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ABSTRACT
In this paper we examine the effects of amendments to local comprehensive plans on interchange performance. Plan amendments over a 15-year period in Oregon resulting in changes to industrial or commercial land use were reviewed to identify those that occurred within one mile of an interchange. Regression analysis was then performed to estimate the impact of nearby plan amendments on subsequent interchange ADT. Plan amendments were found to have a substantial ADT effect on rural interchanges, but their incidence was very limited. In urban core areas, the estimated effect of plan amendments was negligible, possibly due to interchange congestion or effective land use planning. In urban fringe areas, plan amendments were estimated to account for about 5 percent of the subsequent interchange ADT, equivalent to about two years of the design life of these facilities.

INTRODUCTION

Interchanges serve two primary functions. They are the sole entry and exit points connecting freeways to nearby communities, and they provide access to freeway users' services – fuel, food and lodging. Tracts of land near freeway interchanges are accessible to a wide region and have become highly desirable locations for commercial and industrial uses. The convergent land development demands of the multiple functions of serving highway users, shoppers, and employees have produced traffic volumes that have often grown faster than the forecasts upon which the design of interchanges has been based, resulting in congestion and safety problems. Interchange congestion and safety problems are often exacerbated by the proximity of freeway ramps to driveways and access roads, resulting in conflicting turning movements that have to be managed by signals and access management within restricted rights-of-way. Responding to freeway interchange congestion requires a variety of improvements, such as signalization, widening of cross roads, and new turn lanes at freeway ramps. The ability to expand interchange capacity is often financially constrained by intensely developed abutting property.

Whatever the option pursued to mitigate interchange area congestion, an over-arching need is to take a longer-term view of planning interchange capacity and managing interchange areas, including integrated management of access and land development. Even in circumstances where land development and traffic trends can be predicted with relative confidence, resource constraints can preclude building to meet long-range needs. Consequently, the issue is to allow for flexibility to facilitate expansion and, at the same time, to better manage traffic growth to mitigate the need for expansion. Balancing these issues over time is the essence of interchange planning and management.

This paper explores the effect of comprehensive plan amendments on interchange traffic volumes on the Oregon highway system. The Oregon Department of Transportation (ODOT) has implemented a practice of preparing interchange area management plans (IAMPs) in connection with interchange construction or improvement on the state highway system. Generally, these plans are adopted through an intergovernmental agreement between ODOT and the local jurisdiction where the interchange is located. As directed by the Oregon Transportation Commission (OTC), interchange project programming is now conditioned on the adoption of an IAMP.

The IAMPs cover factors affecting interchange performance over time, including access management, the design of the local transportation system, and the planning regulations governing land use and development. These plans represent a departure from the traditional focus on access management by addressing the circulation of traffic in the surrounding area and the land development process that affects traffic generation.

While it has been generally thought that comprehensive plan amendments have contributed to the growth of interchange traffic volumes on the state highway system, there has not yet been a systematic analysis of either the geographic incidence of comprehensive plan amendments or their subsequent impacts on interchange performance.

This paper is organized as follows. Literature related to interchange management is reviewed in the next section. This is followed by an overview of the policies and practices related to interchange area management in Oregon. Following this is an empirical analysis, including an assessment of the geographical incidence of comprehensive plan amendments in Oregon over a 15-year period (1988-2002), as well as a statistical analysis relating traffic growth over the study period on more than 270 interchanges to comprehensive plan amendment activity. The paper concludes with a summary of findings and a discussion of their implications.

LITERATURE REVIEW

While the need to better integrate land use and transportation planning is increasingly noted in the access management literature, its basic orientation still treats the land development process as exogenous (1). Plazak notes that "one of the major obstacles to the successful implementation of access management principles is the seeming disconnect between the activities of agencies responsible for administering roadways and the activities of agencies responsible for local land use planning and regulation." (2: 159). A historical tension exists between the desire of local governments and property owners to gain access to state highway facilities, and the state's interest in maintaining the capacity and safety of the system for through traffic. Local governments often approach access management and traffic impacts on a case-by-case basis in the development approval process, which overlooks the cumulative effects of development on congestion and safety (3).

States with comprehensive land use planning systems appear to have an advantage in integrating state transportation system management with local land use planning systems (3). In these states, land use planning goals commonly call for coordination of land use and transportation planning. In Oregon, the adoption of the Transportation Planning Rule by the Land Conservation and Development Commission has made such coordination a requirement. The rule requires local transportation and land use plans to be compatible with the ODOT's State Highway Plan.

