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

Pradeep K. Gulipalli\textsuperscript{1}, Sukumar Kalmanje\textsuperscript{2}, and Kara M. Kockelman\textsuperscript{3}

Abstract

Congestion pricing (CP) ensures that travelers recognize the true travel-time costs of their trip-making by representing 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.

\textsuperscript{1} Consultant, Marketing and Planning Systems, 201 Jones Road Waltham, MA 02451, Tel: 781-642-6277, pradeepg@gmail.com

\textsuperscript{2} Consultant, Deloitte Consulting LLP, Austin, TX 78705, sukumar@gmail.com

\textsuperscript{3} Associate Professor & William J. Murray Jr. Fellow, The Univ. of Texas at Austin, Civil, Architectural & Environmental Engineering, ECJ 6.9, Austin, Texas 78712, Tel: (512) 471-4379, FAX: (512) 475-8744, Email: kkockelm@mail.utexas.edu
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Introduction

Implementation of any significant transportation policy requires an understanding of the policy’s system impacts, including related costs and benefits and likely stakeholder opinion. Such information allows the policy to be refined, while providing direction for implementation. The system impacts that may be modeled include short- and long-term traffic impacts, land use adjustments, air-quality changes, and individuals’ welfare changes.

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. Transport economists, planners, technologists and others develop this dialogue with their expert opinions. Congestion tolls are key to ensuring that travelers recognize the true travel-time costs of their trip-making (by representing the cost of delays imposed on fellow road users). Credit-based congestion pricing (CBCP) (Kockelman and Kalmanje, 2004) is a congestion management strategy which seeks to overcome the negative equity impacts of congestion pricing (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 perspective in order 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, for example, roadside detection devices, variable
message signs, toll collection, and general program administration), the rest arguably belongs to “the public” at large, 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. Goodwin (1989) and Small (1992) suggested combinations of revenue uses, in order to offset several CP impacts.

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 of persons 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 (1995) suggests 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. In Kockelman and Kalmanje’s (2004) work, the term “credit” refers to a monetary cash out. Every eligible traveler (e.g., every licensed driver living in the designated “priced region”) may be given a monthly budget of “credits” to spend on travel – or on anything else. 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. Kockelman and Kalmanje (2004) polled the Austin, Texas public about such a policy and found it 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. CBCP was found 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. A small overall drop in residential property values was predicted when CP was imposed on all roads, while a small rise in downtown property values was estimated 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.

**Paper Overview**

To begin with, an extensive survey of experts and special interest groups was undertaken to study and obtain opinions of a hypothetical regional application of CBCP. 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 implementation of CBCP 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.
**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. Respondent 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.

**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) 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. A transportation engineering professor felt that 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 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 affected since they tend to choose low-cost housing away from activity centers. So allocating an equal travel budget to everyone might leave persons of low income 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 available alternative travel modes. A similar opinion was expressed by some policy-makers 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**

A majority of the respondents 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 predicted more compact land development if CBCP were to be implemented, thus decreasing sprawl. However, a couple 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 CBD would become less attractive compared to those in suburban sites, since accessing the CBD would become costlier. (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.) 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 some commercial users saw a benefit to less congestion, most reported having 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 bring to many commercial users. However, some of the time and cost savings by couriers is likely to be passed on to shippers in the form of reduced costs.
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 a 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. Many of the individuals in service industries mentioned that any flexibility or 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. Most 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. One indicated that telecommuting could become more necessary, and its effect on congestion may be pronounced.

**Concerns about CBCP**

Respondents were asked to rank CBCP issues that most concerned them. Unranked alternatives are assumed to not pose a serious concern for the respondents. The biggest concern for most transport economists 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. Next was the policy’s administrative cost burden. Most transport economists did not consider privacy and technological feasibility to be major issues. However, a
couple noted these to be their principal concerns. 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. One policy-maker suggested that Texas’s Regional Mobility Authorities (RMAs) created under HB3588 would be an option. But revenue handling could be complicated. “Rat-running” onto some local streets (to avoid tolls) may harm some locations, which may demand some of the collected revenues in order to improve their own infrastructure. Smaller communities, beyond the region’s fringe, may lobby for admission to the policy region, if their residents were not given travel budgets for use of the region’s roadways. Such concerns may make revenue-neutrality a difficult goal.

