Credit-Based Congestion Pricing: Expert Expectations and Guidelines for Application

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Abstract

Congestion pricing (CP) ensures that travelers recognize the true travel-time costs of their trip-making by accounting for the cost of delays imposed on fellow road users. Credit-based congestion pricing (CBCP) is a novel strategy which seeks to overcome the negative equity impacts of CP by allocating monthly budgets to eligible travelers to spend on congestion tolls. Previous works on CBCP have surveyed public opinion and examined the traffic and travel-welfare impacts of an Austin, Texas application. This paper develops the CBCP policy further, examining expert opinions and system cost prediction. Transport economists, toll technology experts, administrators, policy-makers, and commercial interests were surveyed for feedback on credit distribution, revenue uses, public reaction, appropriate technology and configuration, enforcement issues, and system-wide economic, land use, and business impacts. The results of this work are detailed recommendations for CBCP implementation, including estimates of administrative and technology costs for implementation of a CBCP policy in the Austin region.

CE Database Subject Headings: Urban transportation; Transportation management; Traffic management; Pricing; Policies; Surveys; Implementation; Costs.

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Introduction

Transportation policy development can be viewed as an objective dialogue between the public who are the major stakeholders, various interest groups who lobby for or against the policy, and the administrators who guide regional development. Also, the implementation and refinement of any significant transportation policy requires an understanding of the policy's systemic impacts on traffic, land use, air-quality etc., and also related costs and benefits and likely stakeholder opinion. Through their expert opinions, transport economists, planners, and technologists can provide valuable contributions to the transportation policy development process. One such transportation policy in need of expert opinions for further development is credit-based congestion pricing (CBCP) (Kockelman and Kalmanje 2004).

By ensuring that travelers recognize the true travel-time costs of their trip-making (by accounting for the cost of delays imposed on fellow road users), congestion pricing (CP) has proven to be an effective congestion management policy. Even though CP has the potential to benefit society as a whole, it can adversely affect certain user groups (e.g., low income users and commuters with little or no work flexibility). CBCP is a congestion management policy which seeks to overcome the negative equity impacts of CP by allocating monthly budgets to eligible travelers in a priced region to spend on congestion tolls. This work sought to identify and isolate expert perspectives on CBCP budget allocation, equity issues, economic, land use, and business impacts, revenue uses, and toll collection. These were reviewed to produce recommendations for the implementation of a CBCP policy. Cost estimates for such a policy also are provided.

Motivation and Literature Review

Since CBCP seeks to overcome CP's negative equity impacts by providing travel budgets, a closer examination of equity issues and other impacts is required to develop implementation guidelines. In a congested region, CP has the potential to transfer a great deal of money from the traveling public to toll collecting authorities. While a certain portion of such revenues is needed to cover the costs of a CP program (paying for, e.g., roadside detection devices, variable message signs, toll collection, and general program administration), the rest arguably belongs to "the public" who paid for the road's construction and its operation via taxes. Hence, such revenues should be used to compensate the users (directly or indirectly). Of course, if users are compensated in proportion to how much they pay or how much they drive, there is no incentive to change one's travel behavior. Paying a higher amount to users who drive more (and hence pay more) or have higher vehicle ownership actually provides an incentive for people to drive more or own more vehicles, which is not desirable.

Past research has looked into various revenue distribution strategies. For example, Small (1992) proposed a travel allowance for all *commuters*. He recommended a fixed amount per month per employee, regardless of mode or time of travel so that CP incentives (i.e., reduced driving on congested roads) would not be undermined. Taking a different approach, Parry and Bento (2001) recommended that income taxes be reduced, to offset any CP-related labor supply restrictions. To offset several CP impacts, Goodwin (1989) and Small (1992) suggested combinations of revenue uses.

Under standard CP, few travelers may benefit sufficiently from the resulting travel time savings to appreciate the policy. This is particularly true in the short run, due to fixed home, work, and school locations (See, e.g., Arnott et al. 1994, Parry and Bento 2001). Though CP may have the potential to benefit society as a whole (i.e., be Pareto improving), it can adversely affect certain user groups (e.g., low income users and commuters with little or no work flexibility). Researchers have tried to address this issue of offsetting CP's adverse effects while maintaining certain behavioral incentives. Gee and Hannemann (2002) proposed compensation for people negatively impacted by CP in the same "dimension" as the impact (such as free weekend parking for those less able to pay weekday tolls). Dial (1999) recommended always providing a "free" route, via minimum revenue CP. DeCorla-Souza (2000) suggested toll credits for regular drivers via FAIR (Fast and Intertwined Regular) Lanes. And Viegas (2001) proposed providing a certain level of "mobility rights".