State growth management statutes provide substantial authority to local governments in coordinating transportation planning, access management and land development. Such statutes support a variety of planning mechanisms, including a) concurrency, which requires that that the necessary infrastructure (including transportation) be in place to accommodate new development; b) urban growth boundaries, which contain development and facilitate coordination of land use and infrastructure planning; c) impact fees, which levy marginal system infrastructure development costs on land development; and d) comprehensive plans that discourage strip commercial development and promote mixed-use clustered development.

Local zoning and subdivision regulations can include a variety of provisions that serve access and interchange area management objectives (4). These include 1) setback requirements that recognize planned/future right-of-way needs; 2) limits on the number and location of driveways per parcel; 3) driveway density limits and spacing minimums in designated corridors; 3) minimum lot sizes and frontages in designated corridors; 4) limits on lot splits and "flag lot" subdivision; 5) requiring reverse frontage service roads for subdivisions abutting major thoroughfares and interchanges; and 6) limiting driveway permits in commercially zoned corridors to promote joint and cross access to parking facilities.

Induced Traffic

The consideration of induced traffic effects can be traced to the earliest cost-benefit studies of highway improvements. A considerable amount recent research has focused on estimation of the magnitude of the induced traffic response to new capacity, following the work of Hanson and Huang (5), who estimated traffic growth after freeway expansion in California. Noland and Lem (6) provide a synthesis of recent induced traffic research.

It is important to distinguish between short and long run changes in induced traffic. In the short run, induced traffic responses to capacity changes reflect the expression of latent travel demand occasioned by the reduction in the generalized cost of travel. In the longer term, the initial expression of latent demand is supplemented by changes in land development patterns that are occasioned by the improvement in accessibility associated with the change in highway capacity.

The longer-term changes in development patterns are of particular interest in the case of freeway interchanges, given that new interchanges are capable of producing substantial improvements in accessibility. In this context, work by Cervero (7) and Boarnet and Chalermpong (8) provide good examples of the role that land development plays in induced traffic responses to highway capacity changes.

Cervero developed an empirical model that reflects four key effects: 1) increase in travel speeds following road improvements; 2) the change in urban development (accounting for institutional delays) following road and speed improvements; 3) the increase in travel demand following speed improvements and changes in urban development; and 4) the eventual effects of increases in travel demand on the need for road improvements.

The study by Boarnet and Chalermpong offers strong evidence that the construction of toll roads in California produced accessibility benefits that were capitalized in the housing market. The authors argue that the increase in property values is evidence of an "accessibility premium." They find that the willingness to pay for an improvement in accessibility influences both development patterns and induced travel.

INTERCHANGE AREA MANAGEMENT IN OREGON

Oregon's well-established comprehensive planning system gives transportation planners an advantage by formally requiring coordination of transportation and land use planning at the local level, as well as coordination between local and state-level plans. State law requires every city and county to adopt a comprehensive plan and to implement zoning and land division regulations. ODOT has no formal role in reviewing or approving local comprehensive plans; this responsibility is vested in the Department of Land Conservation and Development (DLCD).

Oregon's Transportation Planning Rule (TPR) sets out administrative rules to implement transportation planning goals. With the exception of smaller communities, cities and counties are required to adopt Transportation System Plans (TSPs). A local TSP establishes a transportation network to serve state, regional, and local transportation needs.

The 1999 Oregon Highway Plan (9) includes a number of policies and actions related to the planning and management of interchanges and interchange areas. The general objective of these policies is to preserve the function of interchanges in serving system-level mobility needs and to manage access associated with local traffic. Related to this objective, the Highway Plan directs ODOT to develop coordinated approaches with local governments to ensure that local comprehensive and transportation system plans are compatible with the system-level mobility goals.

Policy 3C addresses interchange access management areas and is directly relevant to the present analysis. Under this policy, ODOT is directed to develop interchange area management plans (IAMPs) to protect the function of interchanges and to minimize the need for major improvements of existing interchanges. The policy calls for adherence to recently-revised interchange access standards (10) in new interchange construction and in improvements to existing interchanges. Where feasible, it also encourages ODOT to purchase access rights in order to meet access standards, with primary consideration given to limiting access on interchange crossroads for a minimum of 1320 feet. Prior to interchange construction, any necessary improvements in the local road network in interchange areas must be identified in the local comprehensive plan, along with funding commitments.

Policy 1G directs ODOT to design major improvements to limit access and protect through-traffic movement. The policy also directs ODOT to develop intergovernmental agreements to establish necessary supporting actions that local governments must take in their comprehensive plans. When major improvements to state facilities are identified in local transportation system and comprehensive plans, ODOT support is made contingent on the existence of local plan measures that would protect the function of the facility.