**Alternative Revenue Uses**

Though Kockelman and Kalmanje’s (2004) CBCP proposal is to be revenue neutral, through issuance of travel budgets, transport economists were asked to rank a set of alternatives for uses of “excess revenues.” Any unranked alternatives are assumed to hold the lowest ranking. Most wanted such revenues to go toward maintaining existing infrastructure and/or to adding capacity. Next was development of alternative modes, such as transit. Those who strongly favored transit were not interested in reducing gas taxes – and vice versa. Some respondents 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. Several alluded to Texas HB3588, which went into effect in September 2003 with very specific guarantees regarding application and use of standard road tolls. (HB3588’s Chapter 227 Sec. 370.174 describes the use of surplus revenue, to reduce tolls, assist in other local transportation projects, or deposit into the State’s Mobility Fund.) The contacted policy-makers believe that Texas toll revenues must be used to cover the construction costs of new transportation infrastructure, much like tolls from IH-30 between Dallas and Fort Worth many years back. One mentioned 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**

Several policy-makers worried about the best way to propose CBCP, since any restrictions on mobility are bound to generate controversy. A commercial user felt public acceptability would be greater for a simpler policy. For example, public who are not used to even 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. 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.
When experts were asked whether collecting non-congestion-related tolls (to finance infrastructure) together with CBCP might create any problems, the general response was that the public needs to be well informed how congestion toll revenues will be re-distributed (as travel budgets), while infrastructure tolls would be withheld for roadway maintenance and improvements. Some respondents were apprehensive that introducing too many tolls at once might confuse the public. A transportation engineering professor suggested 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. However, one transportation planner felt that the infrastructure toll was likely to be much larger than a simple replacement of the current gas tax would suggest. A few respondents 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.

Participants were asked which pricing policies (including CBCP) they would consider first for their regions, and HOT lanes were a 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. They recognized the potential of CBCP to gain greater public support than CP. Other responses included flat tolls, managed lanes, ramp metering, FAIR lanes, parking charges and area-wide roadway pricing (like in London). A commercial user suggested trying flat tolls before implementing CBCP, so as to increase public awareness/acceptability. 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 responses received and our own survey of existing ETC practices, Radio Frequency (RF) tags are recommended. Many respondents recommended RF tags because of their easy availability and cost effectiveness. GPS was also quite popular since it is likely to be a common technology on board future vehicles but skepticism existed following problems with Germany’s truck tolling program ‘TollCollect’. 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 would be used for enforcement with cameras that capture pictures of license plates of vehicles that fail to relay a usable tag ID. 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. Inaccuracies may be due to lack of plate standards, dirty and damaged plates, incorrect plate mounting, differences in vehicle design and plate position, and ambiguity/similarity in letters/numbers (e.g. London VES errors arose from the similarity of letter O and number 0).

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 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**

Policy makers and toll technologists were both asked about user data issues. While the former seemed comfortable using vehicle license information from state records as needed, a few were against a policy. A couple of toll technologists suggested storing credit card information (so as to automatically replenish accounts with cash credits). Those against it 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 felt that data storage would be very burdensome for the associated agency. A policy-maker also expressed concern over people moving into and out of the region, claiming that keeping track of the thousands of movers each month would be “untenable.” Respondents felt that social security number information should not be needed.
Respondents felt that a customer service center would be needed to handle problems regarding faulty tags, incorrect billing, account information and corrections, and other credit dealings. One suggested budgeting for one customer service hour per month for every 100 drivers using the system.

**Overall Opinion of CBCP**

Many respondents (in all four categories: transport economists, toll technologists, policy makers, and commercial interests) expressed concern over the level of administrative costs need 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 (where eligibility is discussed below) a travel budget to spend on congestion tolls, via a transponder account linked to his/her name. 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’s time 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, actual, chosen policies 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 policy, as originally conceived, several changes were made in constructing final policy recommendations, as described here.

_Toll Tags_
All system users should be able to obtain a transponder 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 are used (for example, the eGo™ 2201 (Transcore, 2002) costs less than $10 per tag), then the users could as well be asked to buy their own tags. The transponders will be associated with unique, vehicle-specific accounts (an individual cannot have more than one account), which would have the following user data:

1) User name
2) Vehicle license plate number and/or a unique ID number
3) User address (available from vehicle registration records)
4) Credit card information (optional; required 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 maintained 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 showing an individual’s 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 budget, depending on 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 lead 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 (whose vehicles are properly registered) then would be eligible for travel budgets. Individuals also could 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 set of travel credits. Of course, persons could still register their vehicles under the names of licensed family members and others, and people might hold on to older and more polluting vehicles for such purpose. 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.
Thus, it is unlikely that many persons would hold onto extra vehicles (and re-title and re-register them) for the purpose of obtaining extra travel credits. Moreover, if older vehicles with poorly performing emissions systems were to become a pollution problem, roadside emissions inspection devices – coupled with toll tag readers – could quickly identify such vehicles and reduce or cancel budgets in order to compel compliance with emissions standards. Such technologies are complementary to CBCP and standard tolling. Other policy opportunities (such as speed limit enforcement) also may arise via extensive use of toll tags and roadside readers.