A CBCP policy, as conceived by Kockelman and Kalmanje (2004), has the potential to allay these equity concerns. According to the policy, every eligible traveler (e.g., every licensed driver living in the designated "priced region") may be given a monthly travel budget. Those in the driving population who exhaust their travel budget while paying congestion tolls will pay out of pocket to keep driving, while those who save their travel budget can cash this out as a direct monetary saving. Each month's travel allowance depends on the total revenue collected during that (or the previous) month. Revenue neutrality is maintained by returning all revenues, after covering policy administrative costs. According to a survey reported in the paper, Austin, Texas residents found such a policy to compete reasonably well with transportation policy alternatives. In a different paper, Kalmanje and Kockelman (2004) predicted Austin area trip-based welfare impacts and land value changes under two different CBCP scenarios. They predicted CBCP to benefit most residents, whereas standard CP (without revenue redistribution) benefited relatively few. For Austin, a CBCP policy with all roads priced according to marginal delay costs was expected to return around 50¢ per user per day. They also predicted a small overall drop in residential property values when CP was imposed on all roads, and a small rise in downtown property values when imposing CP only on major highways. *Credit-based* CP could be expected to cause greater property value increases because of the inherent rebate.

Recognizing CBCP's potential as a viable and equitable congestion management strategy, this paper explores the policy in further detail, and refines it based on opinions of transportation experts, policy makers, stakeholders, and special interest groups. Authorities may wish to invest the revenues in a variety of ways; hence, several alternative uses for CBCP revenues have been studied. A thorough review of implementation costs has been undertaken and a set of implementation guidelines has also been developed.

Methodology

To begin with, an extensive survey of experts and special interest groups was undertaken to study and obtain opinions of a hypothetical regional CBCP implementation. These respondents included academicians and practitioners in the field of transport economics, toll technology, administration and policy, and commercial users of the transportation system. Four survey forms were used for these distinct respondent groups. Respondents were asked to predict system impacts and voice their concerns and suggestions for implementation. The questionnaires for the economists, policy makers, toll technologists and commercial users were mailed in February of 2004 to 180 people, of whom 50 responded after multiple follow-ups (including emails and phone calls). These included 19 transport economists, 10 policy makers (all from Texas), 9 toll technologists, and 12 commercial users. Based on the survey results, guidelines for CBCP implementation are suggested. Several enforcement issues also have been resolved, and costs estimates for CBCP toll technology, system operation and administration are provided for the Austin region.

Results: Synthesis of Expert Perspectives

This synthesis of respondent perspectives first discusses the CBCP equity issues raised by the respondents, their initial impressions of the policy, and their suggestions to make it more effective. It then describes predicted economic impacts and land use changes, commercial user reactions, and anticipated business impacts. Respondents' concerns over CBCP, opinions on revenue use and their expectations of public reaction to the policy are presented. Finally, experts' recommendations for technology, dynamic pricing and data requirements are compiled. Not all topics were answered by all the respondents. Some statements in the following pages are suggestions of some respondents, and it is difficult to determine the opinion of the rest of the respondents about these suggestions. In such cases, it is not possible to provide descriptive statistics (proportion of respondents in favor of or against an idea). However, descriptive statistics on some overall opinions are provided, wherever appropriate, and are summarized in Table 1.

Budget Allocation and Equity Issues

The transport economists expressed concern over so many possible persons getting a travel budget, whether or not they used the priced corridors. Some transport economists did not find it fair for everyone with a driver's license (e.g., high school students, people who rarely need to drive) to receive a travel budget. And some felt that differential budget allocations would make CBCP more of a welfare program – and that transportation policies are not efficient for income redistribution.

There was a variety of feedback on issues relating to the policy's equity. The transport economists considered departure time flexibility and value of time to be important factors in determining the policy's benefits for any specific individual. Office workers and others having to travel during peak periods would be most negatively affected, while those traveling at off-peak hours would benefit (e.g., non-workers and industrial shift employees). Some policy-makers and commercial users felt that people living in certain zones could be disadvantaged since alternatives to peak-period solo driving are not the same in all zones (For example, public transit does not serve all neighborhoods).

Several transport economists suggested that low-income people traveling longer distances to work would be adversely, especially those who choose low-cost housing away from activity centers. So allocating an equal travel budget to everyone might leave low-income people less well off than before the policy was implemented. However, this depends on the number of low-income drivers during congested periods, the number who would qualify for a travel budget, and the availability of alternative travel modes. A similar opinion was expressed by some policy-makers (25%) who mentioned that current inequities (e.g., access to facilities and jobs) may be magnified under CBCP. However, some respondents opposed any budget allocation that would be based on income. They felt that verifying income would be administratively burdensome and would create an opportunity for significant fraud. All four respondent types were of the opinion that budget allocation per-adult-resident would benefit the presently disadvantaged while allocation per-registered-vehicle would reward vehicle ownership (and thus benefit the well-off).