Policy 1B also relates to interchange area traffic management. This policy directs ODOT to work with local government to limit the expansion of development along state highways by promoting compact development away from state highways and avoiding expansion of urban growth boundaries near interchanges. When UGB expansions occur, the Plan calls for ODOT to work with local governments to develop an interchange management plan to protect interchange operation.

<u>Interchange Area Management Plans</u>

To date, four IAMPs have been completed in advance of interchange construction projects in Oregon, and an additional 26 plans are in preparation. Two of the completed IAMPs provide a notable contrast. The first, covering two new interchanges at OR 22/OR 99W and OR 22/Dallas Rickreall Highway, addresses two rural interchanges, and its general objective is to ensure that the interchanges will be protected from future development. The second, addressing the Woodburn interchange of I-5 and OR 214, deals with an area that has experienced rapid commercial development over the past 15 years, and its general purpose is to manage future development in order to extend the functional life of an existing interchange.

The provisions of the Rickreall IAMP are intended to preserve the rural status of the area and to limit access to the interchange. The plan calls for the preservation of existing land uses in the nearby unincorporated community of Rickreall, as well as measures that would prevent the City of Dallas (located about two miles away) from expanding its UGB toward the interchange. The county would maintain Exclusive Farm Use zoning and continue protection of resource and exception lands in the area. The county would also construct an access road to divert local traffic from the interchange.

Access rights of selected properties would be purchased to meet state access management standards. The final provision of the plan calls for early inclusion of ODOT in the review of any proposed development or redevelopment in the interchange areas that would substantially increase trip generation.

The Woodburn IAMP is represented in an interchange area overlay district, to be adopted by the City of Woodburn in its comprehensive plan. The primary objectives of the IAMP are two-fold: 1) to establish a "trip budget" in connection with future (20-year) development of vacant land in the interchange area; and 2) to limit comprehensive plan amendments and zoning changes that would increase trip generation. The trip budget is applied to future development of 962 vacant acres contained in four interchange sub-areas. The City of Woodburn can approve development of any parcel whose trip generation would exceed its proportional trip budget, and the proportional trip budgets for any sub-area can be exceeded as long as the overall trip budget for the overlay district is not exceeded over the 20-year period. Comprehensive plan amendments in the overlay district would be subject to several limitations: 1) amendments that would increase commercial land area would be prohibited; and 2) amendments that would allow land uses generating trips in excess of the trip budget would be prohibited.

EMPIRICAL ANALYSIS

To what extent do comprehensive plan amendments affect interchange traffic? In this section we assess the geographic incidence of comprehensive plan amendments and statistically analyze the relationship between plan amendments and interchange traffic volume. With respect to plan amendments, our focus is on changes in designated land use where the subject area is reclassified to either industrial or commercial use. With respect to geographic incidence, our interest relates to the proximity of plan amendments to interchanges on the state highway system. In this analysis, we define an amendment to be proximate if it is located within one mile of an interchange.

The time frame of the analysis is influenced by data availability. The DLCD has maintained a consistent record of comprehensive plan amendments in the state from 1987 to the present. Annual traffic count data for interchanges has been maintained by ODOT over a longer period, with the most recent report covering 2002. Thus, the time period studied is 1987-2002.

Geographic Incidence

Analysis of the incidence of comprehensive plan amendments begins with the selection of 273 grade-separated interchanges on the state highway system. Excluded from the analysis are rest area exits, and recently-constructed interchanges for which traffic count data does not exist prior to 2002.

The next step involved the use of GIS to create a one-mile buffer around each interchange to represent a traffic impact zone, where comprehensive plan amendments and subsequent development could be expected to have the greatest consequence on interchange performance.

The locations of the 273 interchanges selected vary considerably with respect to urbanization status. Three categories were thus defined to distinguish interchange location in relation to UGBs. The first category (rural) includes 103 interchanges whose one-mile buffer lies entirely outside a UGB. The second category (urban) includes 63 interchanges whose buffer lies entirely inside a UGB. The final category (urban fringe) includes 107 interchanges whose buffer crosses a UGB and includes both urban and rural land.

The next step involved the review of comprehensive plan amendments wherein a designated land use was changed to either commercial or industrial activity. The locations of amendments meeting the defined land use change were established to determine whether they resided inside an interchange buffer area. A total of 1,565 amendments to commercial or industrial use occurred between 1987 and 2001 in which a location could be established. (The location of an additional 39 amendments could not be determined). Nearly 29 percent (448) of these amendments were located within an interchange buffer area.

