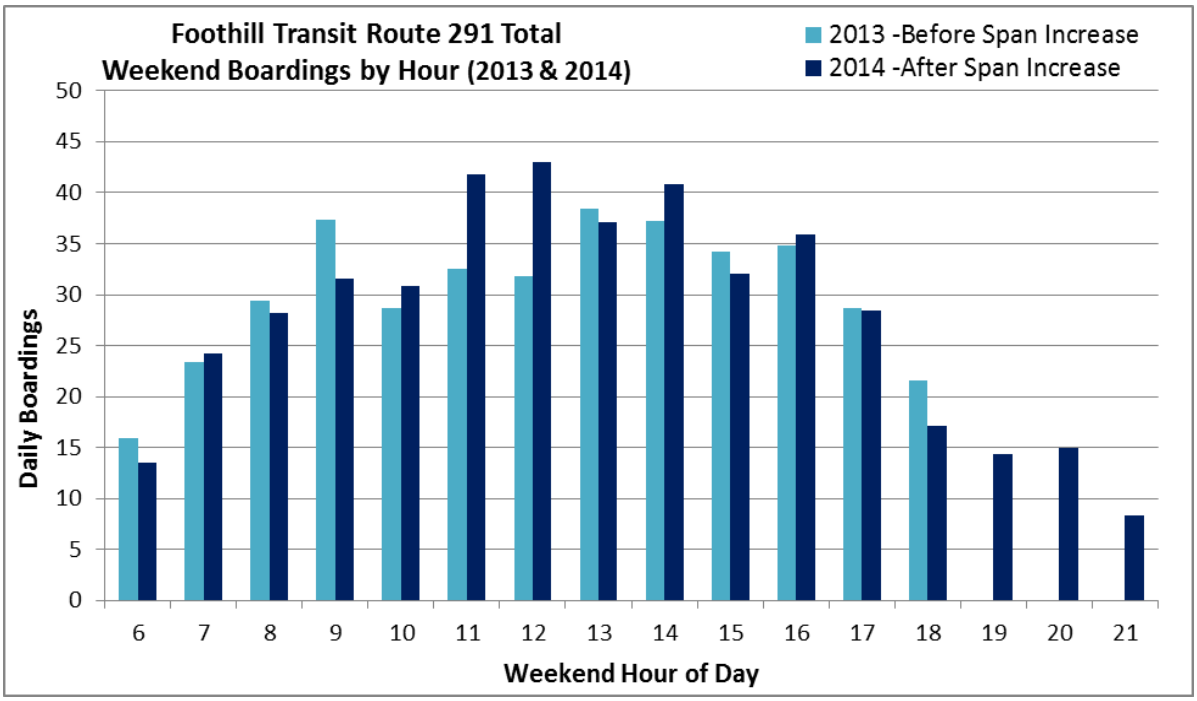

Figure 26. Foothill Transit Route 291 total weekend boardings by hour before and after November 2013 addition of 7:30 p.m. through 9:30 p.m. weekend service.

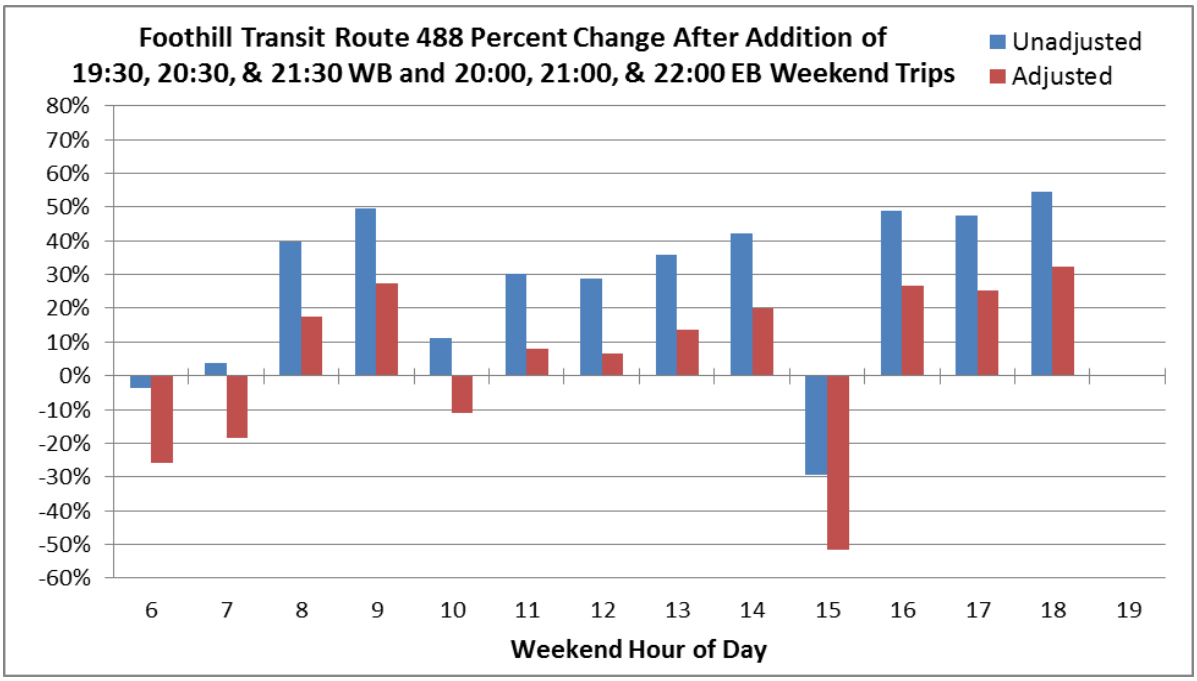

Figure 27. Foothill Transit Route 488 percent change in weekend ridership after addition of 7:30 p.m. - 9:30 p.m. westbound and 8 p.m. – 10 p.m. eastbound weekend trips in November 2013.

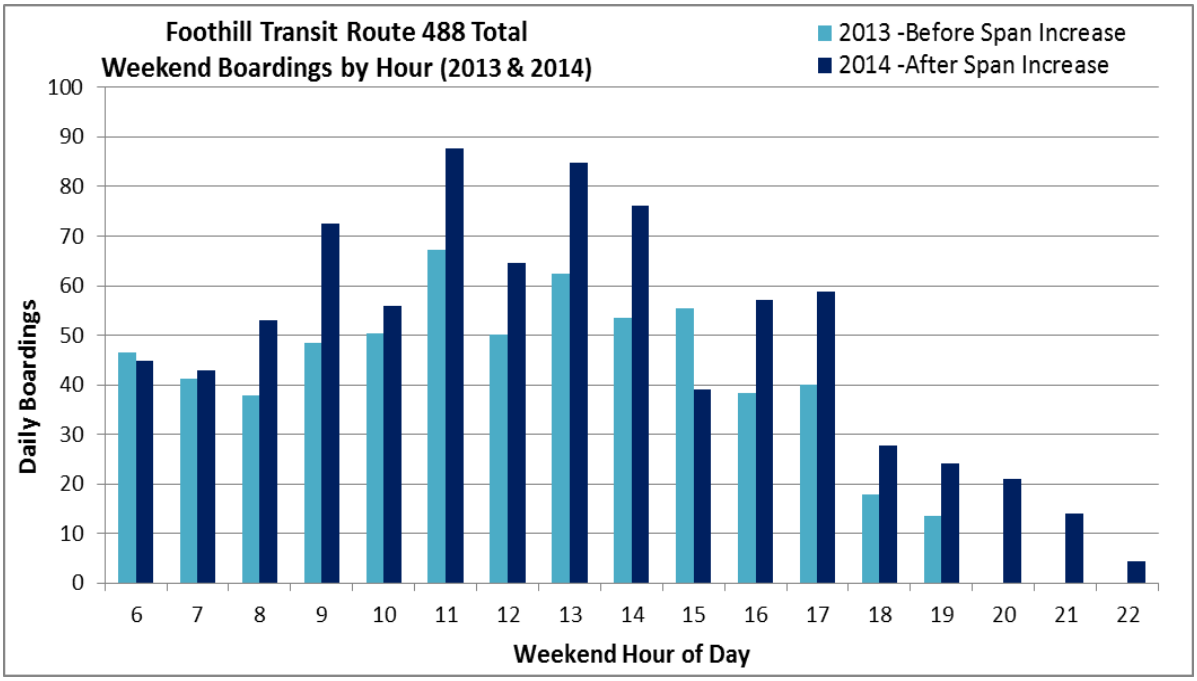

Figure 28. Foothill Transit Route 488 total weekend boardings by hour before and after November 2013 addition of 7:30 p.m. - 9:30 p.m. westbound and 8 p.m. – 10 p.m. eastbound weekend trips.

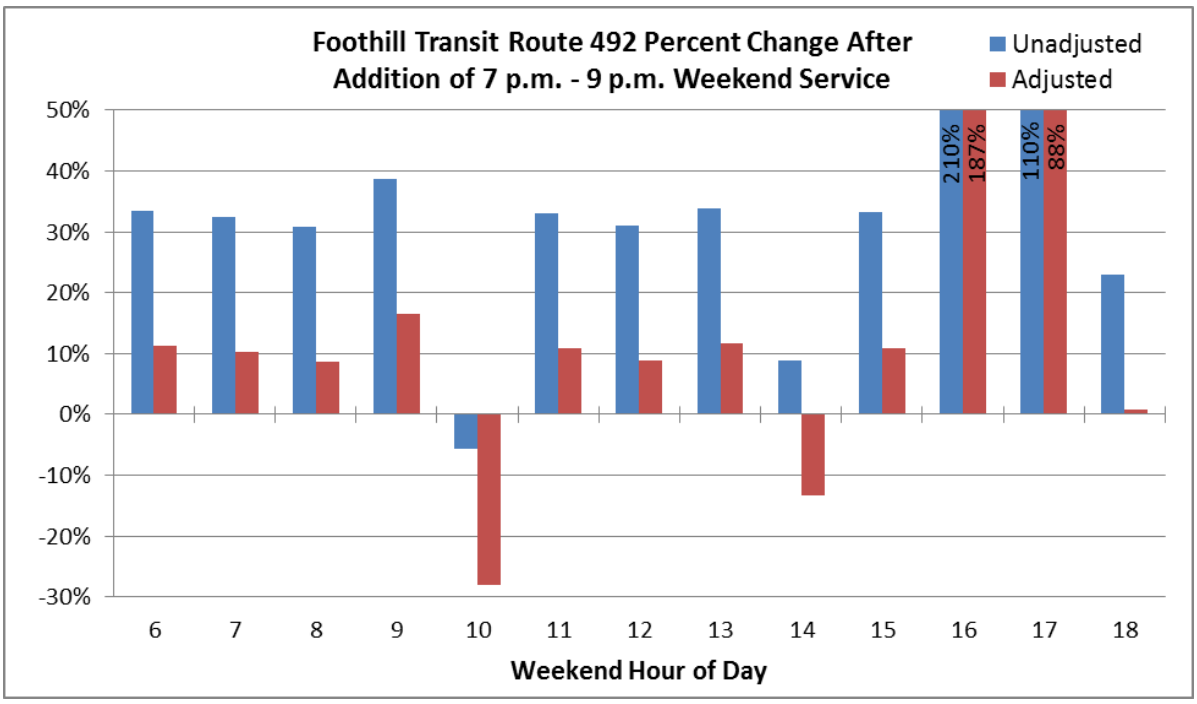

Figure 29. Foothill Transit Route 492 percent change in weekend ridership after addition of 7 p.m. through 9 p.m. weekend service in November 2013.

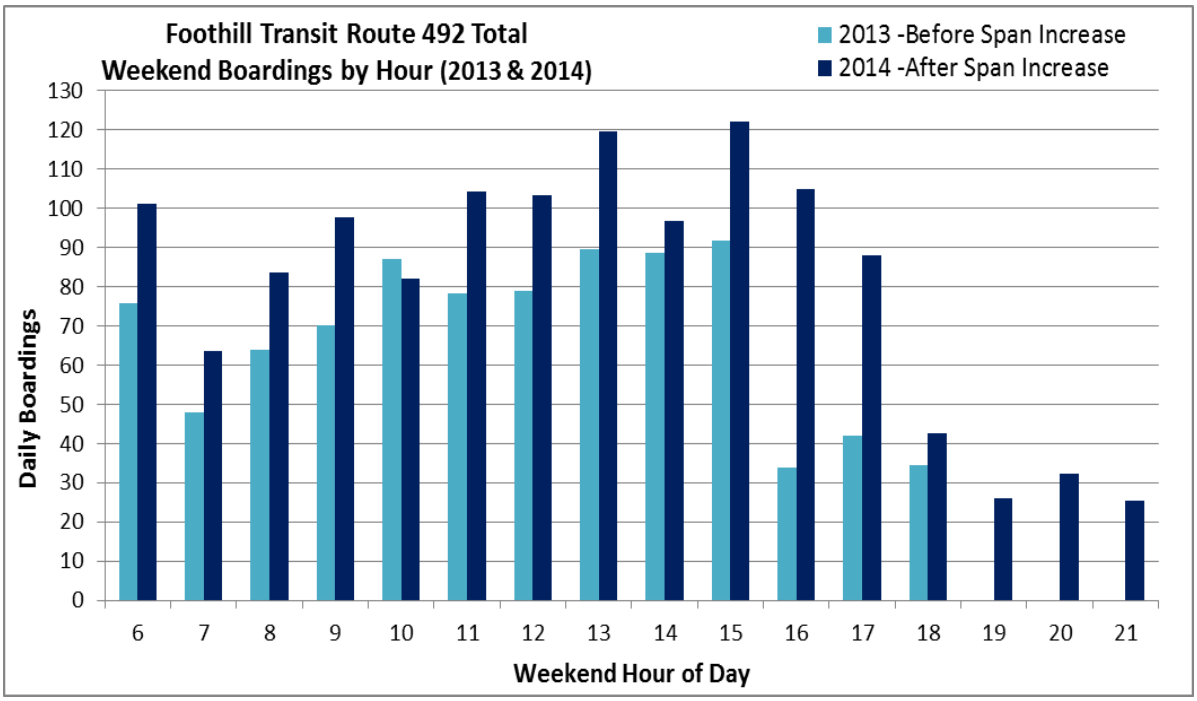

Figure 30. Foothill Transit Route 492 total weekend boardings by hour before and after November 2013 addition of 7 p.m. through 9 p.m. weekend service.

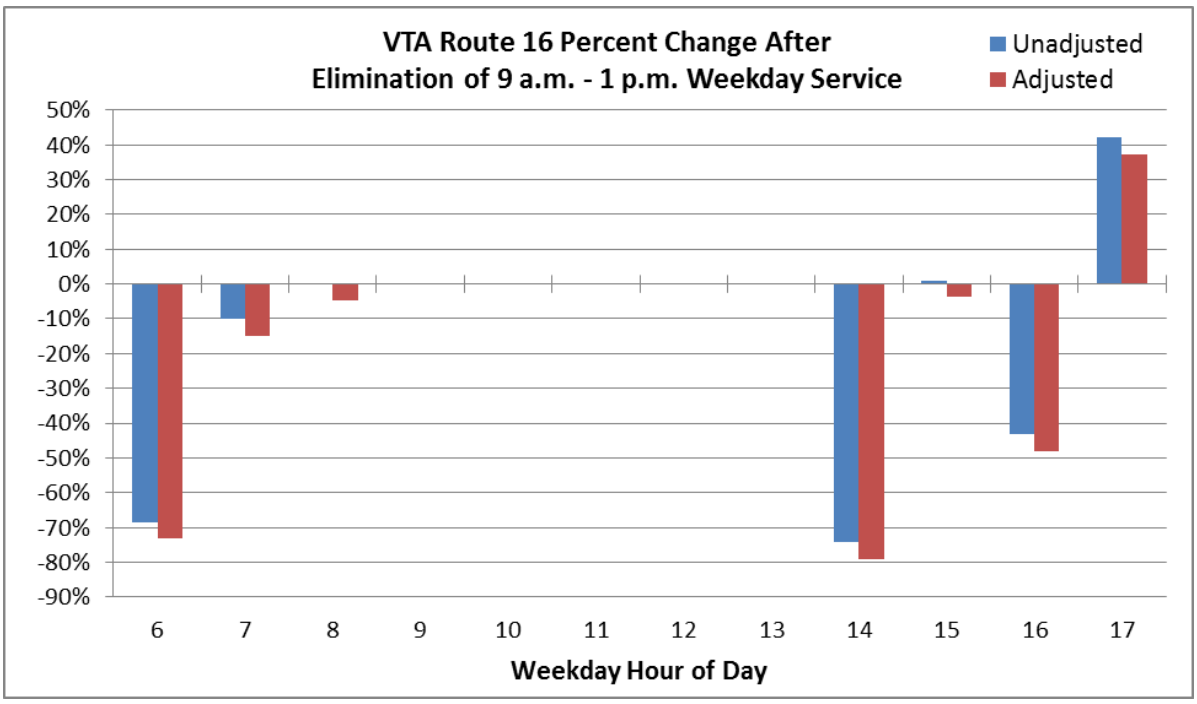

Figure 31. VTA Route 16 percent change in weekday ridership after elimination of 9 a.m. through 1 p.m. weekday service in January 2012.

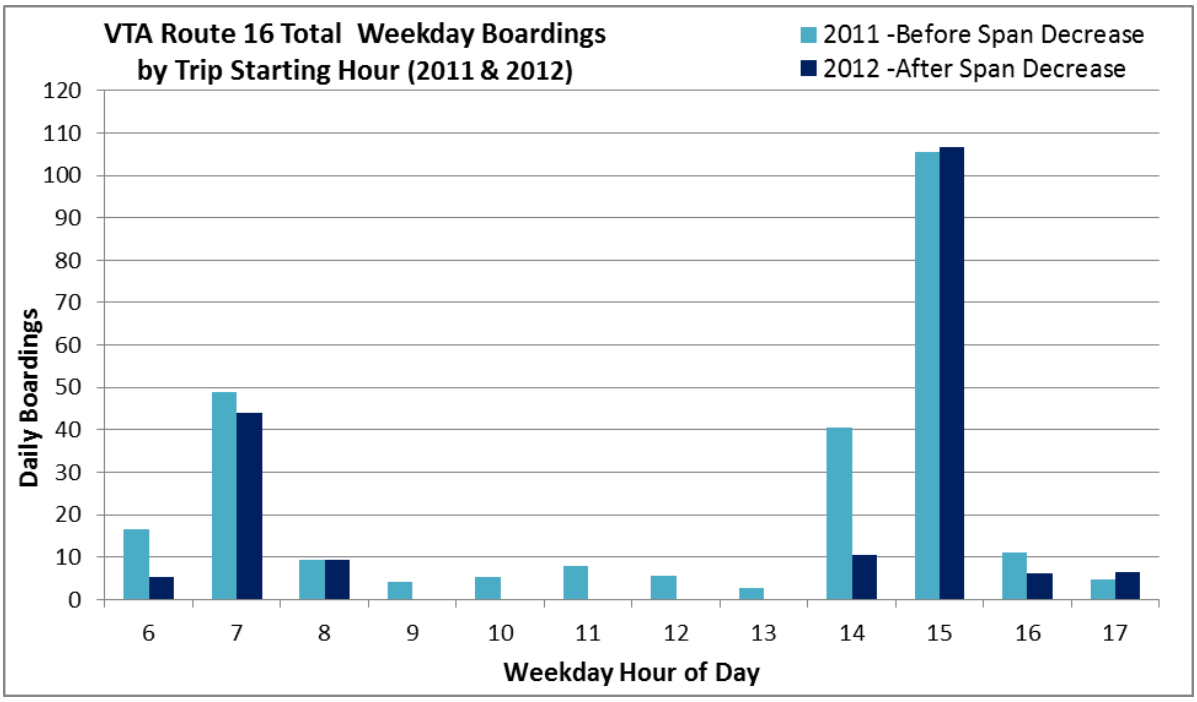

Figure 32. VTA Route 16 total weekday boardings by trip starting hour before and after January 2012 elimination of 9 a.m. through 1 p.m. weekday service.