Economic Impacts and Land Use Changes

The majority of respondents (85%) thought that CBCP would stimulate the economy. However, some did not expect any noticeable changes, and a couple suggested that CBCP might actually dampen the economy. If the strategy is accepted by the public and resolves congestion problems, then it should benefit the local economy. However, this potentially could result in greater population growth, thus increasing travel demands and exacerbating congestion. If capacity expansion is not required, the government might invest a portion of CBCP revenues elsewhere, which also could be good for the economy. A transportation engineering professor, however, expected local investment may fall, if the city becomes viewed as "quasi-communist" by investors and others.

Almost all respondents (85%) predicted more compact land development if CBCP was to be implemented, thus decreasing sprawl, while others did not expect any land use changes. They did expect location and travel demand shifts though: People would have an incentive to move closer to jobs, carpool, and travel off-peak, thus decreasing peak travel (e.g., see Kalmanje and Kockelman 2004). Respondents expected an increase in the demand for transit-oriented development and a decrease in the long-run demand for additional highway capacity. Some predicted housing to become more centralized and employment less centralized. Respondents suggested that businesses based in the Central Business District (CBD) would become less attractive compared to those in suburban sites, since accessing the CBD would become costlier[1]. A CP policy was expected to have similar impacts, and the extent to which its impacts would differ from CBCP impacts would depend on the way each policy is implemented (e.g., budget allocation and pricing policies).

Commercial Users' Perspectives and Predicted Business Impacts

While potential benefits to less congestion were expressed, commercial users had already shaped their business practices to cope with high levels of congestion. In fact, most appeared uninterested in the benefits that their region's transportation and distribution systems might see, and instead considered primarily any *personal* disadvantages (for instance, increased costs of solo commuting). This response may reflect the growing reliance of businesses on outside companies, such as shippers and couriers, for transportation and distribution. As outsourcing of transportation and distribution become more ingrained in business models, incentives for timely delivery no longer reside so much in these commercial entities but in their shippers and couriers. This trend may undercut incentives that reduced congestion levels might have otherwise provided to many commercial users.

Those who depend heavily on timely product and service deliveries indicated a clear willingness to pay a premium to guarantee such deliveries. Office-based employers were willing to support some congestion mitigation policies, as part of an effort to reduce regional pollution. There was very little interest in subsidizing employee-related CBCP costs. A common perspective seems to be that employees must plan to get to work on-time, irrespective of where they live. Also, any flexibility or company policy changes (in their respective firms) caused by CBCP would be slow to come, since decisions regarding flex-time and toll-reimbursement ultimately would have to come from a firm's corporate headquarters. Interviewed employers stressed that they offer, or most likely would offer, a "flex-time" workday option, where employees have a range of hours in which they may work, as opposed to a standard workday. If customer levels increased during a certain time of day due to CBCP, several of the service-centered businesses said that they would change staffing hours to accommodate the flux in customer volumes.

Concerns about CBCP

Respondents were asked to rank CBCP issues that most concerned them. Unranked alternatives were assumed to not pose a serious concern for the respondents. The biggest concern for most transport economists (50%) lay in the proposed uniform allocation of travel budgets to all possible roadway users. For example, the respondents felt that commuters, retired persons, and high school students have different needs and should be provided different travel budgets. Similarly, low-income people might be more adversely affected than high-income individuals and may need higher budgets. Another issue mentioned was the policy's administrative cost burden. Privacy and technological feasibility did not seem to be major issues. Those with privacy concerns do not appear to trust the government, which would then have one's trip information. Others were more concerned about political feasibility, traffic impacts, and land use impacts. Some of the economists also expressed concern about traffic spillovers onto non-priced streets. The policy-makers brought up the issue of the agency that would be needed to administer such a system. Since CBCP could apply region-wide, administration then would have to extend beyond the municipal level, possibly via the power and guidance of Texas' Regional Mobility Authorities But revenue handling could be complicated. Spillover onto some local streets (to avoid tolls) may adversely impact some locations, which may demand some of the collected revenues to improve their own infrastructure. Smaller communities beyond the region's fringe may lobby for admission to the policy region, if their residents are not given travel budgets. Such concerns may make revenue-neutrality a difficult goal to achieve.