The general incidence of plan amendments varies considerably (see Figure 1). Overall, about 54 percent of the study interchanges experienced no plan amendments between 1987 and 2001. The incidence was smallest for rural interchanges, where 95 of 103 interchange areas (92.2%) did not contain an amendment. In the urban fringe category, 39 of 107 interchanges (36.4%) did not contain an amendment within their buffers, while in the urban category, 14 of 63 interchange areas (22.2%) did not contain an amendment. Seventy-eight interchanges (7 rural, 45 urban fringe and 26 urban) – about 29 percent of those in the study – contained one to three amendments. The remaining 47 interchanges (about 17% of the total) experienced more than three amendments, up to a maximum of 17 amendments in the cases of one urban and one urban fringe interchange.

(Figure 1 about here)

Regarding the geographic incidence of comprehensive plan amendments, a central question is whether the likelihood of amendments occurring inside interchange buffers is greater than the likelihood of them occurring outside the buffers. This can be represented by a location quotient, which is a measure of relative geographic incidence (12).

In the present analysis, the location quotient could be distorted by the small number of rural plan amendments in relation to the very large rural area of Oregon. Thus, the location quotient is calculated for the urban and urban fringe interchanges, and is defined as follows:

$$LQ = \frac{\text{Amendments Inside Urban \& Fringe Buffers / Total Urban Buffer Area}}{\text{Amendments Outside Urban \& Fringe Buffers / Net Total Urban Area}}$$

The urban buffer area is defined as the area lying inside a UGB, while the net total urban area is defined as the total area in Oregon within all UGBs less the urban area contained in the urban and fringe interchange buffers. In excluding rural interchanges, we assume that the percentage of rural plan amendments located outside interchange buffers is equal to the overall percentage for all interchanges. Given the small number of plan amendments inside rural interchange buffers, the sensitivity of the amended location quotient to this assumption is very weak. We also assume that all amendments occurring outside urban and fringe interchange buffers are still located inside a UGB. The value of the location quotient will be depressed by extent to which this assumption is violated, making it a fairly conservative estimate of relative geographic incidence. The resulting location quotient value is as follows:

$$ALQ = \frac{424 \text{ Amendments} / 199{,}104 \text{ Acres}}{1093 \text{ Amendments} / 618{,}383 \text{ Acres}}$$

$$= 1.25$$

Thus, it can be concluded that comprehensive plan amendments in urban areas are about 25 percent more likely to occur in interchange areas than elsewhere.

Statistical Analysis

A statistical analysis was designed to estimate traffic volumes on interchanges as influenced by mainline throughput volumes, the functional classification of intersecting routes, selected locational characteristics, a proxy for growth (and traffic generation) in the wider area, and the incidence of comprehensive plan amendments in interchange areas. The primary purpose of the statistical analysis is to isolate the effects of plan amendment activity from a variety of other factors that influence interchange traffic volumes.

The model to be estimated takes the following general form:

$$IADT_{it} = f(CPNO_{it}, RAMPS_{it}, DIST_{it}, TADT_{it}, IRCLS_{it}, APOT_{it}),$$

where

- i = interchange (= 1, … 273);
- t = year (= 1988, … 2002);
- IADT = interchange ADT;
- CPNO = the cumulative number of plan amendments;
- RAMPS = the number of ramps comprising the interchange;
- DIST = the distance between interchanges;
- TADT = throughput ADT;
- IRCLS = intersecting route functional classification;
- APOT = population potential of the interchange travel shed.

ODOT's *Transportation Volume Tables* (13) provide the data for the interchange and throughput ADT variables. Between 1982 and 1992, ADT on highways and interchanges was counted on a two-year cycle. In 1993, the counts went to a three-year cycle. In the intervening years, ADT estimates were based on data from automatic traffic recorders and ramp meters in urban areas.

Throughput ADT (TADT) represents the average daily traffic volumes recorded on the mainline between interchanges. This measure is the average of the bi-directional traffic volumes associated with an interchange in a given year. The RAMPS variable is a count of the number of exit and entry ramps associated with an interchange.

The CPNO variable measures the cumulative number of comprehensive plan amendments that have been adopted within the interchange buffer area. Each increment in the value of this variable occurs in the year following adoption, under the assumption that the subsequent year represents the earliest opportunity to observe a change in interchange ADT associated with traffic from plan amendment-related development. Thus, a plan amendment adopted in 1987 is given a value of one in 1988 and every year thereafter. For a second amendment occurring in 1990, the value of the variable would increase to two in 1991 and subsequent years.