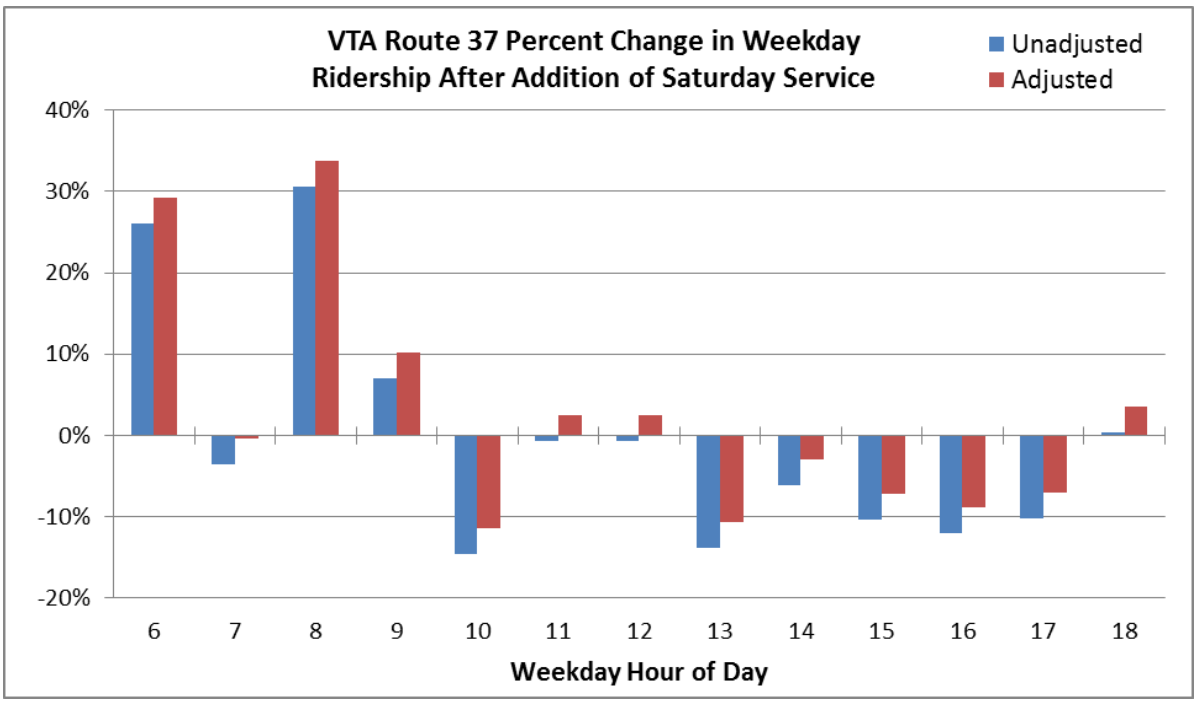

Figure 33. VTA Route 37 percent change in weekday ridership after addition of Saturday service in July 2011.

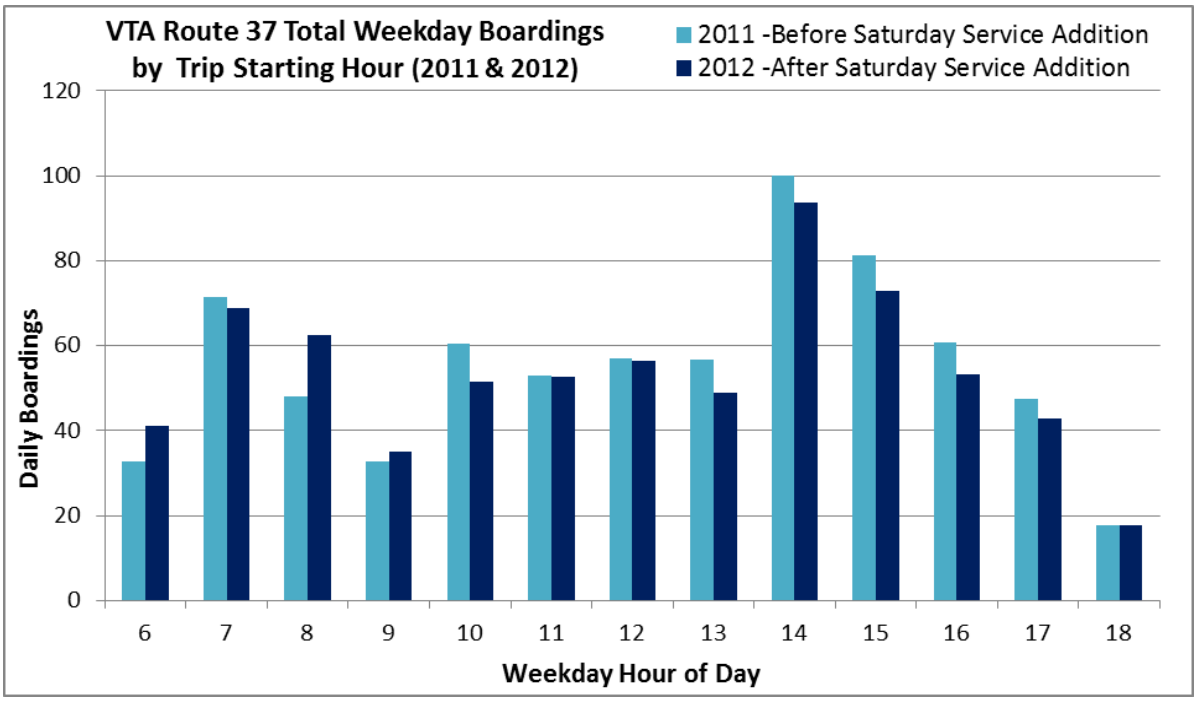

Figure 34. VTA Route 37 total weekday boardings by trip starting hour before and after July 2011 addition of Saturday service.

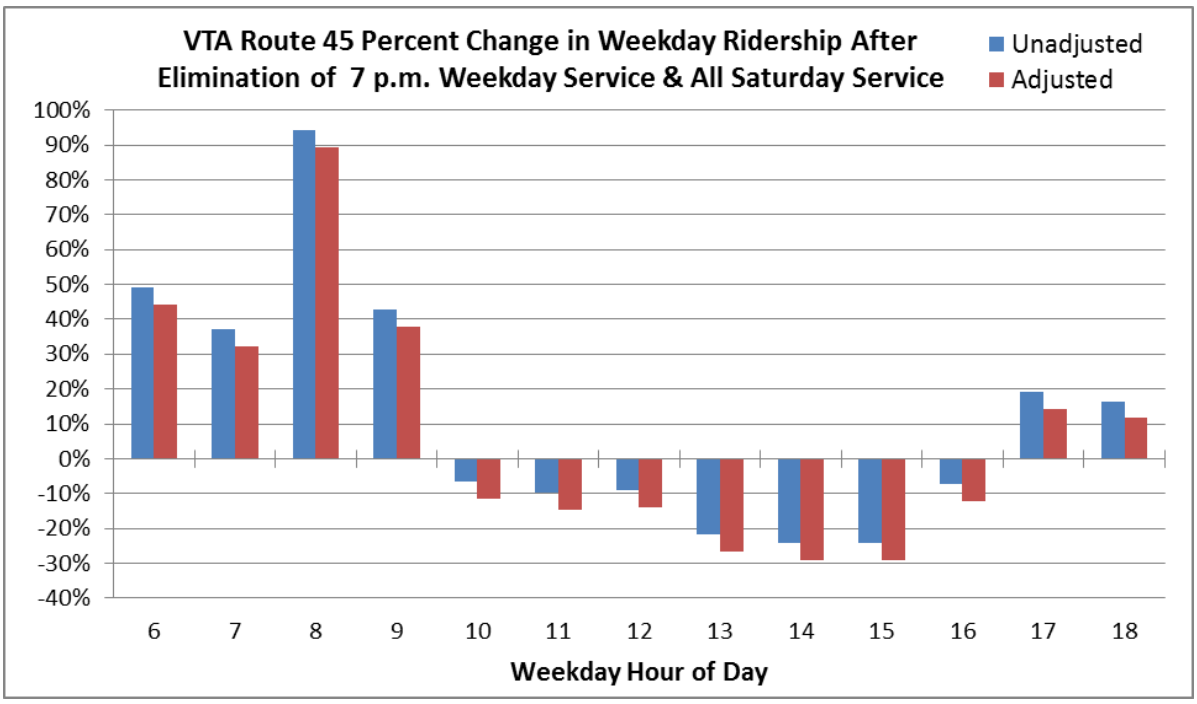

Figure 35. VTA Route 45 percent change in weekday ridership after elimination of 7 p.m. weekday service and all Saturday service in January 2012.

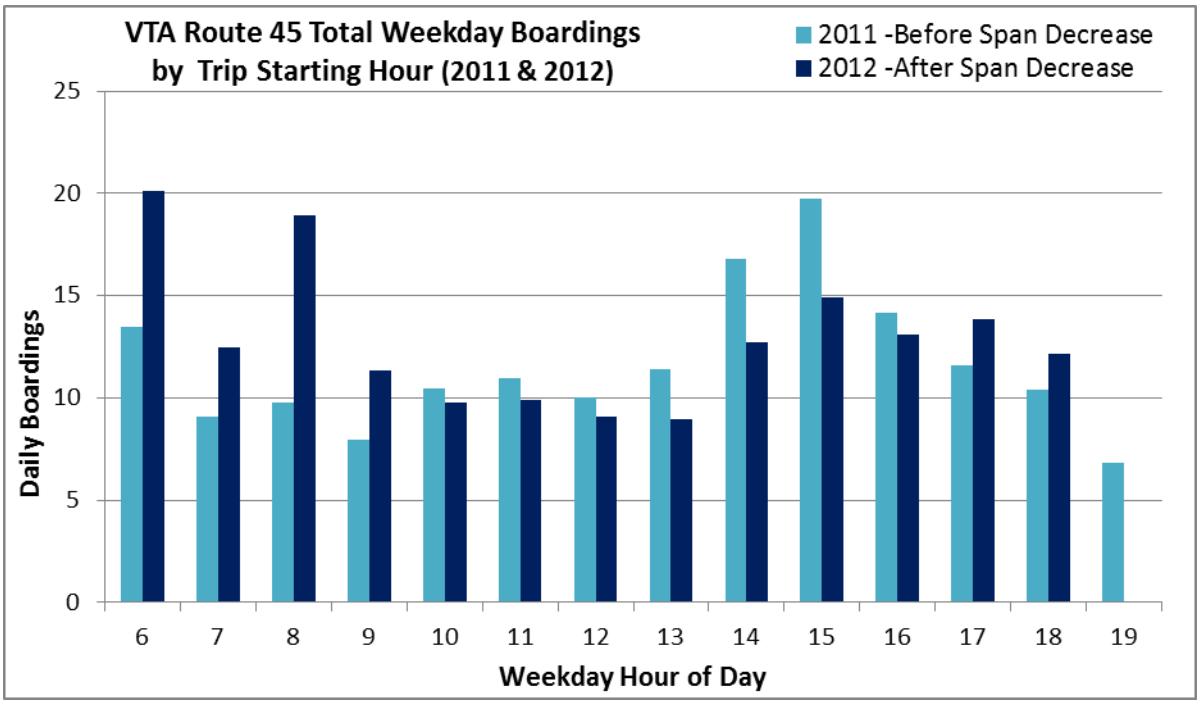

Figure 36. VTA Route 45 total weekday boardings by trip starting hour before and after January 2012 elimination of 7 p.m. weekday service and all Saturday service.

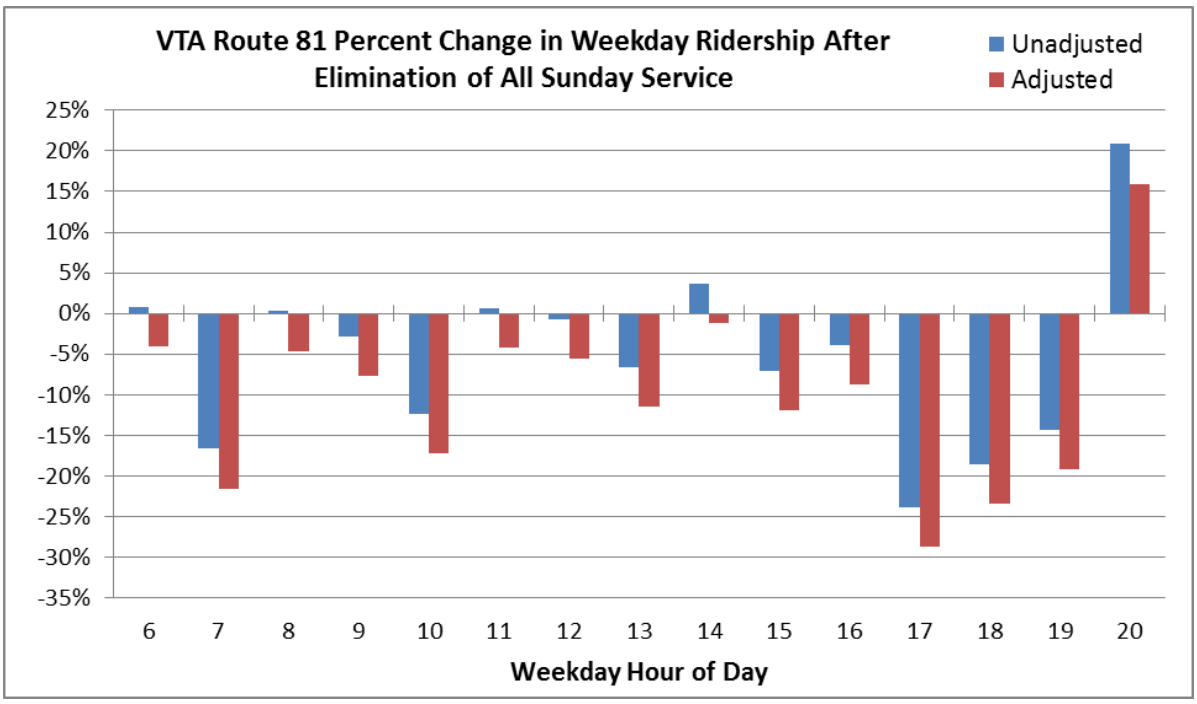

Figure 37. VTA Route 81 percent change in weekday ridership after elimination of all Sunday service in January 2012.

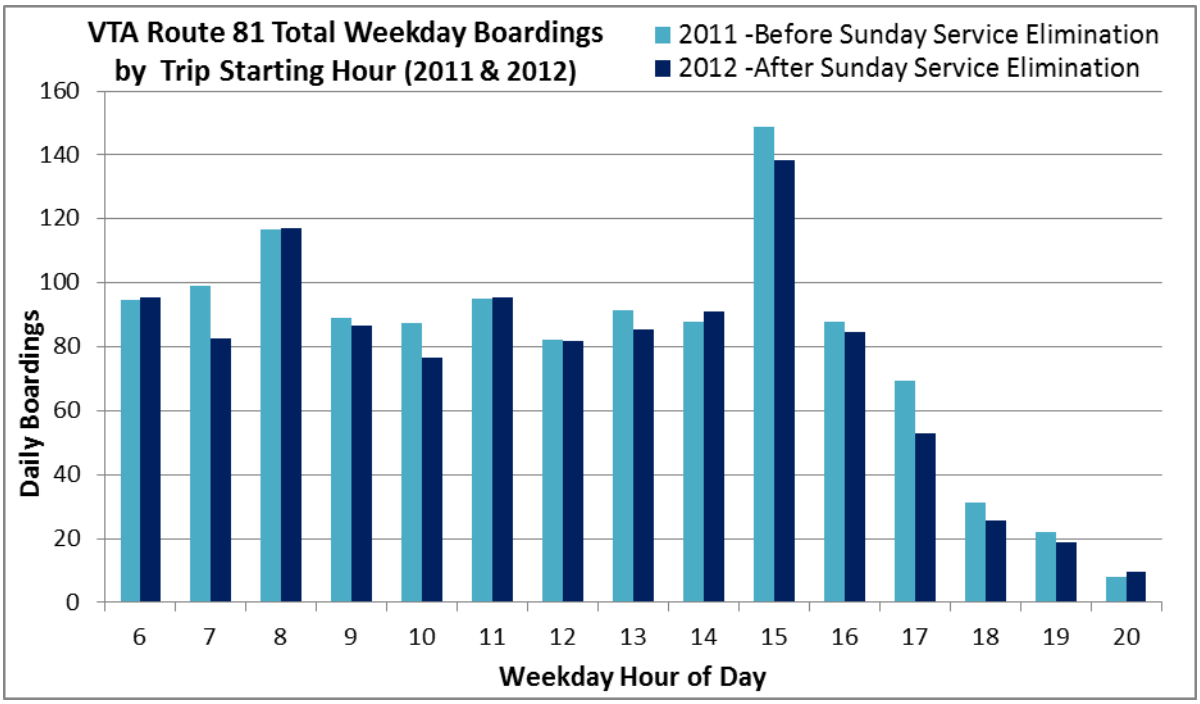

Figure 38. VTA Route 81 total weekday boardings by trip starting hour before and after January 2012 elimination of all Sunday service.

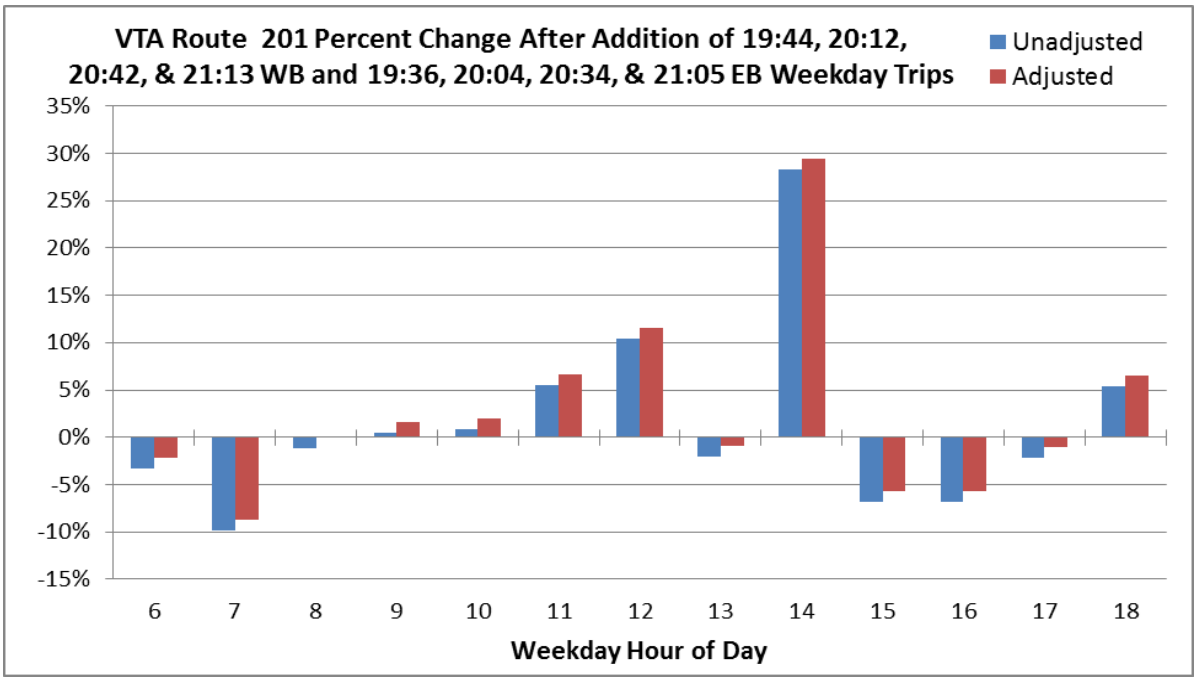

Figure 39. VTA Route 201 percent change in weekday ridership after addition of 7:44 p.m. - 9:13 p.m. westbound and 7:36 p.m. - 9:05 p.m. eastbound weekday trips in July 2013.