Alternative Revenue Uses

Transport economists were asked to rank a set of alternatives for uses of "excess revenues" from a CBCP implementation even though the Kockelman and Kalmanje (2004) CBCP proposal aimed to be revenue neutral through issuance of travel budgets. Any unranked alternatives are assumed to hold the lowest ranking. Most (60%) wanted such revenues to go toward maintaining existing infrastructure and/or to adding capacity. Next was the development of alternative modes such as transit. Those who strongly favored transit (50%) were not interested in reducing gas taxes – and vice versa. Some respondents (20%) suggested reducing general taxes via CBCP revenues. There was not much interest in using such revenues to improve air quality.

The question of revenue use was approached cautiously by policy-makers, all of whom hail from Texas. There were references to Texas HB3588[2], which went into effect in September 2003 with very specific guarantees regarding application and use of standard road tolls. The contacted policy-makers felt that Texas toll revenues must be used to cover the construction costs of new transportation infrastructure, much like toll revenues from IH-30 between Dallas and Fort Worth were used many years ago. One respondent indicated that the revenues from a priced corridor in a particular region would more or less need to stay within the region, and each tolled corridor needs to have a non-tolled alternate route.

Public Response: Expert Opinions

There were concerns about the best way to propose CBCP, since any restrictions on mobility are bound to generate controversy. A simpler policy, to start with, might find greater public acceptability. For example, people who are not exposed to flat tolling might not be very comfortable with a CBCP policy. All policy-makers felt that public acceptability could be rather low, despite the logic of CBCP's design and any congestion-reduction benefits the public would experience. However, the transport economists felt that CBCP could be more acceptable than other pricing strategies. There is some research and practical evidence to support that argument. Kockelman and Kalmanje (2004) found public support for CBCP in Austin (24.9%) to slightly exceed that for flat tolling (24.2%). Support for CBCP was higher (50%) among persons already familiar with CP. Thus, education may be the key to generating popular acceptance. London is an example of increase in CP's public acceptability following people's exposure to that city's cordon toll.

The experts were asked whether collecting non-congestion-related tolls (to finance infrastructure) together with CBCP might create any problems. The general response (80%) was that the public will need to be educated about the redistribution of congestion toll revenues (as travel budgets) versus the use of infrastructure tolls for roadway maintenance and improvements. Some respondents (30%) were apprehensive that introducing too many tolls at once might confuse the public. A suggestion involved replacing the gas tax with a flat toll and introducing CP in the form of off-peak and low-use road *discounts*, so as to increase public acceptability. Another was that infrastructure toll was likely to be much larger than a simple replacement of the current gas tax. Suggestions hinted at using standard CP as a means of financing new infrastructure, delaying the implementation of CBCP until the initial investment is recovered. But such a strategy has associated equity problems (e.g., why should only peak-period users be charged), and maintenance costs remain significant.

When participants were asked about the preferred pricing policy (including CBCP) for their region, High Occupancy Toll lanes emerged the favorite primarily due to public acceptability and political feasibility. CP was also a prominent choice, but some respondents indicated that CBCP could be a better option considering its potential to gain greater public support. Flat tolls could be implemented before CBCP, so as to increase public awareness/acceptability. Other responses included flat tolls, managed lanes, ramp metering, FAIR lanes, parking charges and area-wide roadway pricing (like in London). Flat tolls on a portion of the network may prove a useful transition policy for CBCP across the remaining network's principal corridors.

Electronic Toll Collection (ETC) Technology and Configuration

Toll technology experts across the U.S. responded to a series of technology and CBCP-related questions. Experts recommended technologies that could function over a wide range of frequencies/protocols. Modular technologies were advocated, so that the latest modules could be incorporated as needed. Based on the survey responses and current ETC implementations, we recommend Radio Frequency (RF) tags for their easy availability and cost effectiveness. GPS was another popular choice considering it could be a common technology onboard future vehicles, but skepticism existed following problems with the stability of on-board units in Germany's truck tolling program 'TollCollect' (Tollroadsnews 2003). Some recommended dedicated short range communications (DSRC) transponders, but an ETC company representative indicated that such transponders cost hundreds of dollars while new RF tags cost as little as $5-$10 each. Automated number plate recognition (ANPR) technology was the technology of choice for enforcement using cameras to capture pictures of license plates of vehicles that fail to relay a usable tag identification. Information regarding the owners of such vehicles could be obtained from the State's vehicle registry. The major problem with ANPR is some inaccuracies that require manual verification such as lack of plate standards, dirty and damaged plates, incorrect plate mounting, differences in vehicle design and plate position, and ambiguity/similarity in letters/numbers[3].