**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). 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 level 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 location of residence, 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 every eligible person receives his/her monthly budget on the same day, choice behaviors 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 temporarily 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 credits 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 credits, 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. Those 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 the 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 roads where traffic conditions 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 1), 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 2 shows expenses as computed per lane mile. Depreciation and amortization expenses were excluded since they result from financing decisions. Manual toll collection costs and NJTA 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, expanding ETC operating costs per lane mile is justified. One major distinction arises from maintaining CBCP travel budget accounts. Maintaining such accounts involves creating and verifying budgets and additional, secure record keeping. Thus, it involves personnel from the Legal, Audit, Accounting and Community Affairs departments; so 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, Austinites 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 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. $39.30 per year per resident seems like a reasonable investment 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. Kalmanje and Kockelman (2004) estimated trip-based welfare impacts and land value changes for different CBCP scenarios in Austin.
Conclusions

Kockelman and Kalmanje (2004) first explored public perceptions of their original CBCP policy proposal, and Kalmanje and Kockelman (2004) then examined the policy’s short term traffic and land value impacts for Austin, Texas. This paper folds in stakeholders’ and experts’ opinions and predictions of long-term system impacts to produce recommendations for an even more 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. Options for issues like budget eligibility, system visitors, enforcement, and toll collection methods are suggested. The paper concludes that RFID tags and ANPR may be most appropriate implementable technology. The study developed conservative estimates for both initial and recurring costs of implementing such a policy along Austin freeways; these are estimated to be about $40 per resident when annualized. Given Austin’s current modest congestion levels (relative to larger and denser metropolitan areas), the policy may not be appropriate for widespread application; however application at key bottleneck points, such as
bridges, may make the most sense, along with low-cost vehicle ID tags. However CBCP can be a valid option for cities looking for a viable strategy to implement CP.

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, however: For example, regions with extensive, congested transit systems will want to examine CBCP for those systems as well. More congested systems may want to retain more 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. The information in this report will hopefully assist experts’ efforts to make that potential a reality.

Acknowledgements

We wish to thank the Texas Department of Transportation for financially supporting this study under research project #0-4634, and Ms. Kim Limberg of the Dallas District and other project personnel for their input. We thank all the academicians and practitioners in transport economics, the policy-makers, the toll technology experts, and the commercial users who responded to the survey. Thanks also go to all the people who provided valuable inputs that helped shape the proposed policy. We thank Alexander Marks, undergraduate student researcher, for conducting the policy-maker and commercial user interviews.
References


Table 1. Initial technology cost estimates for a CBCP application in Austin, TX.

(All cost estimates are in 2003 US dollars.)

<table>
<thead>
<tr>
<th>One-time investment</th>
<th>Unit cost estimate</th>
<th>No. of Units</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETC structure</td>
<td>$15,000</td>
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<td>$405,000</td>
</tr>
<tr>
<td>ETC software</td>
<td>7,500</td>
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<td>202,500</td>
</tr>
<tr>
<td>ETC readers</td>
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<td>150</td>
<td>525,000</td>
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<tr>
<td>High speed cameras</td>
<td>7,500</td>
<td>100</td>
<td>750,000</td>
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<tr>
<td>Toll administration hardware</td>
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<td>12,500</td>
</tr>
<tr>
<td>Toll administration software</td>
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<td>1</td>
<td>60,000</td>
</tr>
<tr>
<td>Toll tags</td>
<td>10</td>
<td>945,500(^a)</td>
<td>9,455,000</td>
</tr>
<tr>
<td>Total cost</td>
<td></td>
<td></td>
<td>$11,410,000</td>
</tr>
</tbody>
</table>

\(^a\) 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 2. Recurring (annual) cost estimates for various ETC projects.

<table>
<thead>
<tr>
<th>Toll Road Program</th>
<th>Operating Expenses</th>
<th>Lane-miles of Toll Roads</th>
<th>Expenses per Lane-Mile</th>
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<tr>
<td>NTTA</td>
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<td>NJ Turnpike Authority</td>
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<td>San Joaquin Hills</td>
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