IRCLS is a set of dummy variables representing the functional classification of the intersecting route at each interchange. It would have been useful to have traffic volume data for intersecting routes, but consistent traffic count data over the study period were not available for county and local roads. Thus, a series of dummy variables is used to designate the following categories: interstate highways; U.S. highways; state highways; and county or local roads.

The population potential variable reflects the general level and growth of trip-making in the larger travel shed beyond the interchange buffer. It is a gravity formulation that is directly related to the population of surrounding jurisdictions and their access to a given interchange. Annual values of this variable were calculated using population estimates for Oregon municipalities produced by the Center for Population Research at Portland State University. Distances from interchanges to municipalities were calculated using a GIS. Maximum perimeter distance and distance decay parameters were set according to whether an interchange was located in an urban or rural area. The perimeter distance limit for urban interchanges was set at 5 miles. For rural interchanges, the perimeter distance limit was set at 20 miles. A distance decay value of 2.0 was set for urban areas, and a value of 1.5 for rural areas. The larger decay value for urban interchanges reflects generally lower speeds and closer spacing of interchanges there.

The DIST variable measures the average distance between a given interchange and the facilities that precede and follow it, and was calculated using a GIS. Controlling for other determinants of interchange ADT, it is expected that interchanges that are more separated will experience greater traffic volumes.

Descriptive statistics for the variables across rural, urban fringe and urban interchange categories are presented in Table 1. Interchange spacing clearly differs by level of urbanization, averaging nearly 4 miles between rural interchanges, 2.5 miles between urban fringe interchanges, and 1.3 miles between urban interchanges. The mean population potential associated with urban interchanges is more than seven times the corresponding value for urban fringe interchanges, and more than a thousand times greater than the value for rural interchanges. The low population potential linked to rural interchanges reflects the limited number of municipalities outside Oregon's metropolitan areas. With respect to the functional classification of intersecting routes, freeway-interstate connections range from about 11 percent for urban to about 1 percent for rural interchanges. US highway intersections are most prevalent among urban fringe interchanges (18%), and occur at less than half that average frequency among urban and rural interchanges. State highway intersections occur at more than 25% of urban and urban fringe interchanges and at about 17% of rural interchanges. The remaining interchanges intersect with county and local roads, which account for about 75% of rural interchanges and more than half of the urban and urban fringe interchanges. The mean cumulative incidence of comprehensive plan amendments over the study period ranges from a high of 2.0 for urban interchanges to a low of .2 for rural interchanges. Average throughput volumes range from about 2,300 ADT for rural interchanges to more than 40,500 ADT for urban interchanges.

(Table 1 about here)

Interchange ADT models were estimated by ordinary least-squares regression. Several issues were addressed in the estimation process. The first issue concerned the question of whether the parameter estimates differed across rural, urban fringe, and urban interchanges. This was evaluated using the Chow test (14), which tests for parameter equivalence across sub-models. The hypothesis of parameter equivalence was rejected at the .001 level. The second issue related to serial correlation across the temporal observations in the sample. A Durbin-Watson test revealed significant serial correlation, and the Cochrane-Orcutt estimation procedure (14) was used to correct the problem. The final issue related to the state highway intersecting route dummy variable, which was nearly co-linear with the US highway dummy in several submodels. It was thus deleted, and the reference case for interpreting the coefficients of the remaining interstate and US highway dummies becomes the composite of state, county and local roads.

Regression results for the rural, urban fringe and urban interchange ADT models are presented in Table 2. Overall, the models fit the data fairly well, explaining between 60 and 80 percent of the variation in interchange ADT. Most of the parameter estimates are significant, with t-statistics exceeding the .05 critical value of 1.96.

(Table 2 about here)

Spacing was estimated to have a significant positive effect on rural interchange ADT, with a one-mile increment estimated to result in a 223 vehicle increase in ADT. In contrast, a one-mile increment in urban fringe interchange spacing was estimated to lower ADT by about 790 vehicles, likely reflecting the transition from urban to exurban traffic conditions. Urban interchange ADT was not found to be influenced by changes in spacing.

Increases in population potential were estimated to have a positive effect on interchange ADT across all categories. Evaluated at the mean population potential, the estimated marginal interchange ADT effect is 168 vehicles for rural, 653 vehicles for urban fringe, and 2,130 vehicles for urban interchanges, respectively.