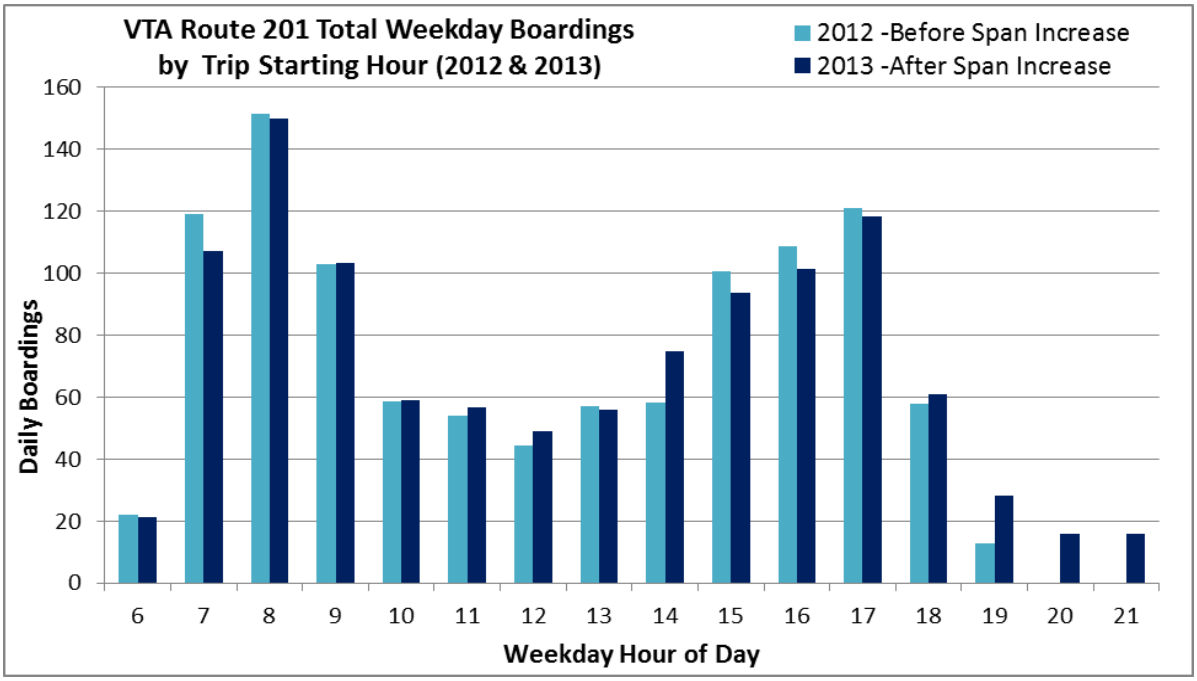

Figure 40. VTA Route 201 total weekday boardings by trip starting hour before and after July 2013 addition of 7:44 p.m. - 9:13 p.m. westbound and 7:36 p.m. - 9:05 p.m. eastbound weekday trips.

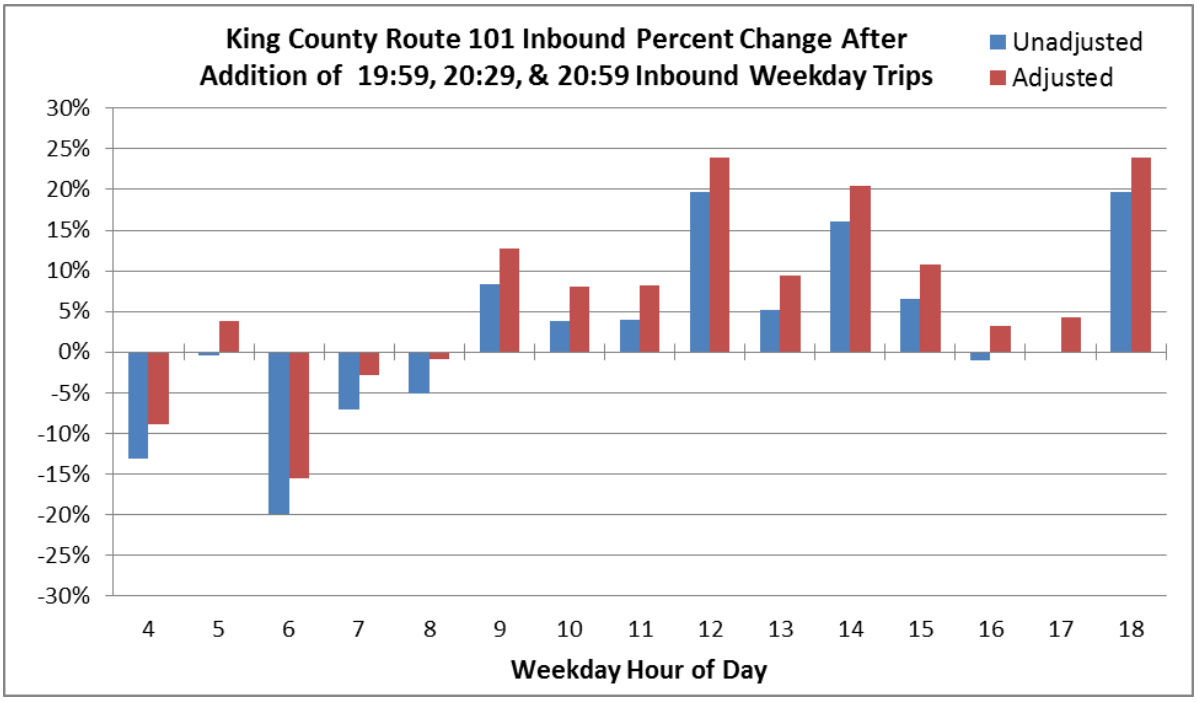

Figure 41. King County Route 101 inbound percent change in weekday ridership after addition of 7:59 p.m., 8:29 p.m., and 8:59 p.m. inbound weekday trips in February 2002.

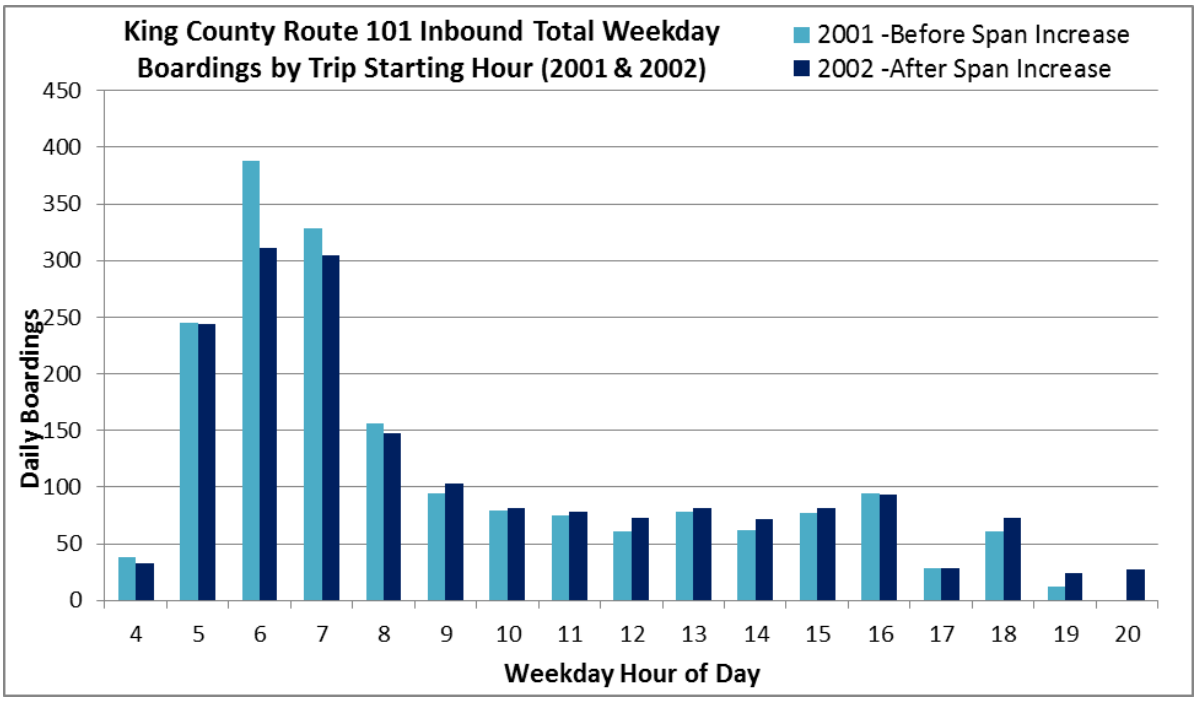

Figure 42. King County Route 101 inbound total weekday boardings by trip starting hour before and after February 2002 addition of 7:59 p.m., 8:29 p.m., and 8:59 p.m. inbound weekday trips.

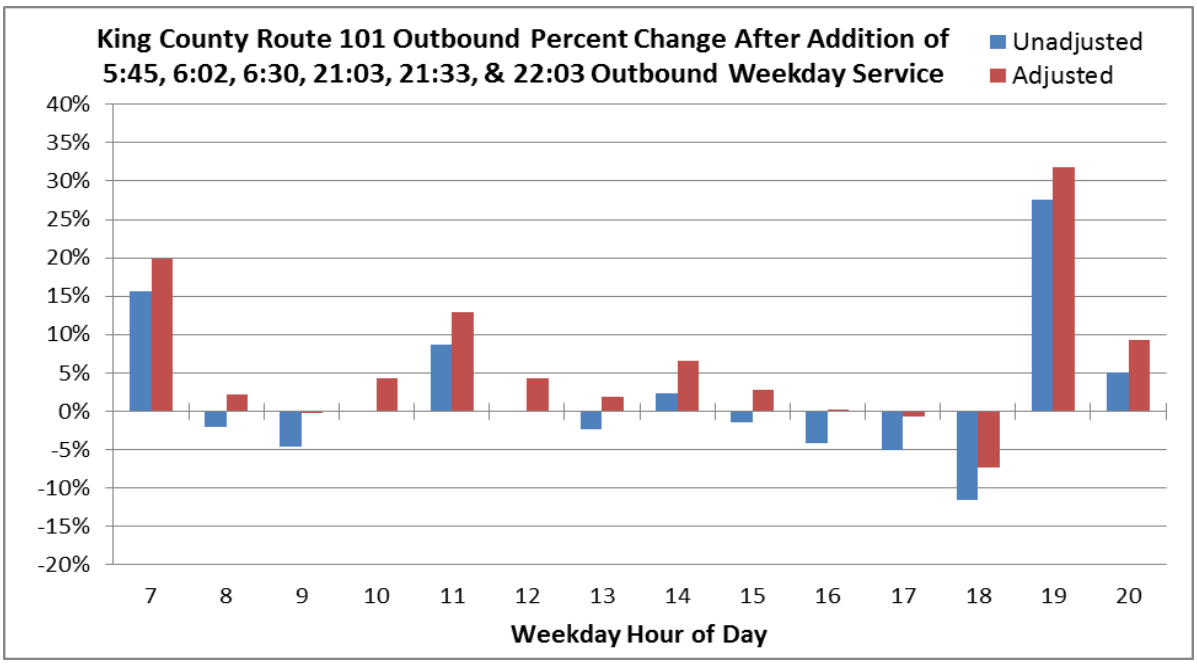

Figure 43. King County Route 101 outbound percent change in weekday ridership after addition of 5:45 a.m. – 6:30 a.m. and 9:03 p.m. – 10:03 p.m. outbound weekday service in February 2002.

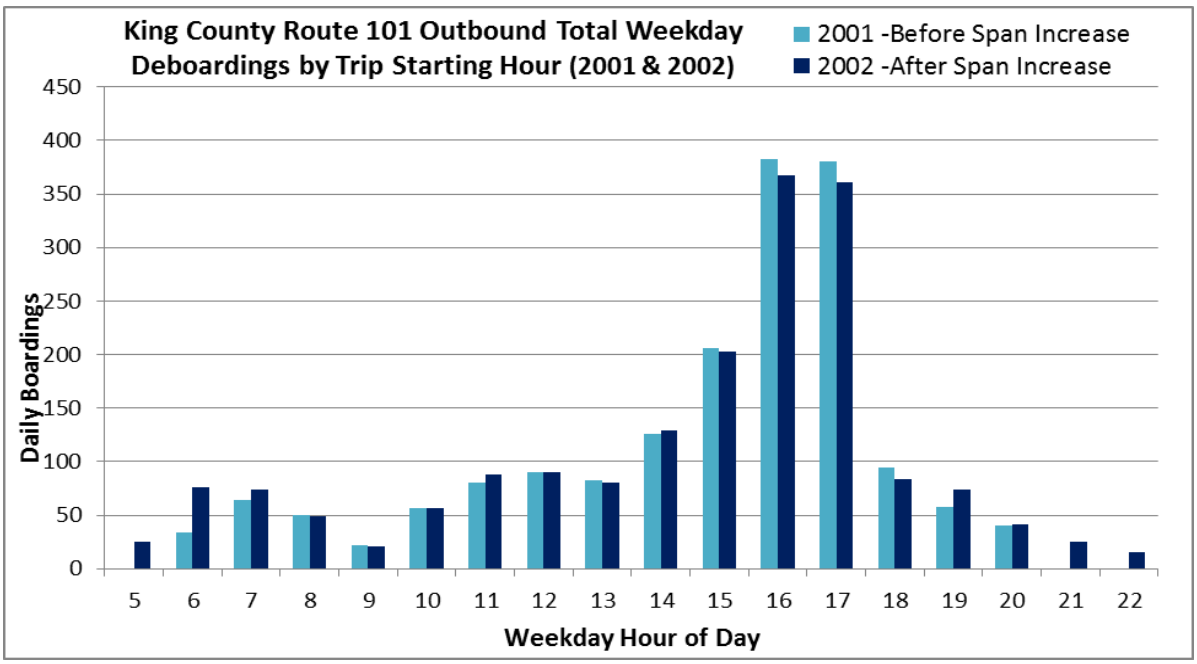

Figure 44. King County Route 101 outbound total weekday deboardings by trip starting hour before and after February 2002 addition of 5:45 a.m. – 6:30 a.m. and 9:03 p.m. – 10:03 p.m. outbound weekday service. Note that deboardings are used on this route due to interlining with another route.

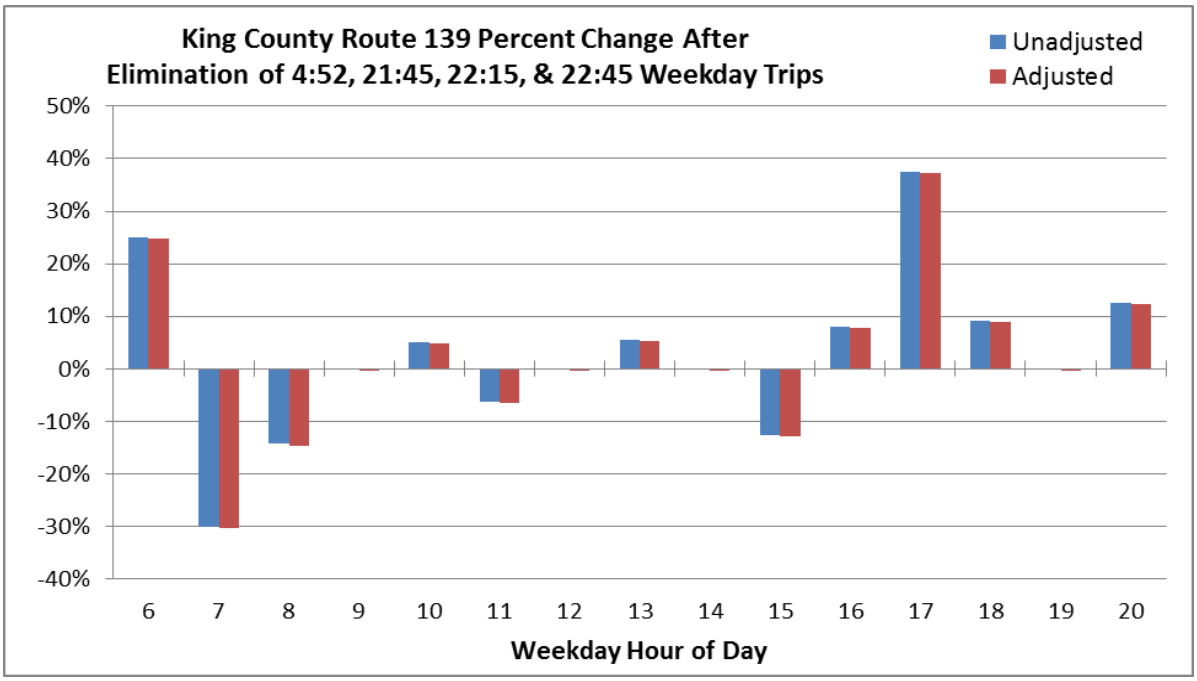

Figure 45. King County Route 139 percent change in weekday ridership after elimination of 4:52 a.m., 9:45 p.m., 10:15 p.m., and 10:45 p.m. weekday trips in February 2010.