¶Respondents recommended placing ETC units at freeway entrances and exits unless such ramps are rather frequent (i.e., every two miles or less). In that case, placing antennas/readers at two to four mile intervals might be more cost effective. Placing antennas/readers at entrance and exit ramps (on an access-controlled highway) would involve fewer transactions; but, if one of the readings is flawed or missing, the trip record is lost. Frequent antennas/readers involve more transactions but, even if data from one reader is missing, data from other readers can be used to determine the appropriate toll. The cost estimation analysis assumed that ETC units are spaced every 3 miles (on average), along these facilities. Respondents felt that dynamic pricing (where tolls vary with traffic levels) can be implemented, despite some user concerns over unpredictable toll levels. While marginal cost pricing (MCP) of roadways, as a function of traffic levels, is theoretically the best, such dynamic pricing adds uncertainty to travel options and may not be tenable. Some balance between pre-determined tolls (by time of day) and flexible tolls may be best in practice, as done in the case of SR91 (OCTA 2003). To increase acceptability, provision of alternative, non-priced routes and appropriate positioning of variable message signs (VMS) boards were suggested.

Issues with User and System Data

When policy makers and toll technologists were queried about user data issues, the majority of policy makers (90%) seemed comfortable using vehicle license information from state records as needed. Some toll technologists (50%) suggested storing credit card information (so as to automatically replenish accounts with cash credits). Those against it (25%) cited the possibility for fraudulent use of such information and unease over being automatically billed for a dynamically priced product. Both groups also were concerned that people might not trust the government with their credit card information; hence, a third party might be needed for this purpose. Irrespective of the type of information stored, respondents (75%) felt that data storage would be very burdensome. For example, keeping track of the thousands of people moving into and out of the region each month would be “untenable.” Respondents felt that social security number information should not be needed. Respondents suggested that a customer service center would be needed to handle problems regarding faulty tags, incorrect billing, account information and corrections, and other credit dealings.

Overall Opinion of CBCP

Many respondents (85% of transport economists, toll technologists, policy makers, and commercial interests) expressed concern over the level of administrative costs needed for a CBCP policy implementation. Transport economists extended support for CBCP, since it employs market signals (prices) to allocate scarce resources (highway capacity), resulting in more effective infrastructure use. A majority of experts agreed that CBCP is more effective than flat tolling and normal CP. All policy-makers that responded to the survey felt that CBCP would ease traffic congestion in their regions. And many acknowledged that user fees are becoming increasingly common in municipal and state operations. Several transport economists seemed comfortable with the policy and its equity implications. Commercial users seemed to appreciate the policy for its contribution to more reliable travel times. The responses from toll technologists suggest that CBCP is technologically viable.

Recommendations for Implementation

Based on all expert responses, prior survey work (Kockelman and Kalmanje 2004), and thoughtful consideration of all reasonable policy options, a set of guidelines have been developed for CBCP application. These address issues pertaining to practical trade-offs in budget allocation, enforcement, and administration. Network pricing for CBCP policy could be implemented in many ways. Since the cost of pricing all roads in a region with today's technology is estimated to be prohibitively high, pricing only the major, congested corridors may be the most feasible implementation option, at least at the start. Roads that then suffer from significant CBCP-related traffic spillovers also could be priced. The recommended policy is as follows:

A CBCP policy provides all eligible travelers (Note: eligibility is discussed below) with a travel budget to spend on congestion tolls using a transponder account linked to their names. Ideally, Marginal cost pricing for delays induced by added road users would be imposed on all major, congested roads, and the net revenues would provide for these monthly travel budgets. Without system-wide roadway pricing, the optimal tolls will not reflect true, marginal delay costs since many non-priced (yet congested) routes are still available between origins and destinations. For efficient system operation, all complementary and substitute routes must be appropriately priced. Any budget not spent by the end of the month may or may not, depending on the chosen policy, serve as a cash savings or credit to the account holder. Those exceeding their budgets have to pay for any additional tolls out of pocket. Kalmanje and Kockelman (2004) provide estimates of total revenues and average travel budgets for a CBCP implementation in Austin. As originally conceived, the policy was meant to be revenue-neutral in that all revenues collected each month were to be distributed among all qualifying drivers in the region, after covering system administrative costs. In practice, the actual chosen policy may differ. Returning cash to participants is an incentive for fraudulent activity (via, e.g., ineligible persons claiming eligibility) that can be difficult and costly to regulate. In light of expert caution and concern regarding the administrative burdens of the originally conceived policy, several changes were made in constructing final policy recommendations.