Relative to the reference case of state, county, and local intersecting roads, a freeway intersection with an interstate highway is estimated to produce an increment of about 6,250 vehicles on rural, 11,250 vehicles on urban fringe, and 34,570 vehicles on urban interchanges. The ADT increment associated with a US highway intersection is substantially smaller, estimated at about 2,270 vehicles on rural, 805 vehicles on urban fringe, and 8,690 vehicles on urban interchanges.

Given the definition of interchange ADT, additional ramps are estimated to contribute to increases in total interchange traffic. On a per-ramp basis, the estimated ADT increment is about 540 vehicles on rural, 4,720 vehicles on urban fringe, and 9,750 vehicles on urban interchanges.

Interchange ADT is estimated to be positively affected by changes in through-traffic volume. In this case, through traffic is represented by both linear and quadratic terms. When the linear term is positive and the quadratic term is negative (as is the case for rural and urban interchanges), this indicates that interchange ADT increases at a decreasing rate with the growth of through traffic. When both terms are positive (as they are for urban fringe interchanges), this indicates that interchange ADT increases at an increasing rate (i.e., exponentially) with the growth of through traffic. The combined marginal effects of the linear and quadratic terms can be derived at the mean through traffic values for the three interchange categories. The resulting marginal interchange ADT effect associated with through traffic is .228 for rural, .348 for urban fringe, and .344 for urban interchanges. In other words, a 10-vehicle increase in through traffic ADT is estimated to result in a 2.3 vehicle increase in rural interchange ADT, a 3.5-vehicle increase in urban fringe interchange ADT, and a 3.4-vehicle increase in urban interchange ADT.

The final term in the regressions relates to the effects of comprehensive plan amendments on interchange ADT. In this case, an amendment is estimated to result in a subsequent, sustained 1,890-vehicle increase in rural interchange ADT and a 615-vehicle increase in urban fringe interchange ADT. The estimated plan amendment effect on urban interchange ADT is quite small and not significant.

Given the limited number of plan amendments near rural interchanges, the substantial estimated traffic impact may reflect specialized traffic-serving or traffic-generating development. Interpreting the negligible impact of plan amendments near urban interchanges is complicated by competing possibilities. One possible explanation is that a number of plan amendments in the Portland area, where a majority of the urban interchanges are located, have sought to intensify commercial and mixed-used development in town centers and corridors served by bus transit, and in light rail station areas. These town centers, corridors, and station areas also tend to be fairly proximate to interchanges. It may be that the incremental trips resulting from the intensified development have been effectively served by transit and other alternative modes, with little vehicular impact on interchanges. An alternative interpretation is that with many urban interchanges already experiencing congestion, additional development is simply contributing to latent interchange traffic demand, with the consequence being a diversion of traffic to less congested alternative routes and trips that are rescheduled to less congested periods or foregone altogether, reflecting Down's (15) triple convergence principle. If so, it would complicate future design capacity decisions relating to urban interchange construction or improvement in terms of accounting for non-trivial induced demand effects.

One way of summarizing the system-level interchange ADT effects of comprehensive plan amendments is to jointly consider their estimated marginal effects and their incidence in relation to the mean interchange ADT, as expressed in the following equation:

Impact (%) = (Marginal Effect * Mean Incidence / Mean Interchange ADT) * 100

As Table 3 shows, in circumstances where the estimated marginal effect of plan amendments is quite large and the incidence of amendments is fairly limited, as is the case for rural interchanges, the resulting ADT impact per interchange in that category is substantially reduced. The alternative also holds where the incidence of amendments is much greater and the marginal effect is very small, as is the case for urban interchanges.

(Table 3 about here)

The resulting ADT impact of plan amendments per rural interchange is about 300 vehicles, which represents nearly 13 percent of average interchange ADT. This is still a fairly substantial impact in percentage terms, equivalent to over five years of the historic ADT growth in that interchange category. However, nearly all of these rural facilities are diamond interchanges, and given their low mean ADT, it may be more relevant to relate the nominal impact (i.e., 300 ADT) to their design capacity.

The ADT impact of plan amendments on urban fringe interchanges is more than twice that of rural facilities, but given that the traffic these facilities accommodate is more than six times the rural amount, the impact in percentage terms is much smaller. Nevertheless, at more than 5 percent of mean interchange ADT, the impact of amendments is equivalent to just under two years of historic growth of urban fringe interchange traffic. Finally, for urban interchanges, the impact of amendments is negligible in both ADT and percentage terms, representing just over one month of historic traffic growth on those facilities.