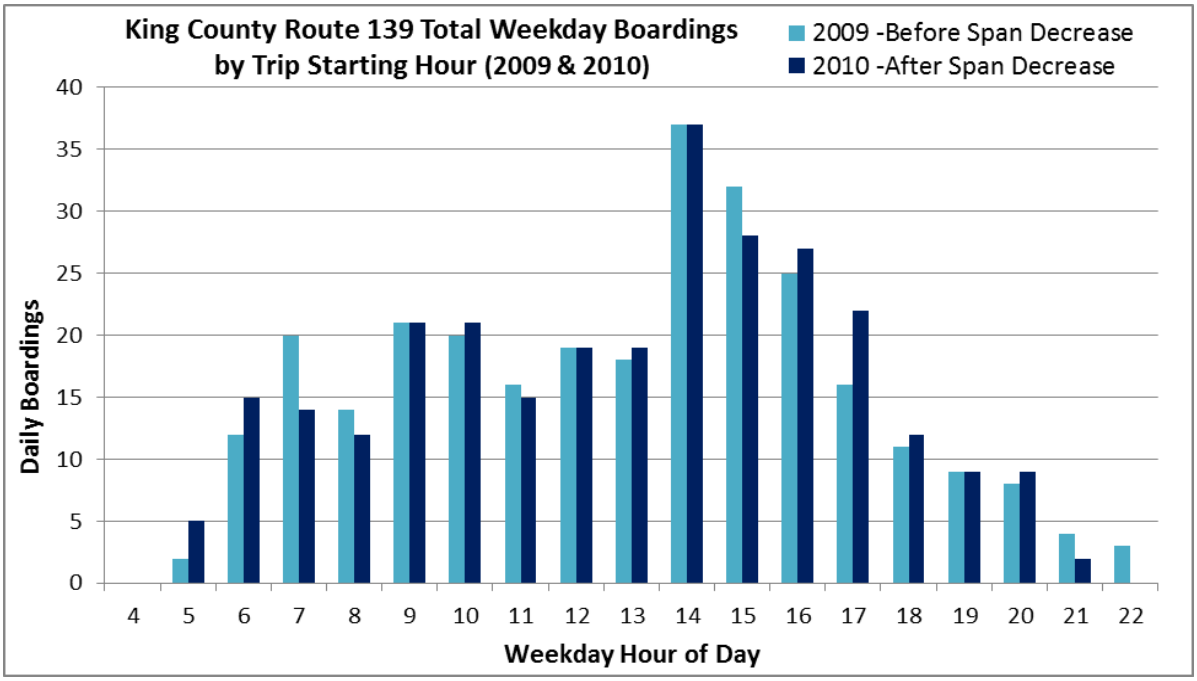

Figure 46. King County Route 139 total weekday boardings by trip starting hour before and after February 2010 elimination of 4:52 a.m., 9:45 p.m., 10:15 p.m., and 10:45 p.m. weekday trips

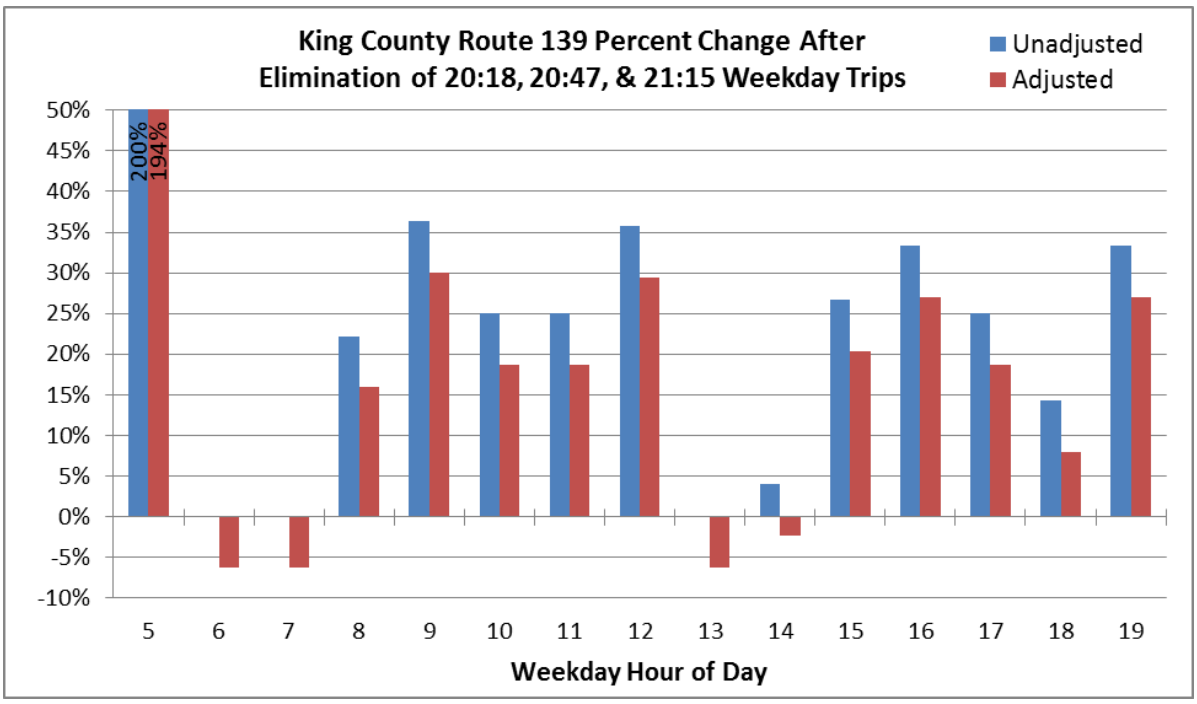

Figure 47. King County Route 139 percent change in weekday ridership after elimination of 8:18 p.m., 8:47 p.m., and 9:15 p.m. weekday trips in June 2012.

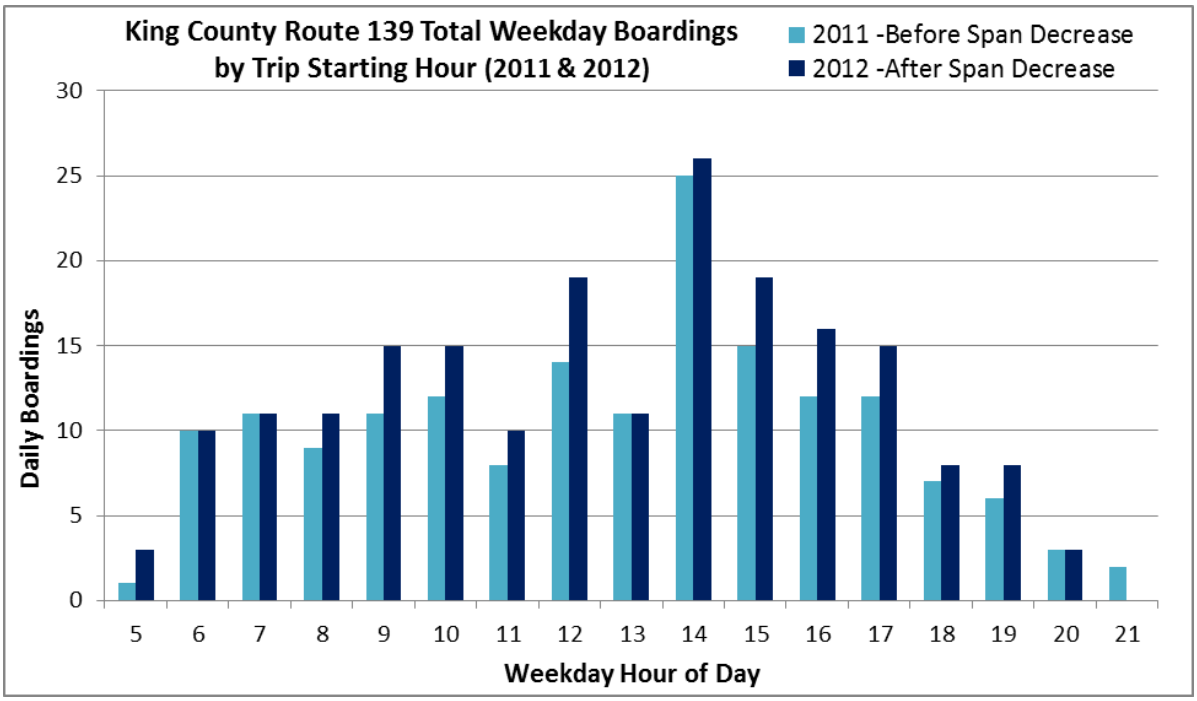

Figure 48. King County Route 139 total weekday boardings by trip starting hour before and after June 2012 elimination of 8:18 p.m., 8:47 p.m., and 9:15 p.m. weekday trips.

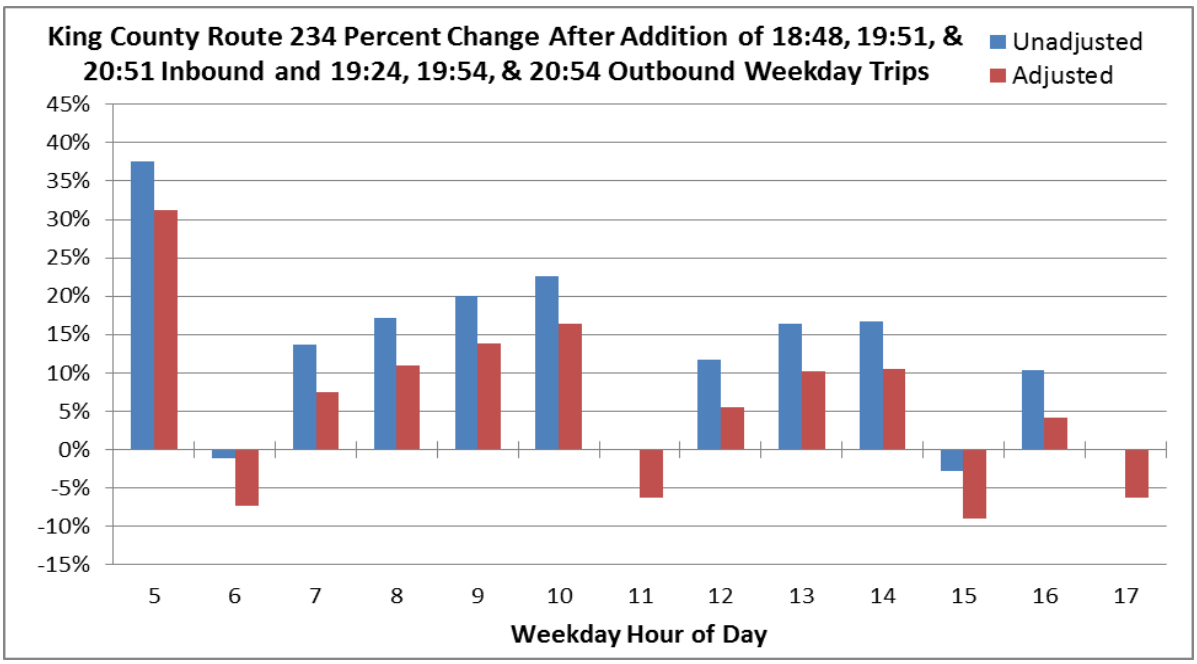

Figure 49. King County Route 234 percent change in weekday ridership after addition of 6:48 p.m., 7:51 p.m., & 8:51 p.m. inbound and 7:24 p.m., 7:54 p.m., & 8:54 p.m. outbound weekday trips in February 2007.

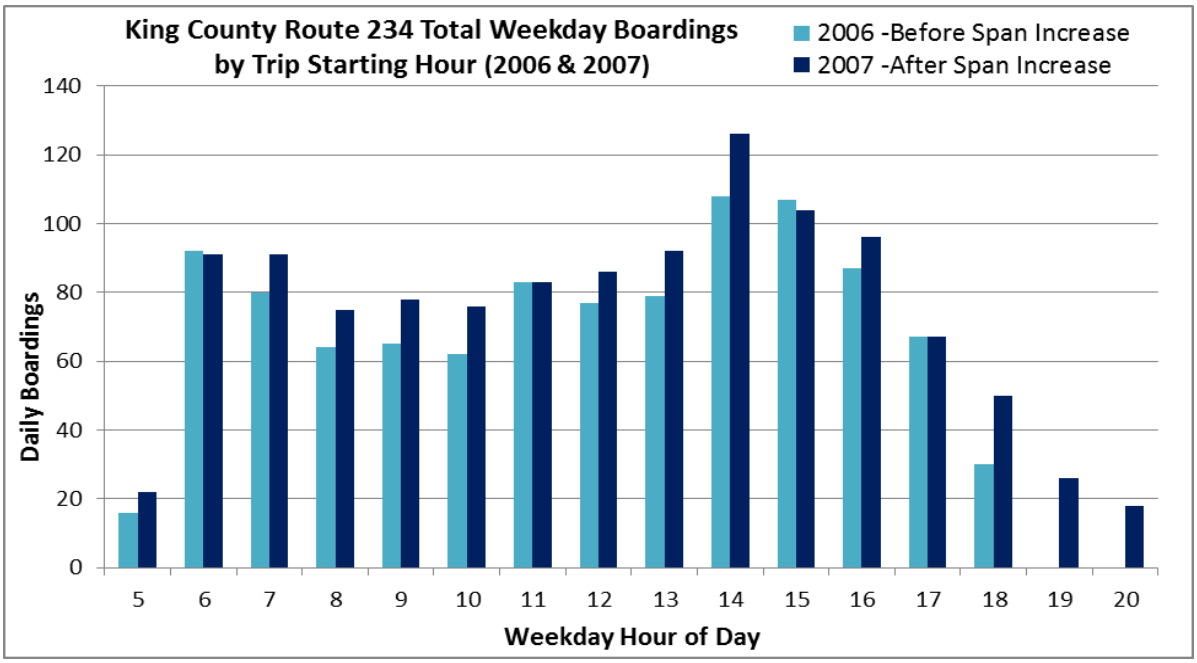

Figure 50. King County Route 234 total weekday boardings by trip starting hour before and after February 2007 addition of 6:48 p.m., 7:51 p.m., & 8:51 p.m. inbound and 7:24 p.m., 7:54 p.m., & 8:54 p.m. outbound weekday trips.

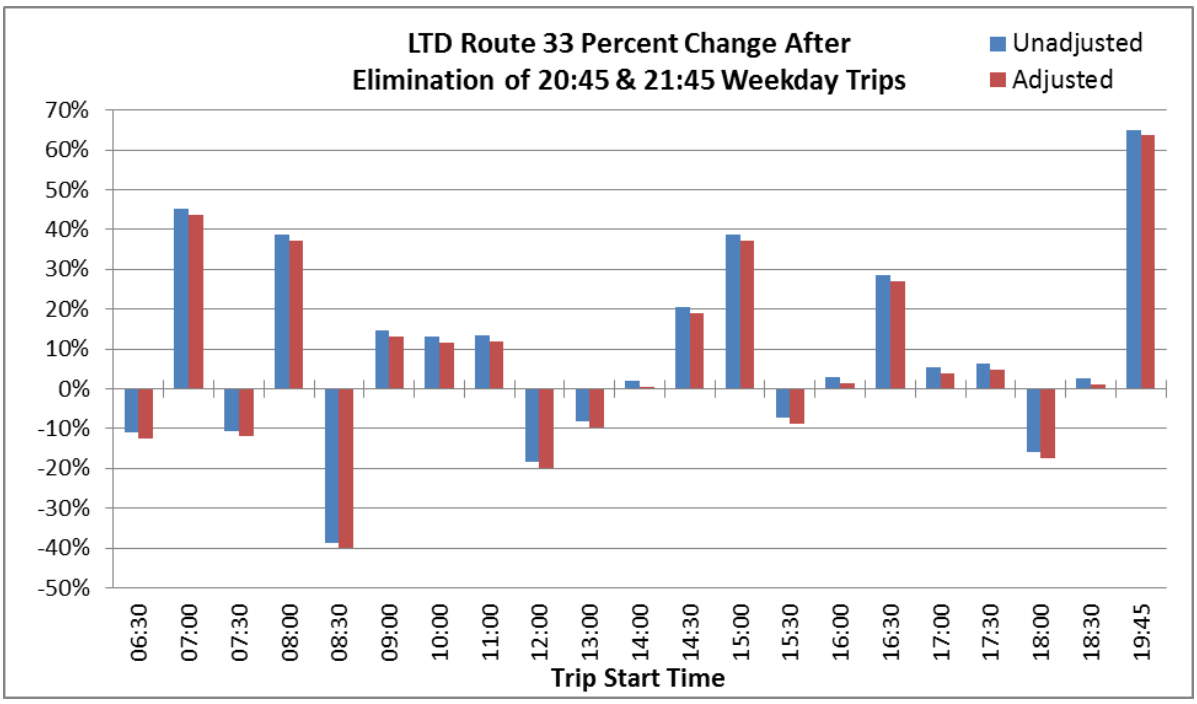

Figure 51. Lane Transit District Route 33 percent change in weekday ridership after elimination of 8:45 & 9:45 p.m. weekday trips in September 2010.

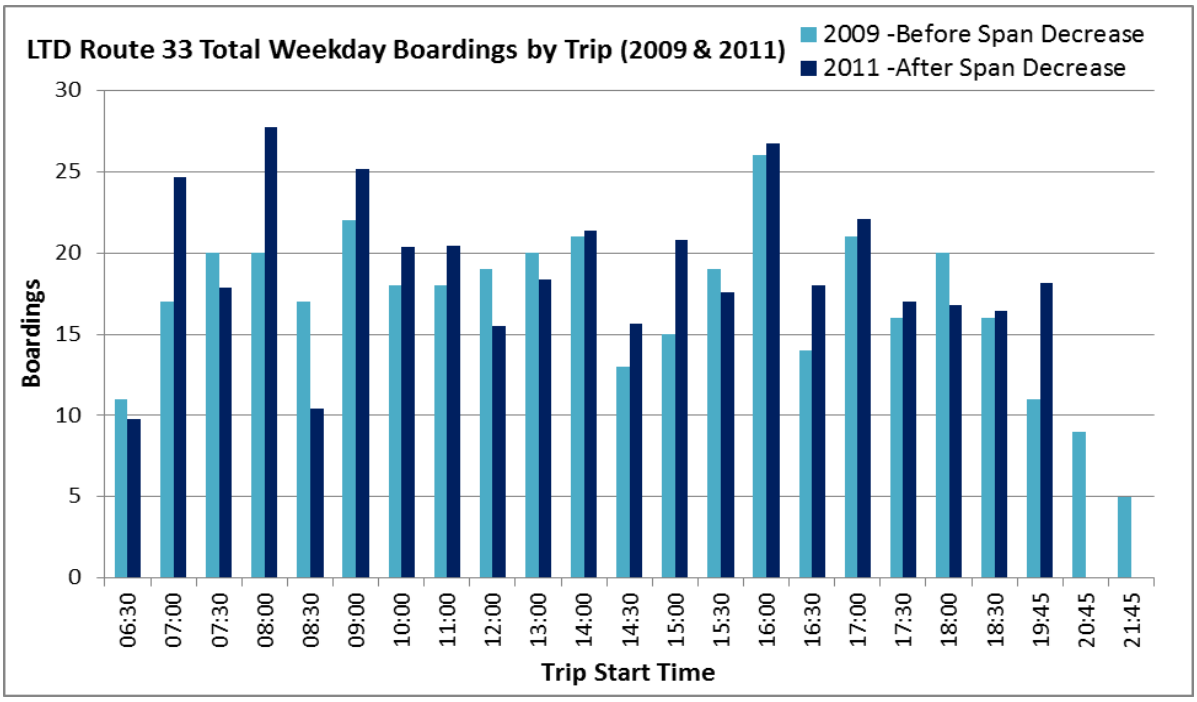

Figure 52. Lane Transit District Route 33 total weekday boardings by trip start time before and after September 2010 elimination of 8:45 p.m. & 9:45 p.m. weekday trips.

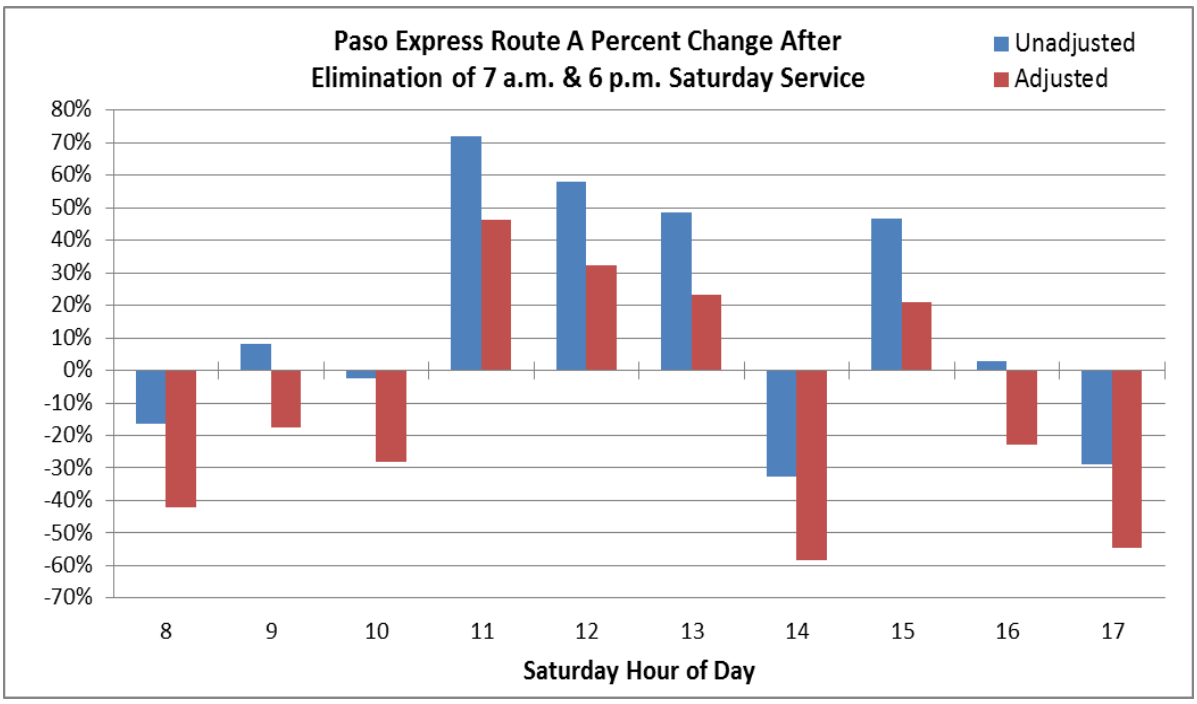

Figure 53. Paso Express Route A percent change in Saturday ridership after elimination of 7 a.m. & 6 p.m. Saturday service in August 2012.