Toll Tags

All system users should be able to obtain transponders for their vehicles upon paying a refundable deposit. Users of IH 15's FasTrak lanes (in San Diego) and users of Dallas-Fort Worth toll roads presently pay a refundable deposit of $40 in order to obtain a transponder. However, if low-cost tags[4] are used, the users could be asked to buy their own tags. The transponders will be associated with unique, vehicle-specific accounts[5] that hold user data such as name, vehicle license plate number and/or a unique ID number, user address (available from vehicle registration records), and credit card information (required only if user chooses to pay tolls using his/her credit card). Because travel credits/budgets are involved, CBCP involves more personal data collection than a CP application. Additional information could be stored based on the methodology adopted to identify people eligible for a travel budget. For example, if budgets are to vary as a function of corridor use, such data could be kept. In addition, budgets may only be granted when sufficient identifying information is presented, such as documents proving the vehicle to be insured and registered in the region of CBCP application.

Travel Budget Eligibility

One of the most difficult decisions and implementation issues associated with a CBCP policy is that of budget eligibility and distribution. The two most likely criteria for eligibility are based on use of priced roadways and on location of residence. Both approaches have strengths and limitations – as well as several variations. A user-based criterion (based on a minimum number of miles or days driven, for example) seems most relevant in a region where relatively few roadways are priced, so that those who really need the corridor are identified through use. A residence-based criterion works best when a well-defined region's network is extensively priced; and residents of different locations may be eligible for different levels of travel budgets, depending on the expectation of need and/or contribution to the network's provision (via property taxes, for example).

Different budget-eligibility criteria and their associated limitations were considered here, such as allocating budgets only to registered vehicle owners versus all licensed drivers in a region. The potential for fraudulent representation of use and/or residence is what led to the strategy recommended here: travel budgets are best tied to a vehicle (based on its use or its registration address), rather than to an individual's transponder (which can be shared easily with others). Drivers' own transponders also can be read, in addition to vehicle identification tags, but that would require additional investment in technology. So the final recommendation is for transponders attached to vehicles. Only licensed vehicle owners with registered vehicles would be eligible for travel budgets. Individuals can be asked to share their insurance records in order to become eligible for a travel budget, thus reducing incidence on uninsured motorists.

Those owning more than one vehicle would be eligible to receive only one travel budget. Of course, people could still register their vehicles under the names of licensed family members and others, and people might retain older and more polluting vehicles just to obtain additional budget. However, vehicle licensing, registration, insurance, inspection and maintenance costs are likely to substantially exceed base travel budgets, in most regions, particularly in regions where revenues are largely reserved for use towards transportation system expansion and enhancement. It is unlikely that people would retain old polluting vehicles to obtain budgets since the cost of titling and registration would exceed the budget.

Treatment of Visitors

Toll technology experts indicated that enforcement is usually not easy if both ETC users and non-users use the same corridor. This could very well happen in a CBCP scenario since visitors (drivers) to the system may not have readable transponders. One option is to let visitors drive for free. This would require the system to keep track of such vehicles (via ANPR) so that fines are not pursued. Ideally, visitors would be required to purchase a 'day pass' to use the priced corridors. Melbourne, Australia's CityLink program has a similar daily pass option for its users (CityLink 2004). Visitors would be asked for their vehicle license plate information on purchase of a day pass, which could be bought online or at a roadside store, as in London's cordon toll application (TFL 2008). Vehicles without transponders, which use the priced corridors, would be detected by ANPR. And vehicles tied to a purchased 'day pass' would be removed from the violator list at day's end.

Budget Distribution

In general, the same budget level may be granted to everyone. However, if equity is a key consideration, multiple budget levels may be useful. Budget levels could be based on employment status and household income. People with special needs could apply for a higher budget. If budget eligibility is determined by residence location, then different packages/discount programs could be designed for people residing outside the CBCP budget eligible zone. For example, users of SR91 express lanes can opt for one of the four available account types: 91Express Club, Standard plan, Convenience plan, and Special access.

It should also be noted that if eligible people receive their monthly budgets on the same day, choice behaviors regarding when to spend one's travel budget could result in undesirable traffic patterns depending on time of the month. People might drive initially and then shift to transit as they run out of travel budget, creating a temporary high demand for transit services (and low demand for road space). To prevent such fluctuations, revenue distribution should be staggered.

Record Management

Every user would have an online account (updated daily) to access all charges, credits, and other account information. Tolls and any fines would be charged to users' accounts and would be accessible (and contestable) online. If payment is not received within a certain grace period, the State police could issue a citation (as in the case of North Texas Tollway Authority's Tolltag users in the Dallas-Ft. Worth region). Use of pre-paid accounts and automatic deposit options can ensure balances remain positive.