CONCLUSIONS

In this paper we have examined the effects of comprehensive plan amendments on interchange performance on the Oregon highway system. Our examination has included a review of literature related to interchange and access management, induced traffic, and the experiences of other states. The review also covered ODOT policies and practices related to land development in interchange areas, including the recent practice of preparing interchange area management plans in connection with interchange construction or improvement. We documented the geographic incidence of plan amendment activity in Oregon, finding a relatively greater likelihood of plan amendments occurring near interchanges than elsewhere in urban areas. We estimated ADT models for rural, urban fringe, and urban interchanges, and found that plan amendments account for a significant (though not necessarily substantial) share of interchange traffic volume in the cases of rural and urban fringe facilities. The absence of significant effects on urban interchange traffic can potentially be ascribed to either effective land use planning or a growth in latent demand.

While our findings provide insights to some questions, they also lead to the identification of other issues that may deserve future investigation. First, although we have documented the geographic incidence of comprehensive plan amendment activity, we do not yet have a good understanding of why this activity occurs where it does, recognizing that amendments were entirely absent in the vicinity of more than half of the interchanges studied and varied considerably among the remainder. From a statistical perspective, investigating this question would entail moving plan amendments from the right hand to the left hand side of the regressions, and then identifying a new set of factors representing key determinants of the land use regulation and development processes. It is possible that the resulting specification would include some of the same variables employed in this study, recognizing that traffic and population accessibility can also drive the land development process, especially in the commercial market. Statistically, this suggests that a simultaneous equations approach, wherein plan amendment/development and interchange performance are jointly determined, may provide a more comprehensive treatment of these two processes.

Second, given that plan amendment activity has been found to affect interchange traffic, the rationale for preparing IAMPs has been substantiated. These plans can be seen as a means of ensuring that interchanges achieve their design life. The agreements also act to reduce the uncertainty associated with the traffic forecasting process that contributes to the determination of interchange design capacity. Reduced uncertainty is likely to lead to more efficient use of resources when interchange design capacity corresponds more closely to future traffic growth.

Although the agreements supporting the IAMPs do not contain language addressing future amendment, their 20-year time horizon raises the possibility that changing conditions could warrant re-negotiation. In her review of agreements between state DOTs and local governments related to corridor management plans, Williams (2004: 27) concludes that the most effective agreements are sustained by a recognition of the need "… to make compromises from time to time to keep an agreement alive." Oftentimes, compromise or change in such agreements can also raise fundamental questions related to financing and cost responsibility.

Presently, with most of the IAMPs in Oregon still in the process of preparation, there is no compelling reason to take up questions of re-negotiation and financing. In the future, however, consideration of a financial approach that will create a revenue stream to fund infrastructure expansion in interchange areas may be needed. Given the differing development circumstances prevailing in rural, urban fringe, and urban settings, several general alternatives can be envisioned.

In the case of new interchanges, impact fees on new trips could be levied to create a revenue stream to pay for improved access roads and/or expansion of interchange cross roads. The local government could administer the impact fee program and the IAMP could provide for sharing revenue with ODOT if improvements were needed for state routes. In the case of interchange areas that have already experienced development that has overtaxed the interchange and connecting roads, a Local Improvement District (LID) could be formed to create a revenue stream to finance both local road improvements and freeway interchange expansion. The Interchange Management Plan would have to include an estimate of the total cost of improvements. The local government would need to agree to a cost-sharing arrangement for financing interchange expansion or other related improvements to state facilities. Shares of the LID could be assigned to property based on floor area that is recalculated annually. This approach would allocate the financial responsibility of infrastructure expansion to both existing and new development.