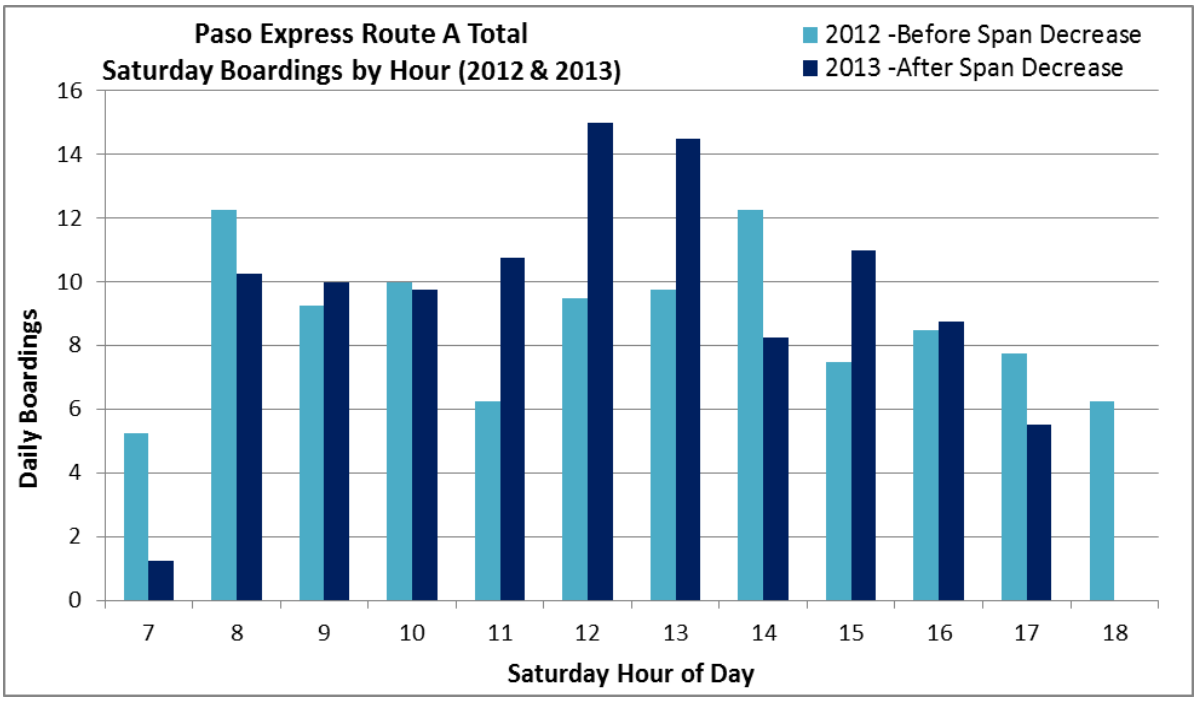

Figure 54. Paso Express Route A total Saturday boardings by hour before and after August 2012 elimination of 7 a.m. & 6 p.m. Saturday service.

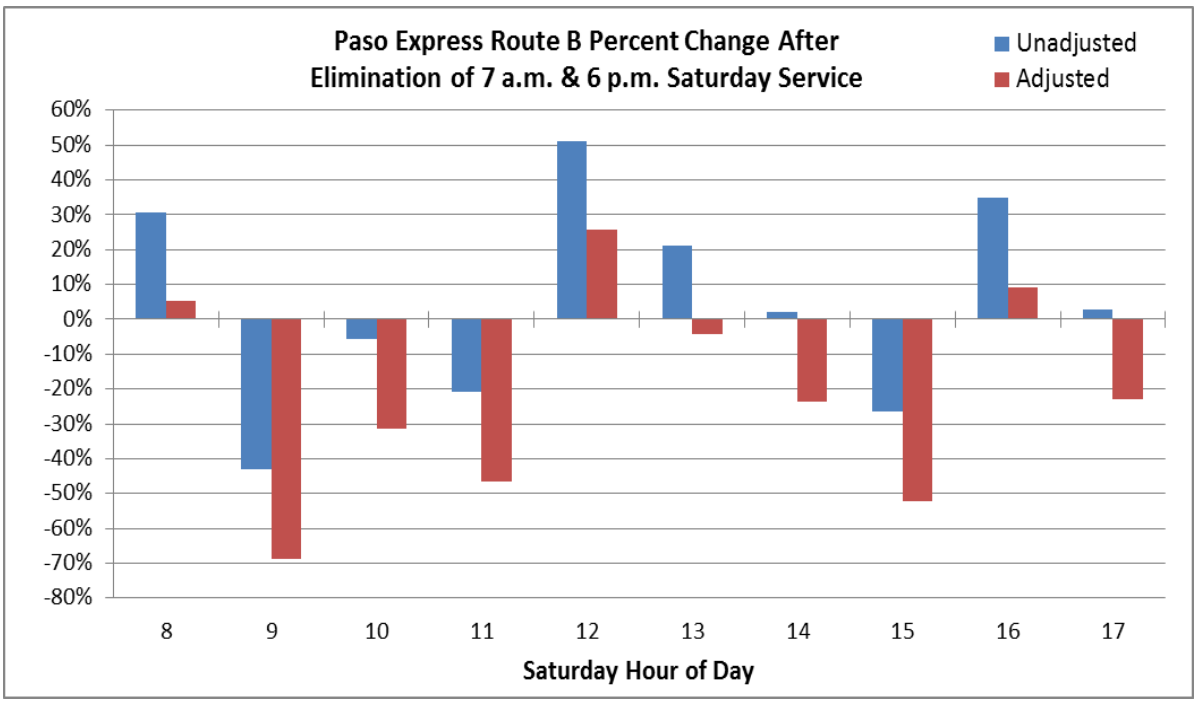

Figure 55. Paso Express Route B percent change in Saturday ridership after elimination of 7 a.m. & 6 p.m. Saturday service in August 2012.

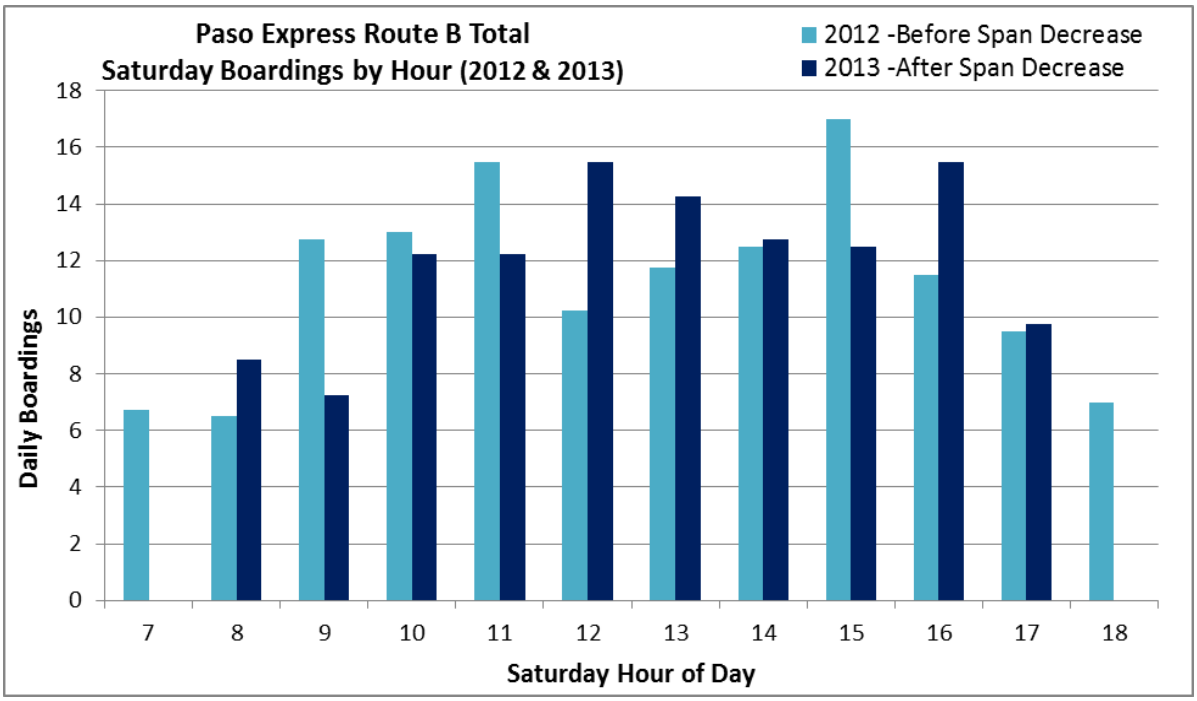

Figure 56. Paso Express Route B total Saturday boardings by hour before and after August 2012 elimination of 7 a.m. & 6 p.m. Saturday service.

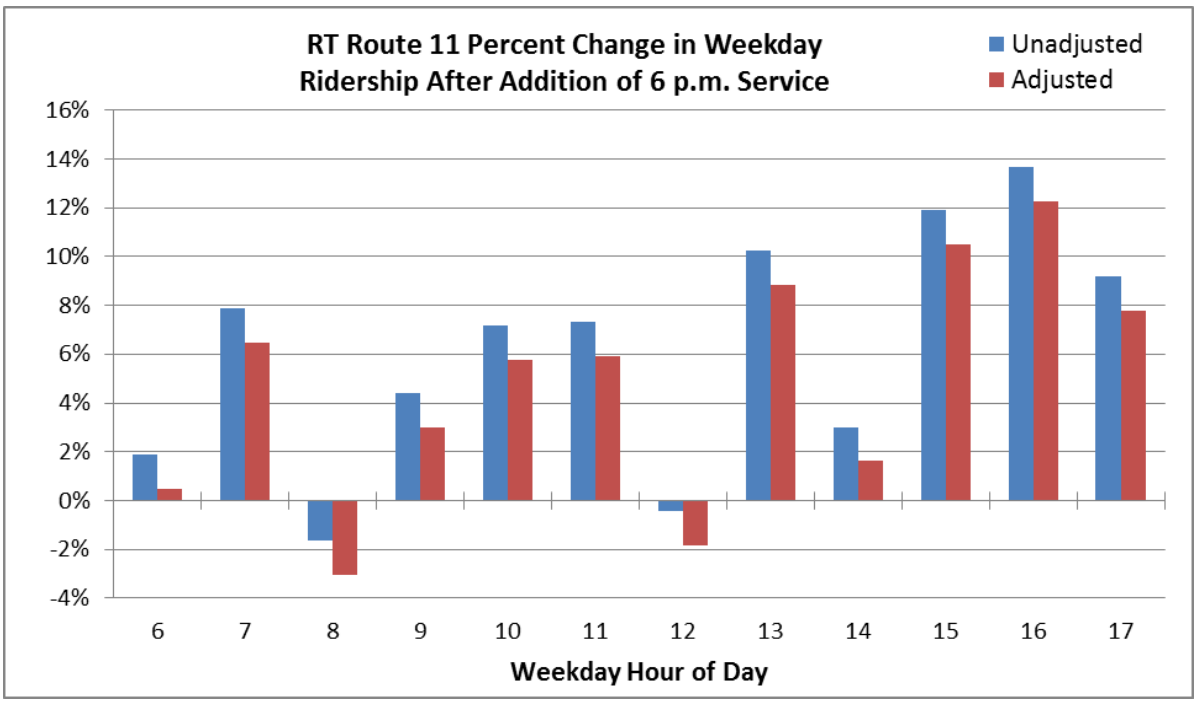

Figure 57. Regional Transit Route 11 percent change in weekday ridership after addition of 6 p.m. weekday service in September 2012.

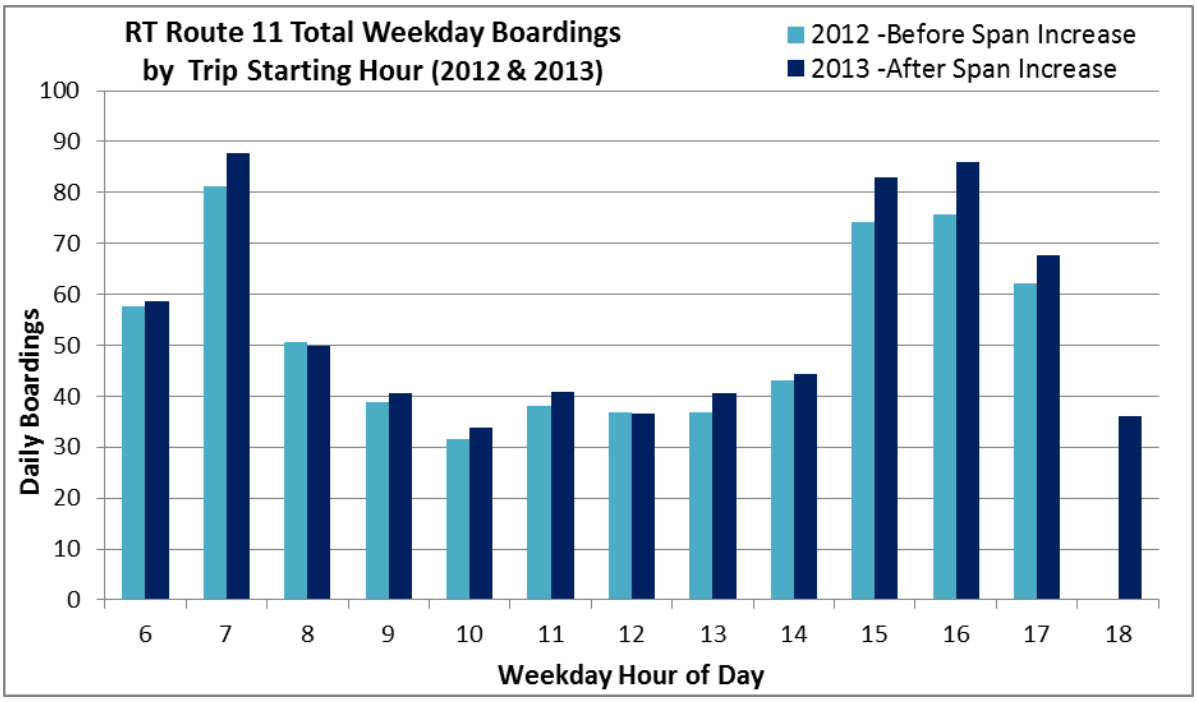

Figure 58. Regional Transit Route 11 total weekday boardings by trip starting hour before and after September 2012 addition of 6 p.m. weekday service.

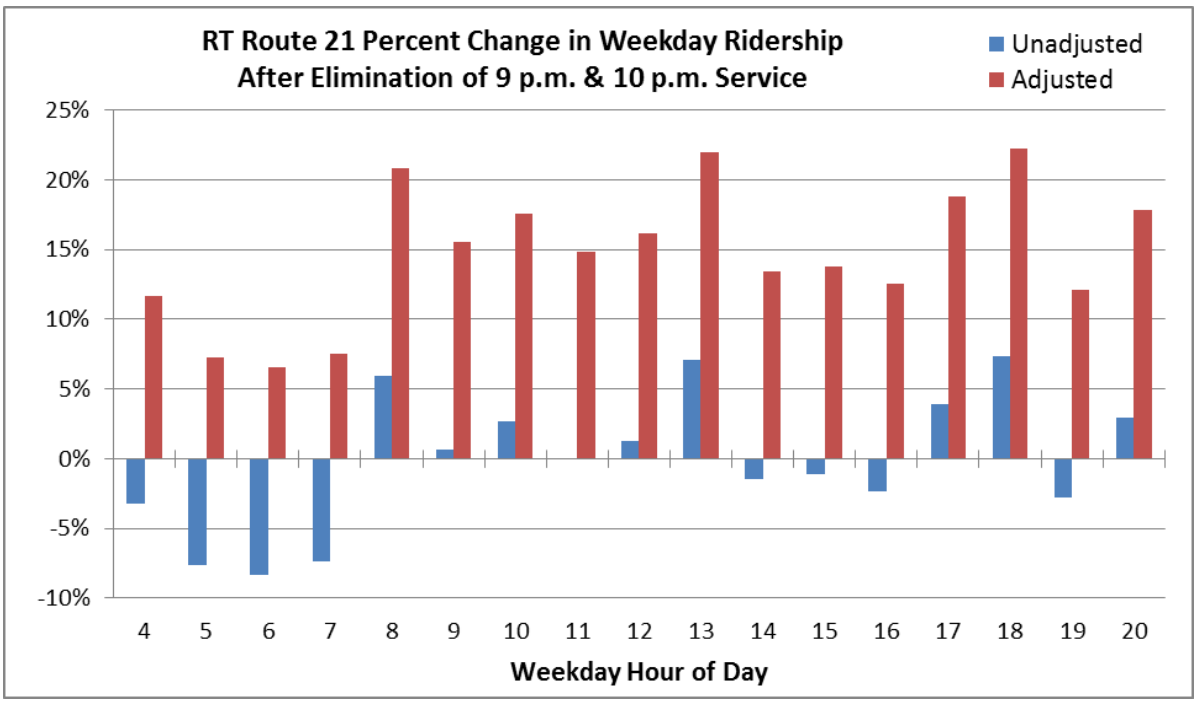

Figure 59. Regional Transit Route 21 percent change in weekday ridership after elimination of 9 p.m. & 10 p.m. weekday service in June 2010.