Credit Controls

As originally conceived, CBCP involves a monetary transaction (in the form of a travel budget that can be accumulated and used to purchase other goods) from the managing agency to all travelers, including those without vehicles. Such an approach provides a relatively strong incentive for fraud (where ineligible persons claim eligibility) – along with administrative burdens and significant enforcement costs. To avoid such issues budget can be linked to locally registered (and insured) vehicles, and individuals not be permitted to accumulate – or cash out – their travel budgets.

¶By not returning all revenues in the form of cashable budget, system managers can retain a portion of revenues for alternative uses. And, by keeping travel budgets low (relative to revenues) and tied only to registered and licensed vehicle owners, fraudulent representation of eligibility becomes less of an issue and more revenues become available for alternative uses. The uses most popular among experts surveyed are maintaining existing roads, adding capacity, and investing in alternate modes like transit. Of course, a region's stakeholders and policymakers can make their own determinations. In some regions, transit subsidies may be most desirable; in others, new expanded bridges and other bottleneck points.

Cost Estimates

Estimates of initial investment and recurring costs are required to predict net revenues. The paper computes the one time investment costs based on the cost estimates provided by USDOT. The North Texas Tollway Authority's (NTTA) administrative expenditures for the financial year 2003 were used to estimate operations and management (O&M) costs for an Austin, Texas CBCP. To assume that all freeways would be priced is conservative, since not all freeways are congested. Austin has 105 centerline miles and 570 *lane* miles of freeways (USDOT 2000c), 55% of which are "congested" (Schrank and Lomax 2003). Here "congested" refers to traffic conditions that do not allow travel at the speed limits (60 mph on freeways and 35 mph on major streets). The following analysis assumes that fully 75% of the Austin freeway network is priced, making it a conservative cost estimate.

Initial Costs

Two USDOT reports (USDOT 2000a and 2000b) give a range of costs for toll plaza equipment and toll administration equipment, used here to estimate total initial costs. Assuming one toll plaza for every 3 miles (as suggested by toll technology experts) requires around 27 toll plazas. Since only one structure is assumed for all the lanes at any point, the estimate uses the higher USDOT estimate for mainline structure. Since there are multiple lanes at each plaza, 150 electronic toll readers are required (one reader per lane). Around 100 high speed cameras would be required (one for every two lanes, to ensure violation detection [USDOTa 2000]). It is expected that users would cover their transponder costs by purchasing the tags or by paying a deposit, as appropriate.

¶As mentioned earlier, the latest transponders like eGo™ 2201 (TransCore 2002) cost less than $10 per tag. The initial cost is estimated to be $11.4 million (Table 2), which amounts to about $9 per Austin resident. Readers should note that Austin's MPO, the Capital Area MPO (CAMPO), recently approved a $2.2 billion toll road plan for the region. Initial CBCP cost estimated here for transponders (which represent 84 percent of all initial costs) should overlap nicely with toll road plan costs.

Recurring Costs

Operating expenses for the NTTA (NTTA 2003), New Jersey Turnpike Authority (NJTA 2003), and San Joaquin Hills Transportation Corridor Agency (SJHTCA 2003) were used to arrive at system costs of an ETC application in Austin. Table 3 shows expenses as computed per lane mile. Depreciation and amortization expenses were excluded since they result from financing decisions. Manual toll collection costs, state police, snow removal, and toll-tag pre-payment expenses also are not included, since they are not recurring costs for an Austin CBCP application.

Since a CBCP application is very similar to a standard ETC application, its operating costs can be assumed to be comparable to ETC operating costs. One major distinction arises from maintaining CBCP travel budget accounts. Maintaining such accounts involves creating and verifying budgets and an additional secure record keeping. Thus, it involves personnel from the Legal, Audit, Accounting and Community Affairs departments. Therefore, the corresponding NTTA expenses were doubled, resulting in a cost "cushion" of 9.1% over a regular ETC facility.

CBCP operating expenses per lane mile are estimated at $113,569 per year, or a total of $48.5 million for the Austin region annually. This corresponds to $38.10 per Austin resident. In comparison, Austin residents are estimated to experience an average annual congestion cost of $590 (per resident), which includes delay and fuel costs on all congested roadways (Schrank and Lomax 2003). The daily vehicle miles traveled on freeways and other major roads and the percentage of peak period person-trips that are congested (Schrank and Lomax 2003) were used to estimate that around 75% of the congestion costs in Austin are on freeways (assuming similar congestion levels on freeways and other traveled roadways). This is equal to $442.50 per Austin resident. The total cost per resident obtained by applying a capital recovery factor to the initial cost (at an interest rate of 6% over a period of 10 years, the lifetime of the ETC system) equals $39.30. Annual investment of $39.30 per resident seems reasonable in order to address freeway congestion. These cost calculations appear to support the case for CBCP as a worthwhile congestion mitigation strategy in a region like Austin.