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List of Tables and Figures

Figure 1: Frequency Distribution of Plan Amendments in Interchange Areas

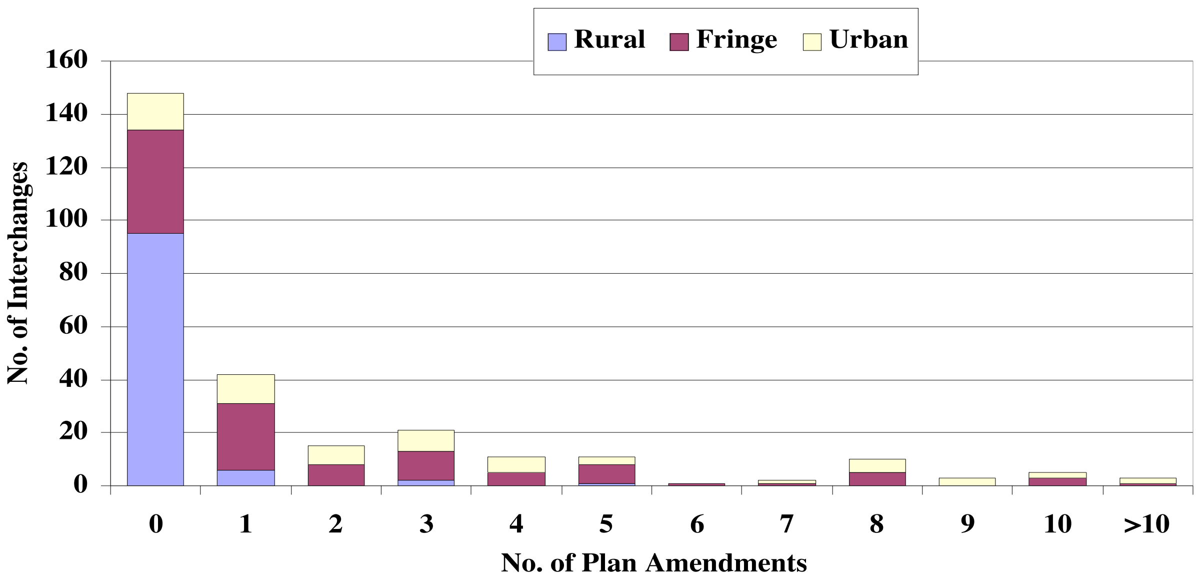

Table 1: Means and Standard Deviations of Interchange Model Variables

Variable	**Rural Interchanges**	**Urban Fringe Interchanges**	**Urban Interchanges**
Distance Between Interchanges (miles)	3.94	2.48	1.27
S.D.	(1.91)	(1.52)	(.58)
Population Potential	.00018	.033	.245
	(.0014)	(.075)	(.440)
Intersecting Route Class. (0, 1)			
- Interstate Highway	.010	.028	.113
	(.098)	(.166)	(.316)
- U.S. Highway	.078	.180	.086
	(.268)	(.384)	(.280)
- State Highway	.166	.277	.258
	(.372)	(.448)	(.438)
Number of Interchange Ramps	3.66	4.17	4.35
	(.87)	(1.21)	(1.46)
Through ADT (vehicles)	8,448.2	18,645.0	51,100.0
	(6,259.0)	(15,271.0)	(17,051.0)
Through ADT^2 (vehicles)	110.5E+06	580.7E+06	290.2E+07
	(204.6E+06)	(975.5E+06)	(286.0E+07)
Comp. Plan Amendment-Years	.159	1.206	1.908
	(.776)	(2.07)	(2.77)
Interchange ADT (vehicles)	2,323.6	14,534.0	40,517.0
	(3,717.5)	(15,652.0)	(30,733.0)
Sample Size	1,537	1,586	932

Table 2: Parameter Estimates for the Interchange Models*

Variable	Rural Interchanges	Urban Fringe Interchanges	Urban Interchanges
Distance Between Interchanges (miles)	223.0	-790.9	553.1
	(6.7)	(-6.4)	(.4)
Population Potential	9.35E+05	19,690.0	8,679.5
	(20.0)	(7.8)	(5.3)
Intersecting Route Class. (0, 1)			
- Interstate Highway	6,249.2	11,252.0	34,568.0
	(10.5)	(9.7)	(12.6)
- U.S. Highway	2,267.5	805.0	8,689.9
	(10.1)	(1.7)	(3.5)
Number of Interchange Ramps	543.0	4,724.1	9,747.1
	(7.4)	(29.3)	(18.7)
Through ADT (vehicles)	.25	.24	.42
	(8.5)	(5.8)	(5.4)
Through ADT^2 (vehicles)	-.000002	.000006	-.000001
	(-2.4)	(8.9)	(-3.2)
Comp. Plan Amendment-Years	1,887.7	615.2	25.6
	(21.5)	(6.9)	(.8)
Intercept	-3,088.4	-12,890.0	-26,601.0
	(-9.8)	(-15.7)	(-6.0)
Adjusted R^2	.63	.79	.59
Standard Error of Estimate	2,265.1	7,103.9	19,605.0
Durbin-Watson Statistic	1.98	1.99	2.0
Sample Size	1,537	1,586	932

* t-statistics are reported in parentheses.

Table 3: Systematic Plan Amendment Impacts on Interchange Traffic Volume

Interchange Category	Marginal Effect	Mean Incidence	Mean IADT	Impact per Interchange ADT	Impact per Interchange (%)
Rural	1,887.7	.159	2,324	300.1	12.91
Urban Fringe	615.7	1.206	14,534	742.5	5.11
Urban	25.6	1.980	40,517	50.7	.13