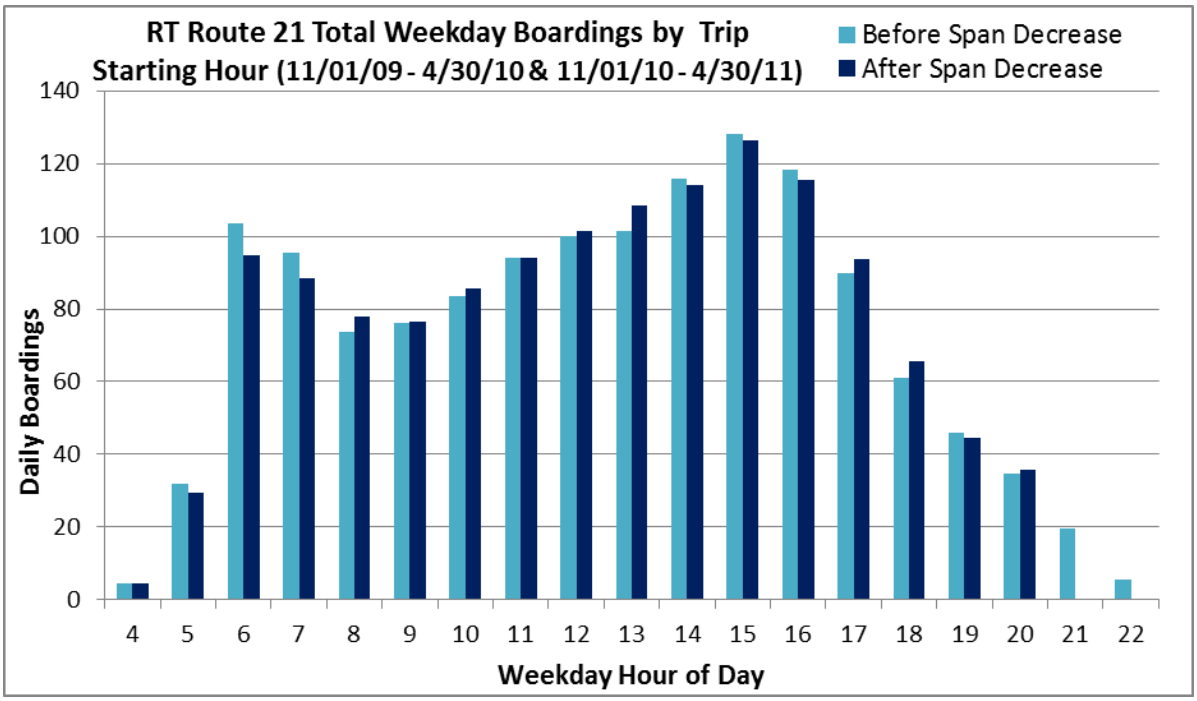

Figure 60. Regional Transit Route 21 total weekday boardings by trip starting hour before and after June 2010 elimination of 9 p.m. & 10 p.m. weekday service.

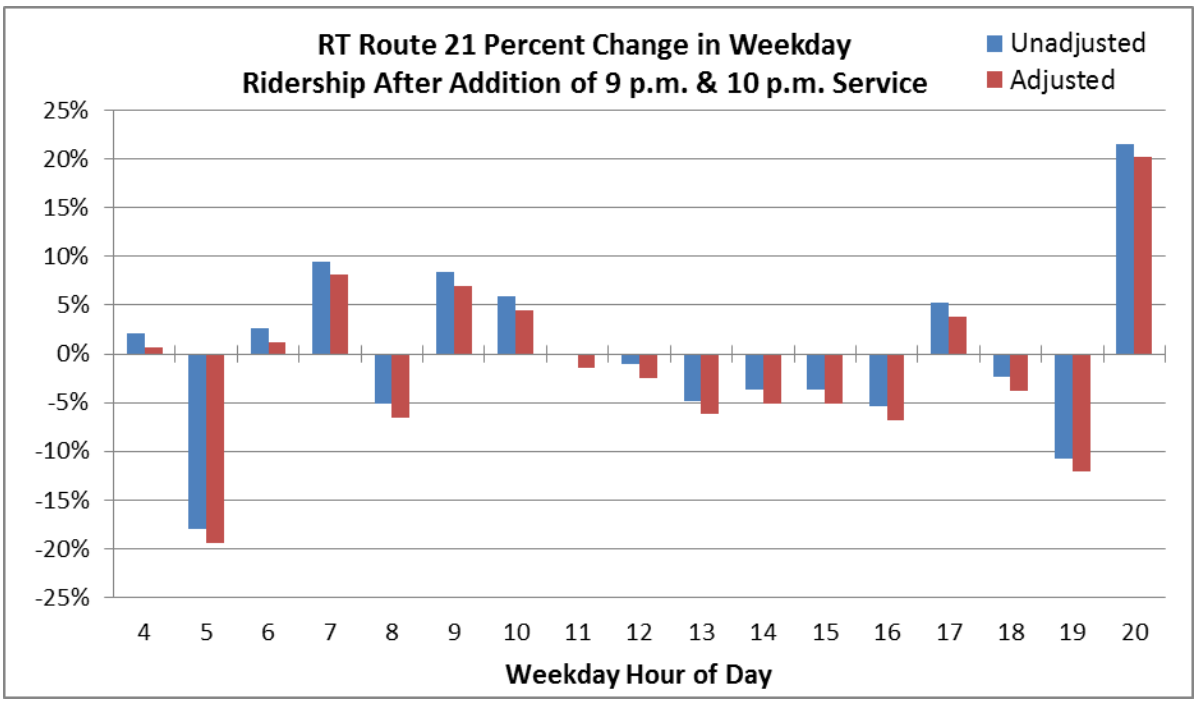

Figure 61. Regional Transit Route 21 percent change in weekday ridership after addition of 9 p.m. & 10 p.m. weekday service in September 2012.

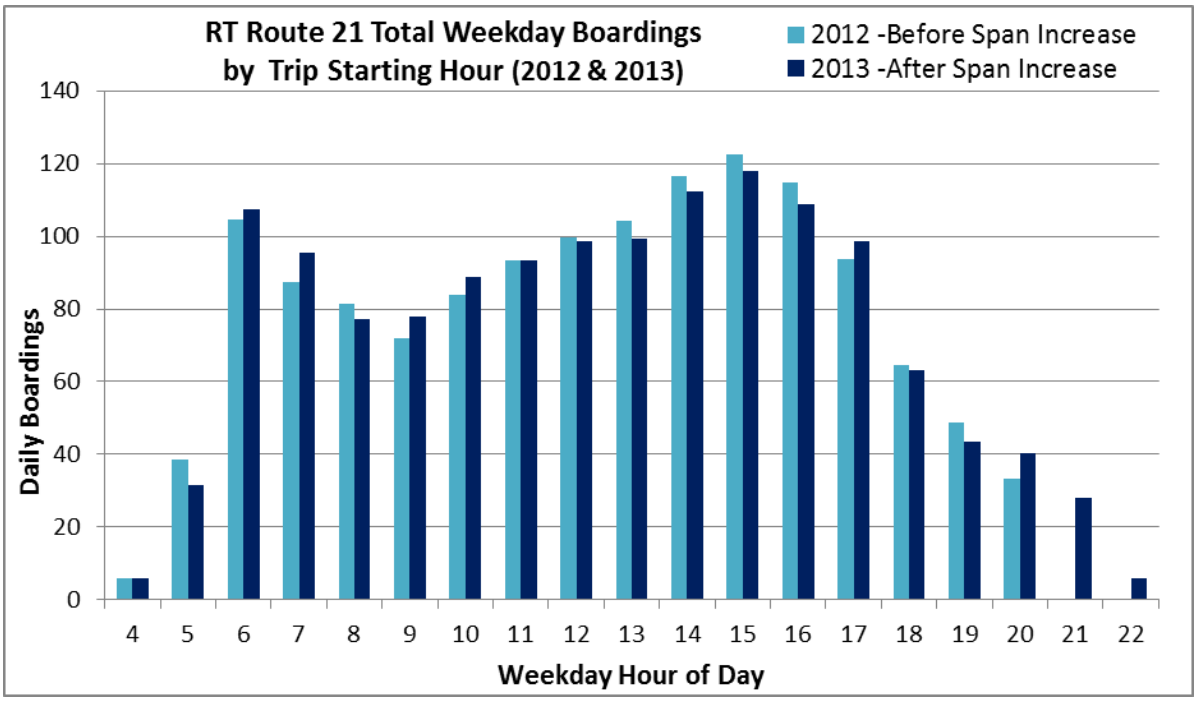

Figure 62. Regional Transit Route 21 total weekday boardings by trip starting hour before and after September 2012 addition of 9 p.m. & 10 p.m. weekday service.

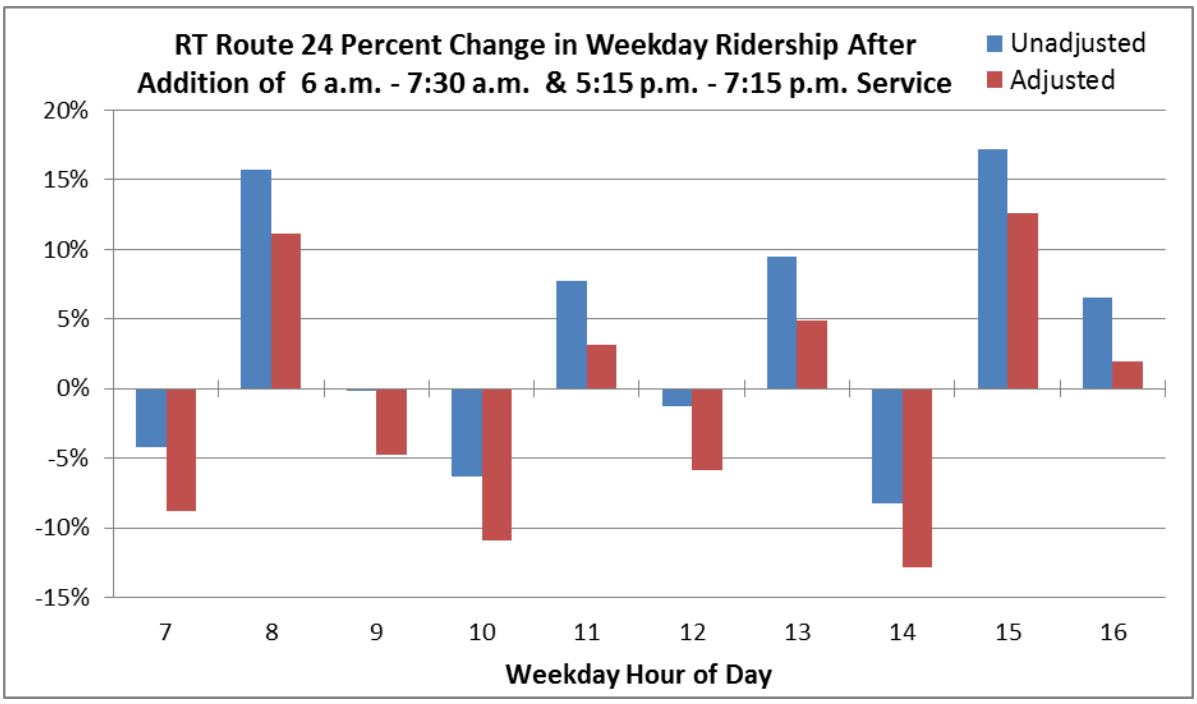

Figure 63. Regional Transit Route 24 percent change in weekday ridership after addition of 6 a.m. – 7:30 a.m. & 5:15 p.m. – 7:15 p.m. weekday service in January 2013.

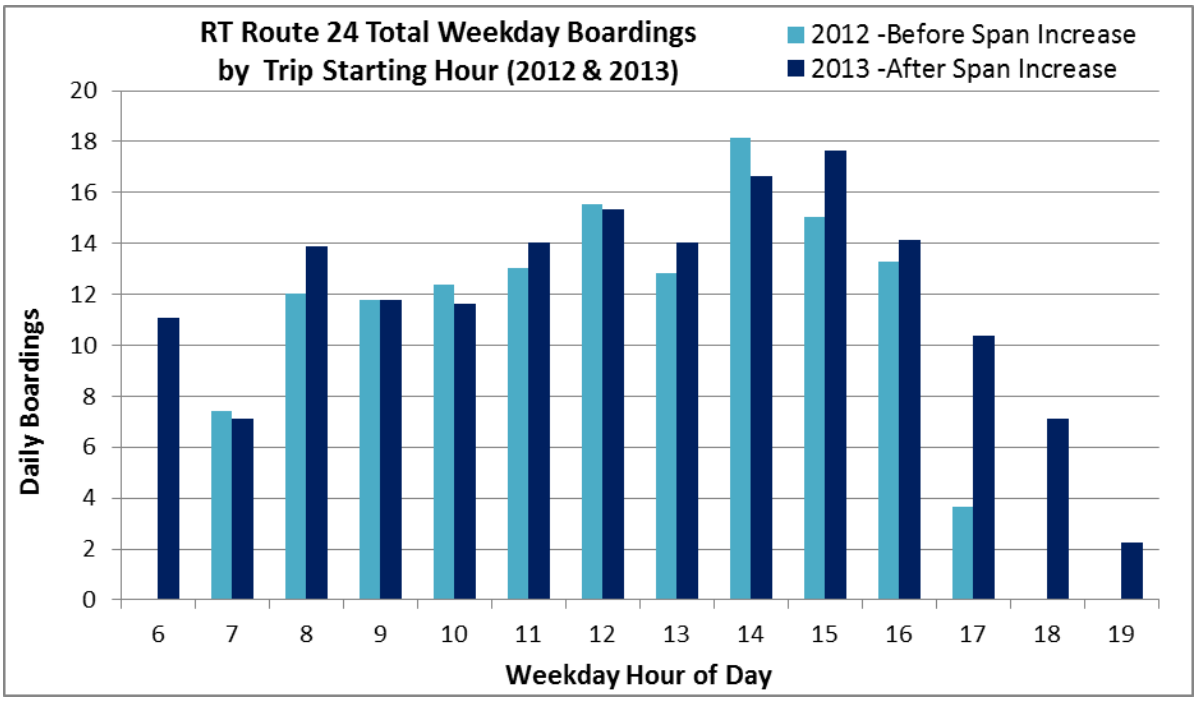

Figure 64. Regional Transit Route 24 total weekday boardings by trip starting hour before and after January 2013 addition of 6 a.m. – 7:30 a.m. & 5:15 p.m. – 7:15 p.m. weekday service.

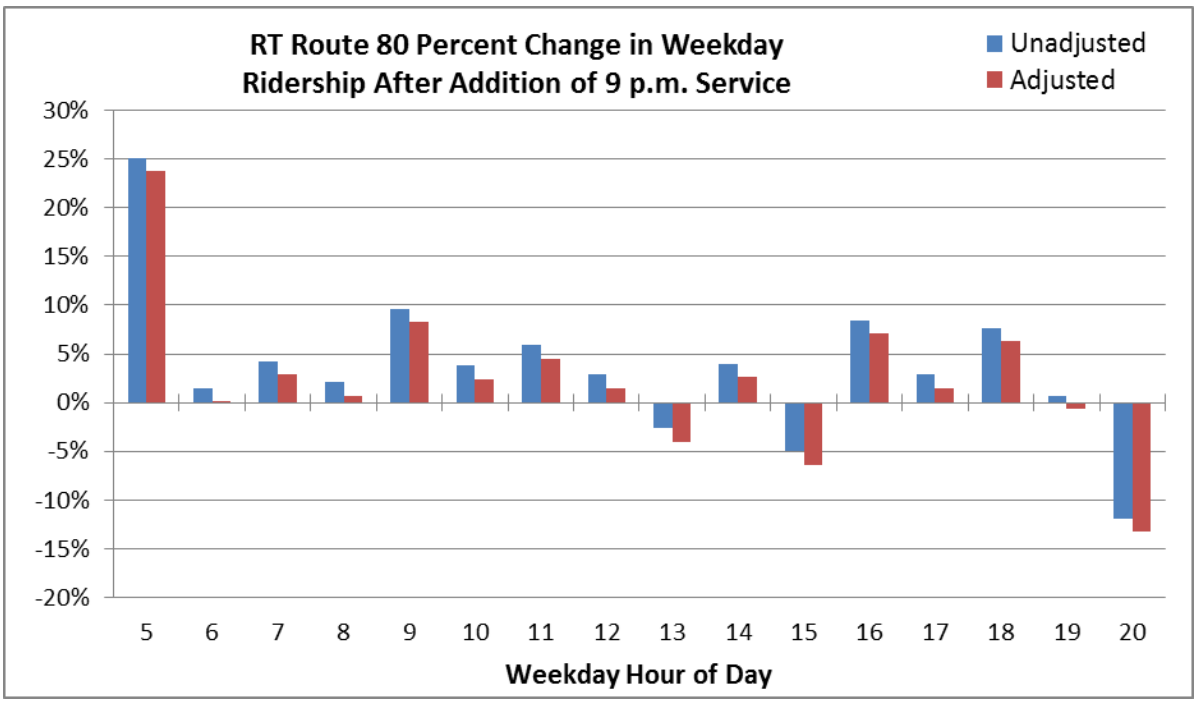

Figure 65. Regional Transit Route 80 percent change in weekday ridership after addition of 9 p.m. weekday service in September 2012.

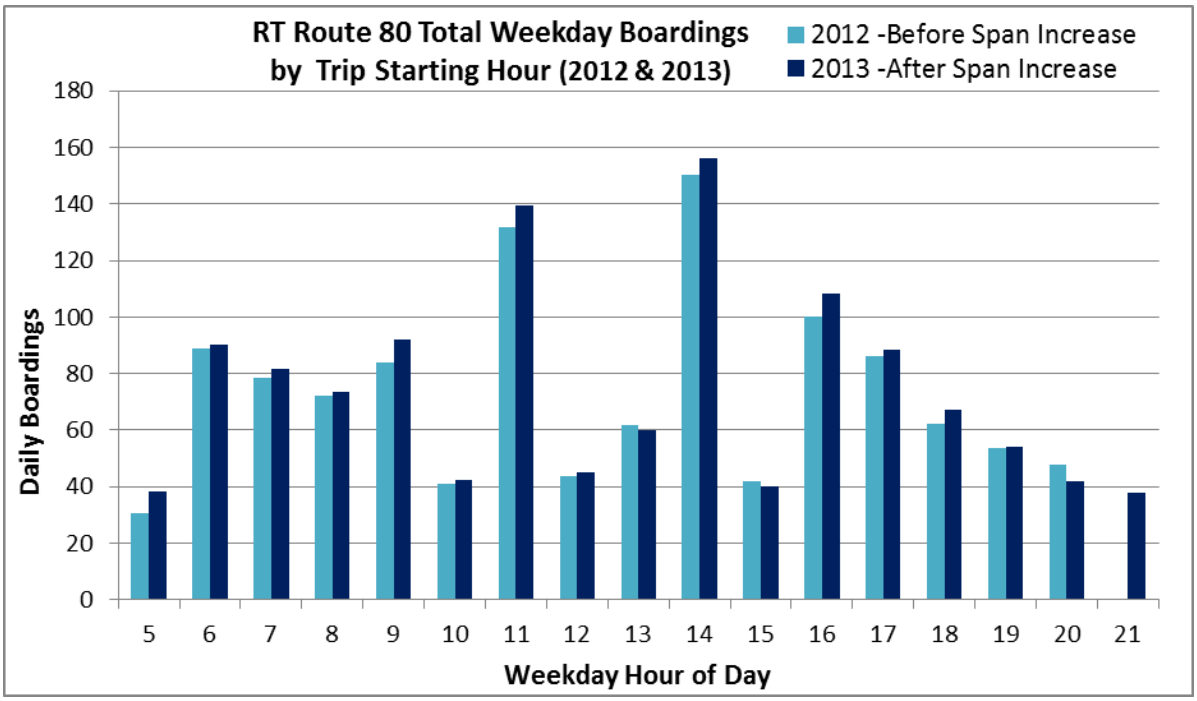

Figure 66. Regional Transit Route 80 total weekday boardings by trip starting hour before and after September 2012 addition of 9 p.m. weekday service.