Conclusions

Kockelman and Kalmanje (2004) first explored public perceptions of their original CBCP policy proposal, and Kalmanje and Kockelman (2004) examined that policy's short term traffic and land value impacts for Austin, Texas. This paper synthesizes stakeholders' and experts' opinions and predictions of long-term system impacts to produce recommendations for a further refined CBCP policy. Academicians and practitioners in the field of transport economics, policy-makers, administrators, and commercial users provided valuable feedback on issues of travel budget allocation, equity, efficiency, land use change, economic impacts, and alternative revenue uses. Toll technology experts provided recommendations for ETC technology (RFID and ANPR), system configuration, dynamic pricing issues, and variable message signs.

The revised CBCP policy proposal and associated implementation strategies aim to address stakeholders' and experts' concerns relating to the original policy proposal, including ease of implementation and use of revenues. Instead of offering cash credits to all licensed drivers in a "region", it proposes travel credits only for registered vehicle owners. Political atmosphere and financial constraints may govern if cash out will actually be allowed. Travelers with special needs can apply for additional travel credits, and net revenues can be reinvested in the transportation system. Strategies to deal with issues such as budget eligibility, system visitors, enforcement, and toll collection are outlined. The paper concludes that RFID tags and ANPR may be the most appropriate technologies for implementation.

The study estimated conservative costs (including initial and recurring costs) for a CBCP policy implementation along Austin freeways to be about $40 per resident when annualized. Given Austin's current modest congestion levels (relative to larger and denser metropolitan areas), the CBCP policy may not be appropriate for widespread application: However, its application at key bottleneck points, such as bridges using low-cost vehicle ID tags may make the most sense. However CBCP can be a valid option for cities looking for a viable strategy to implement CP. Regions with extensive, congested *transit* systems may also want to examine CBCP for their road networks.

Building such a novel proposal from its theoretical foundation to everyday practice can face considerable challenges. This work strives to advance the concept and address hurdles that can be anticipated at this point. One of the strengths of CBCP is its flexibility at the field-level. More congested systems may want to retain substantial portions of CBCP revenues for system enhancement. Smaller communities may opt for cashable credits, rather than travel credits that expire each month. CBCP in its current form has been galvanized by expert perspectives and is now a feasible demand management strategy. CBCP can help tackle the problem of congestion in an economically viable, equitable, and efficient fashion and, as such, is a powerful idea with significant potential. This paper will hopefully assist experts' efforts to make that potential a reality.

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Table 1. Descriptive statistics on expert opinions about CBCP

	# Responses	% Supporting
Clear **equity** benefits	12	75%
Effective and economically **efficient**	12	75%
Attractive features	13	85%
Land use benefits	14	86%
Positive effect on local **economy**	13	85%
Advocate **road pricing** (CBCP/others)	13	92%

Table 2. Initial technology cost estimates for a CBCP application in Austin, TX.

(All cost estimates are in 2003 US dollars.)

One-time investment	Unit cost estimate	No. of Units	Total Cost
ETC structure	$15,000	27	$405,000
ETC software	7,500	27	202,500
ETC readers	3,500	150	525,000
High speed cameras	7,500	100	750,000
Toll administration hardware	12,500	1	12,500
Toll administration software	60,000	1	60,000
Toll tags	10	945,500[a]	9,455,000
Total cost			$11,410,000

[a] This is the number of vehicles in Austin, where average vehicle ownership is 1.81 vehicles per household (as taken from Austin's travel survey of households) and the projected number of households for the year 2003 is 522,372 (United States Census of Population 2000).

Table 3. Recurring (annual) cost estimates for various ETC projects.

Toll Road Program	Operating Expenses	Lane-miles of Toll Roads	Expenses per Lane-Mile
NTTA	$32,553,600	313	$104,005
NJ Turnpike Authority	$140,023,307	1,219	$114,867
San Joaquin Hills	$9,530,000	108	$88,241

ENDNOTES

[1]Of course, such "cost" depends on the traveler's value of time, so CBD access actually should become less expensive for those who are willing to pay to avoid delays.

[2]HB3588's Chapter 227 Sec. 370.174 describes the use of surplus revenue, to reduce tolls, assist in other local transportation projects, and/or deposit into the State's Mobility Fund.

[3]E.g. London VES errors arose from the similarity of letter O and number 0.

[4]E.g. the eGo™ 2201 (TransCore 2002) costs less than $10 per tag.

[5]An individual cannot have more than one account.