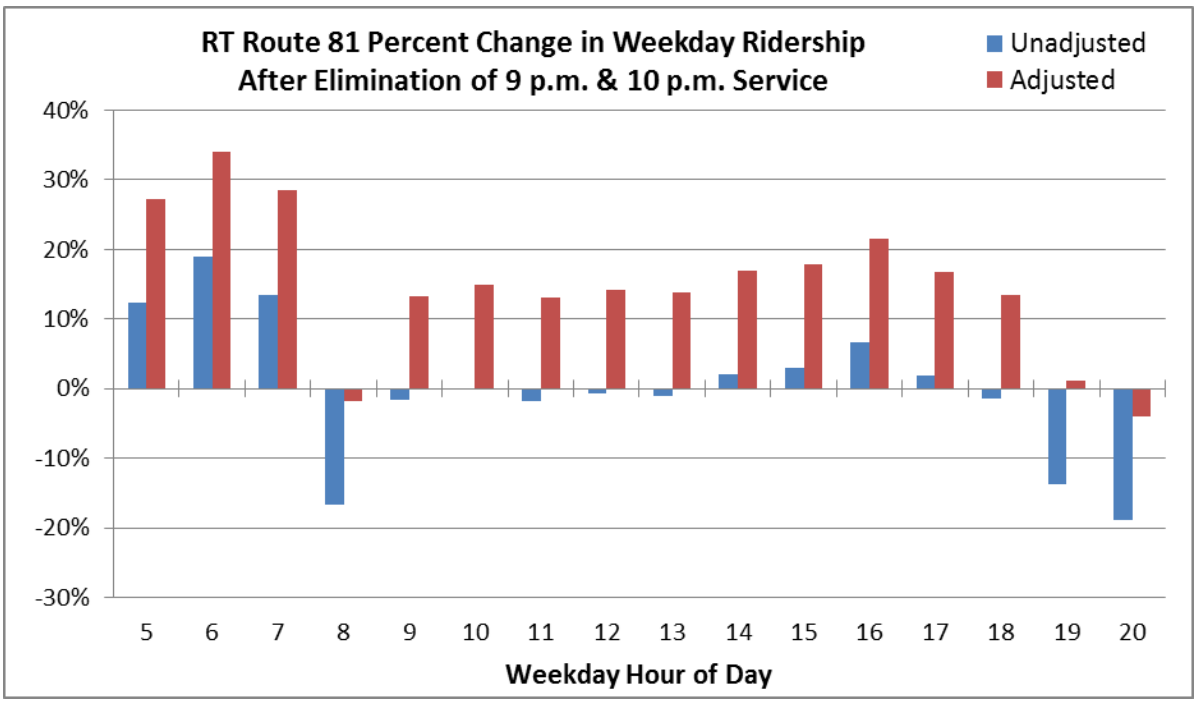

Figure 67. Regional Transit Route 81 percent change in weekday ridership after elimination of 9 p.m. & 10 p.m. weekday service in June 2010.

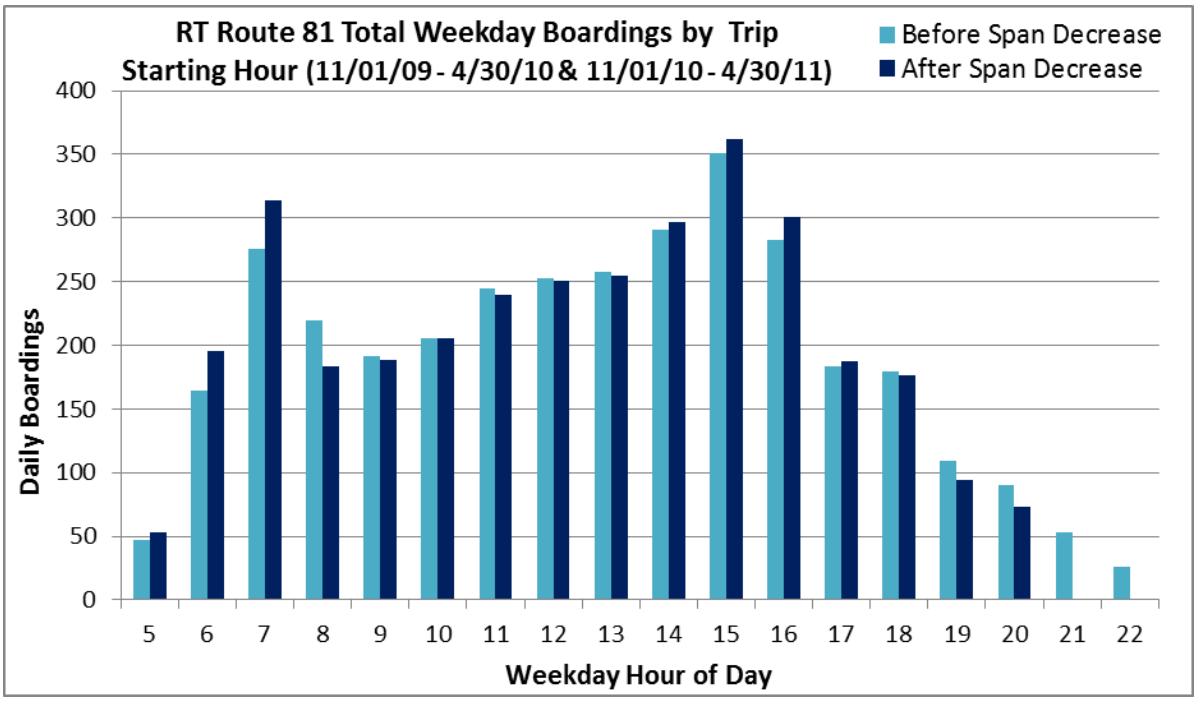

Figure 68. Regional Transit Route 81 total weekday boardings by trip starting hour before and after June 2010 elimination of 9 p.m. & 10 p.m. weekday service.

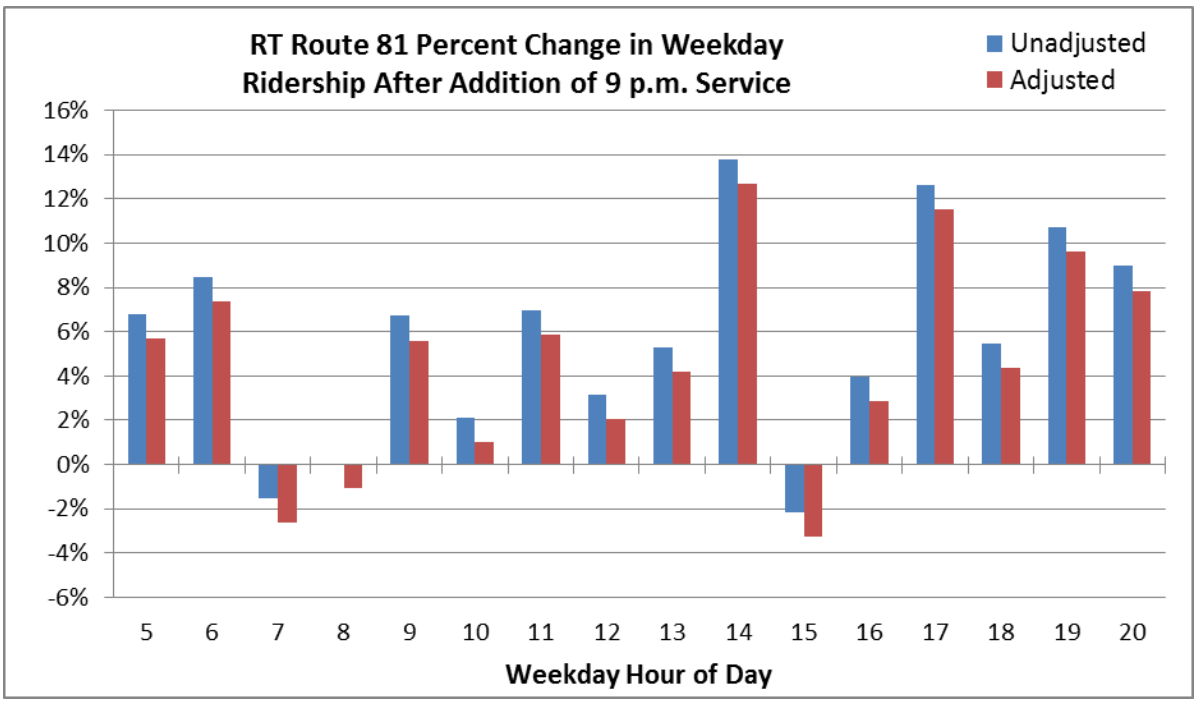

Figure 69. Regional Transit Route 81 percent change in weekday ridership after addition of 9 p.m. weekday service in September 2012.

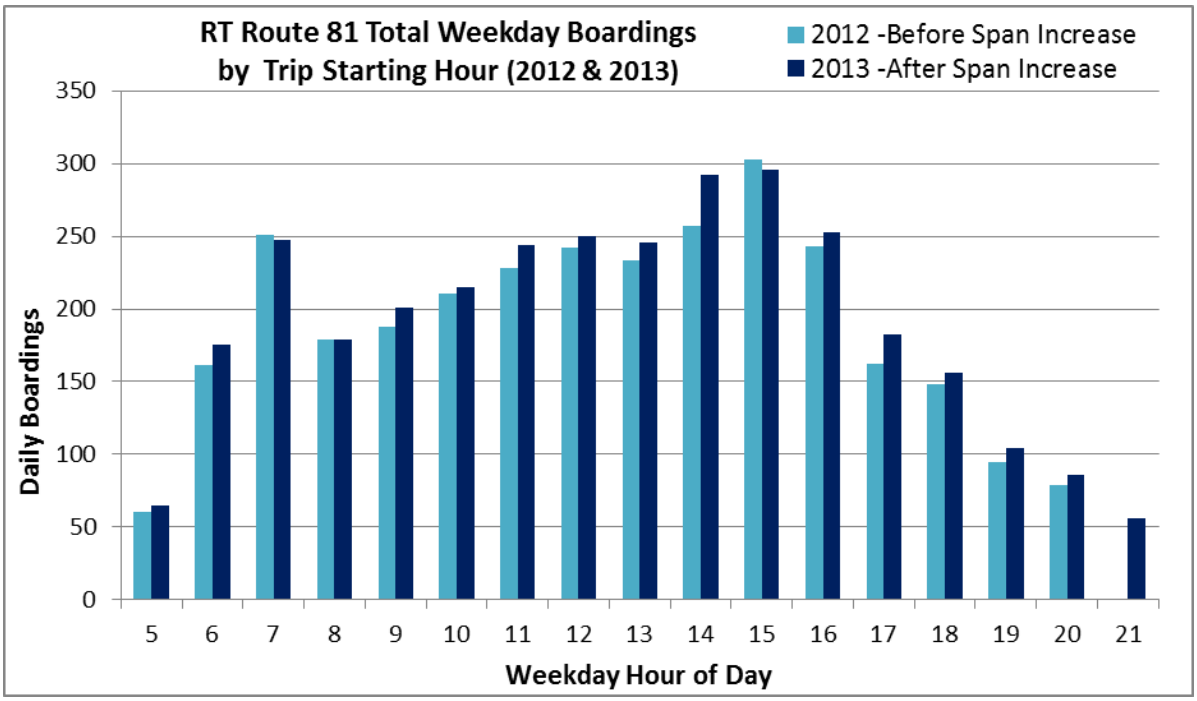

Figure 70. Regional Transit Route 81 total weekday boardings by trip starting hour before and after September 2012 addition of 9 p.m. weekday service.

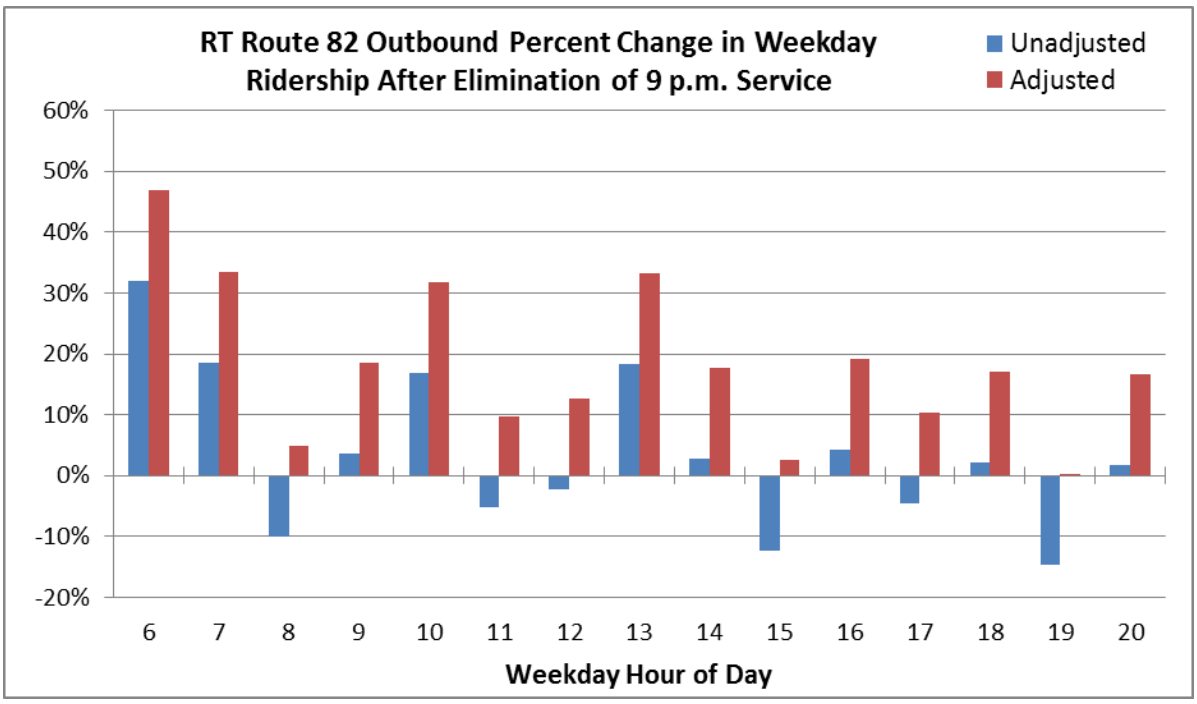

Figure 71. Regional Transit Route 82 Outbound percent change in weekday ridership after elimination of 9 p.m. service in June 2010.

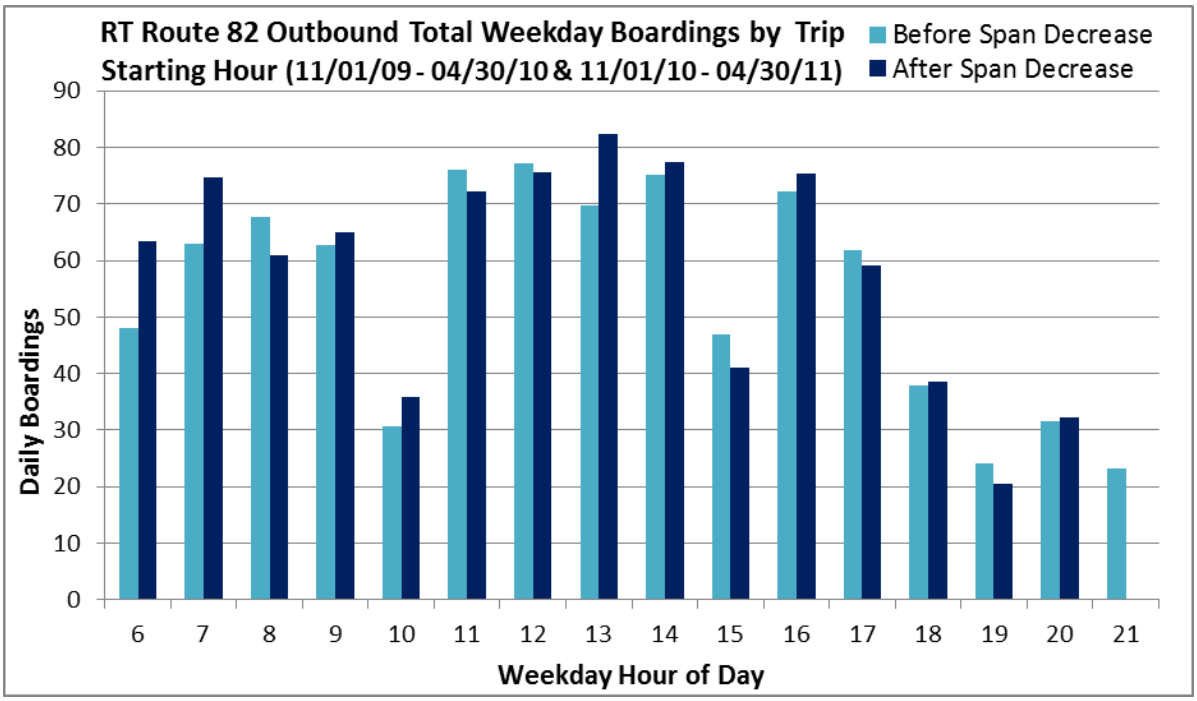

Figure 72. Regional Transit Route 82 Outbound total weekday boardings by trip starting hour before and after June 2010 elimination of 9 p.m. weekday service.

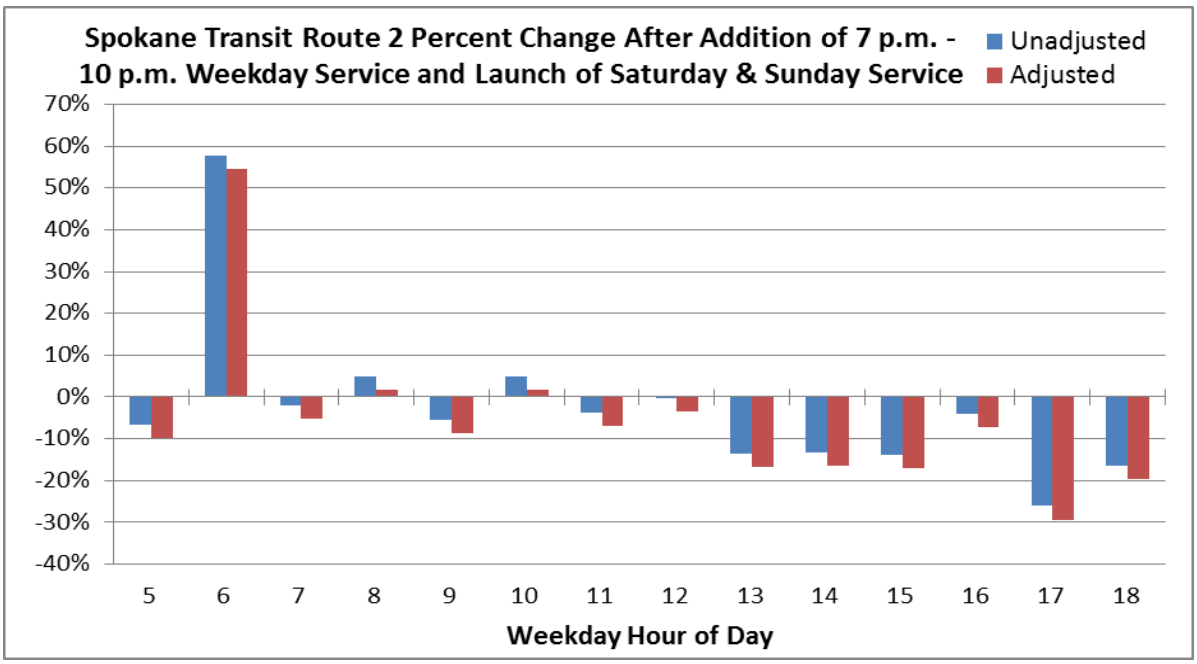

Figure 73. Spokane Transit Authority Route 2 percent change in weekday ridership after addition of 7 p.m. through 10 p.m. weekday service and launch of Saturday & Sunday service in September 2011.

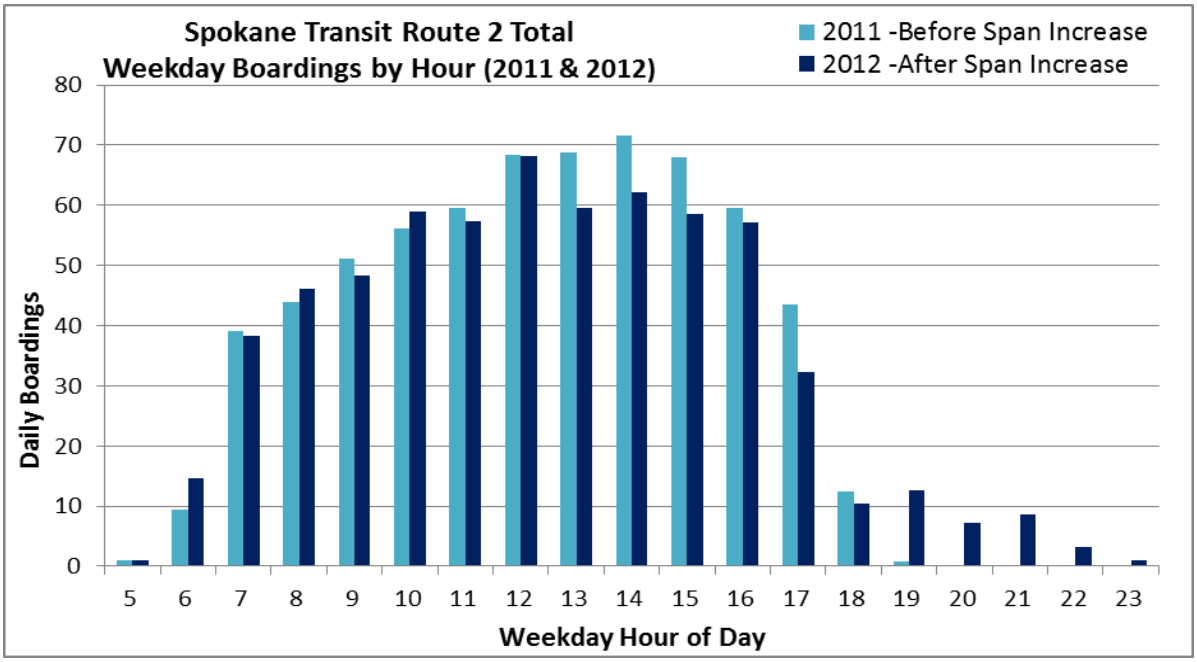

Figure 74. Spokane Transit Authority Route 2 total weekday boardings by hour before and after September 2011 addition of 7 p.m. through 10 p.m. weekday service and launch of Saturday & Sunday service.

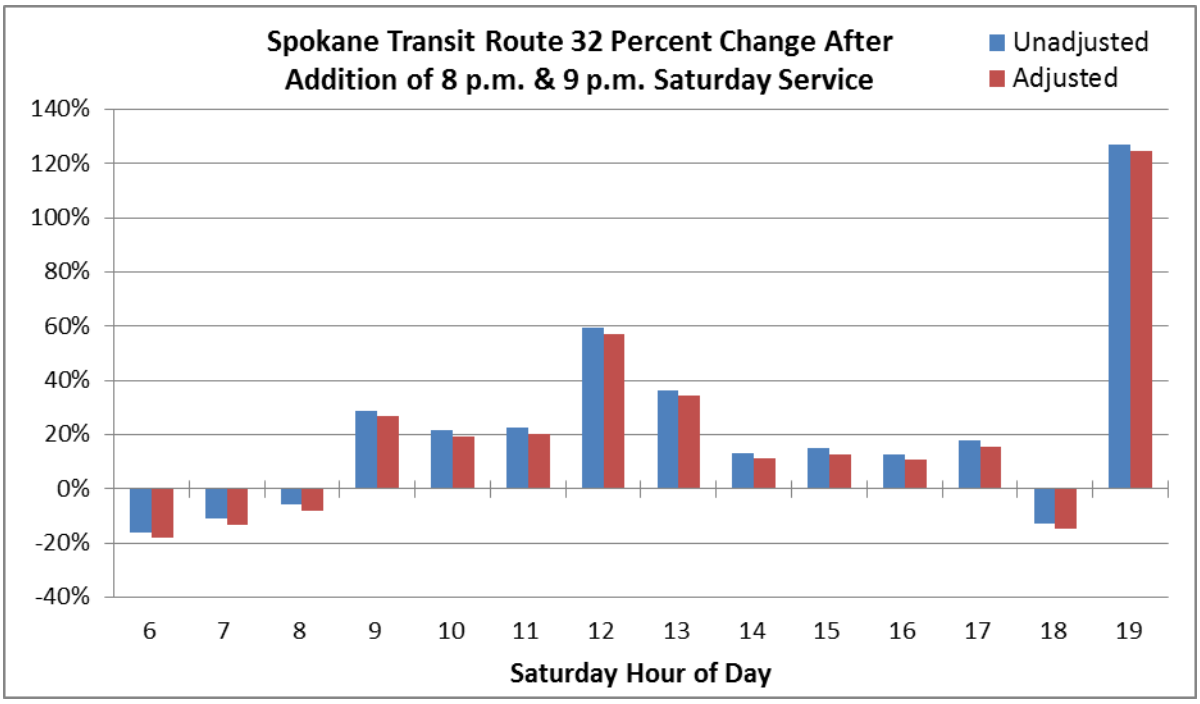

Figure 75. Spokane Transit Authority Route 32 percent change in Saturday ridership after addition of 8 p.m. & 9 p.m. Saturday service in January 2012.

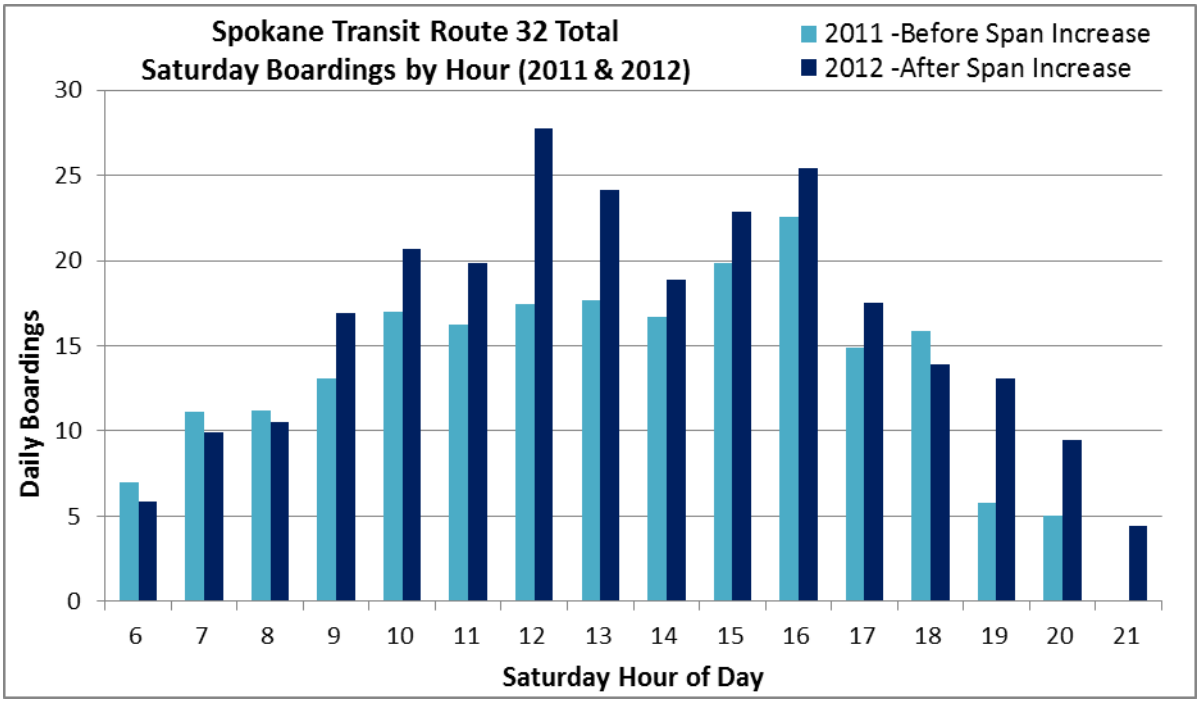

Figure 76. Spokane Transit Authority Route 32 total Saturday boardings by hour before and after January 2012 addition of 8 p.m. & 9 p.m. Saturday service.

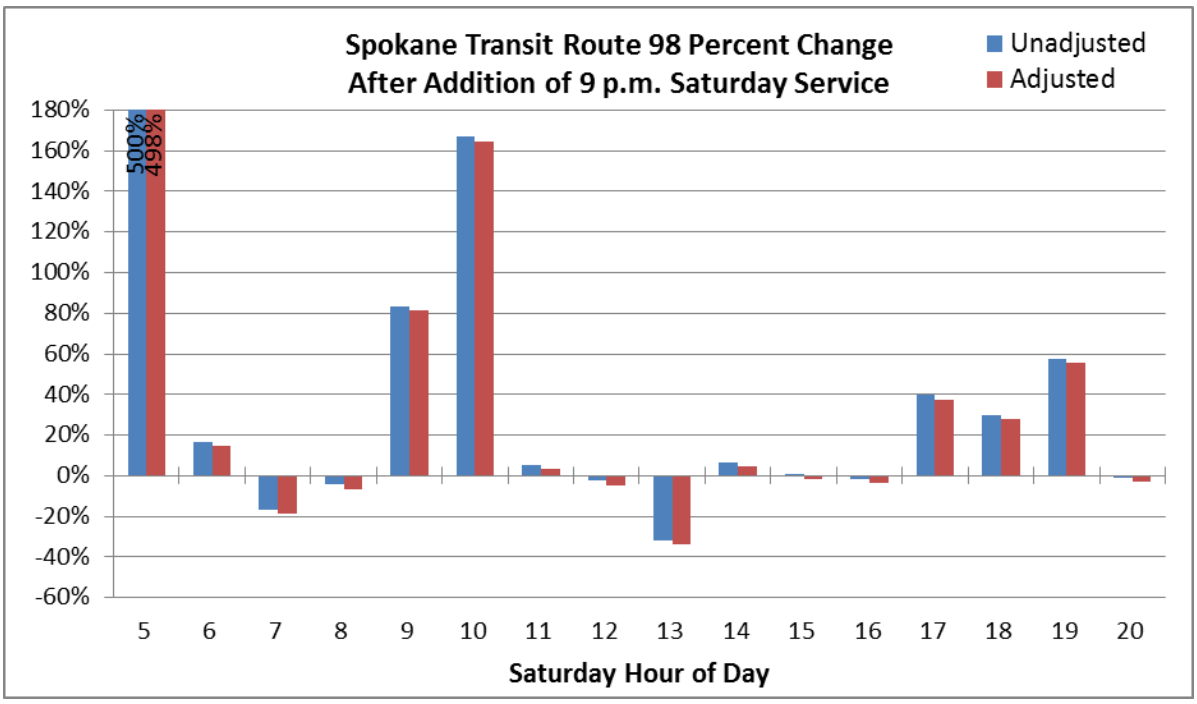

Figure 77. Spokane Transit Authority Route 98 percent change in Saturday ridership after addition of 9 p.m. Saturday service in January 2012.

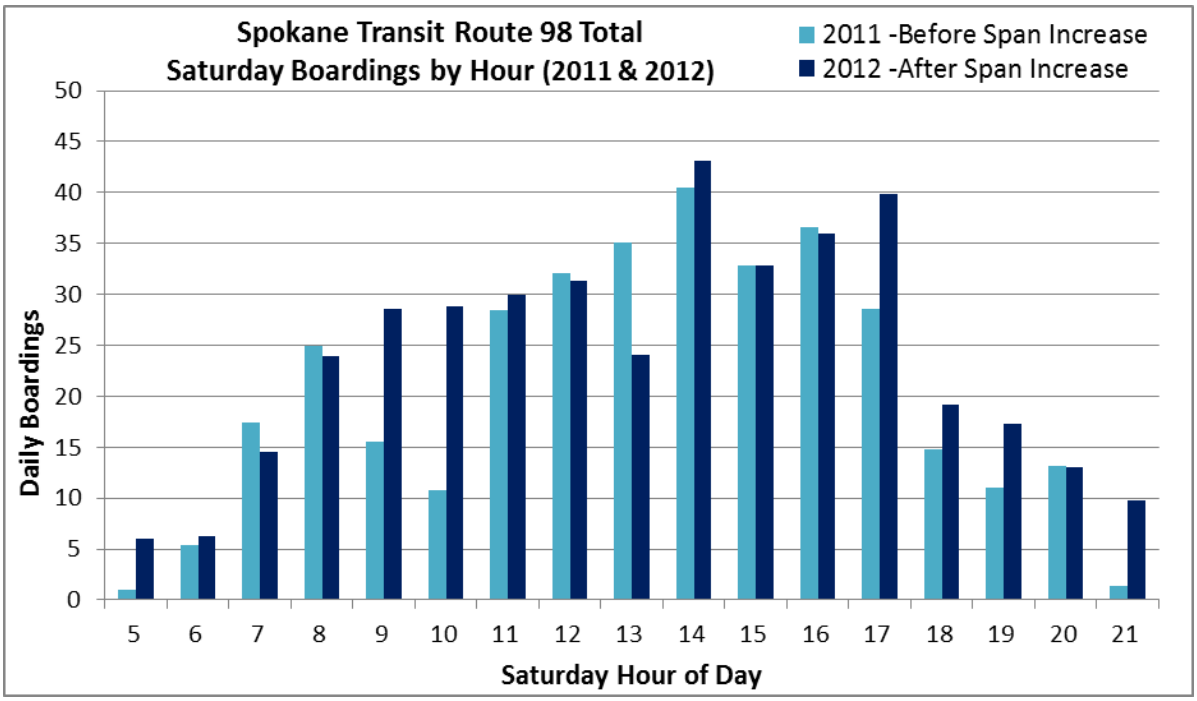

Figure 78. Spokane Transit Authority Route 98 total Saturday boardings by hour before and after January 2012 addition of 9 p.m. Saturday service.

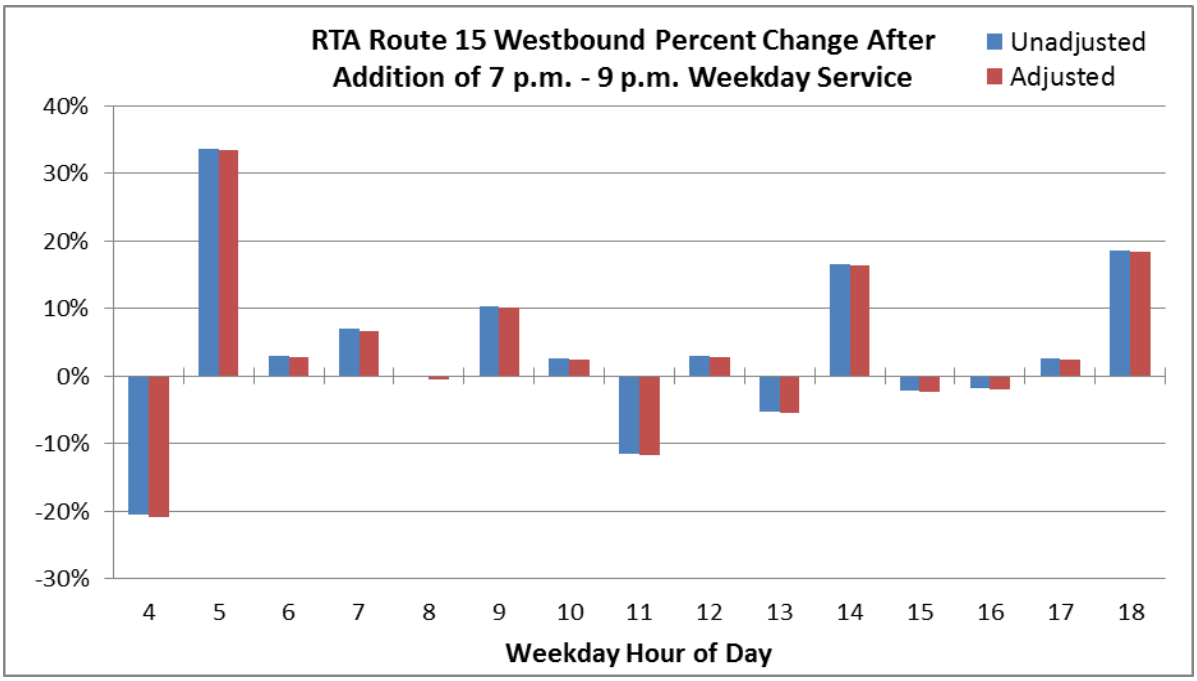

Figure 79. Riverside Transit Agency Route 15 westbound percent change in weekday ridership after addition of 7 p.m. through 9 p.m. weekday service in September 2013.

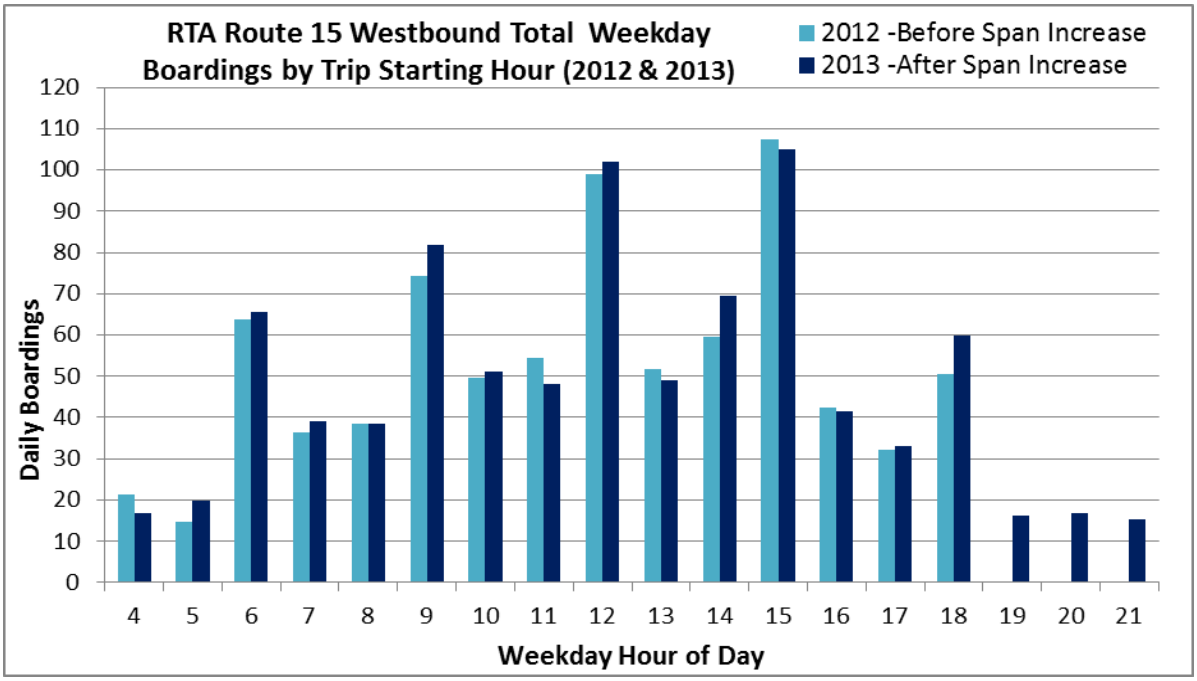

Figure 80. Riverside Transit Agency Route 15 westbound total weekday boardings by trip starting hour before and after September 2013 addition of 7 p.m. through 9 p.m. weekday service.