A Game-Theoretic Approach to Cooperative Bus Industry Strategies

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INTRODUCTION

1. The private bus industry is a major player in the provision of metropolitan bus services in Victoria. There are about 50 operators with a combined fleet of over 1,000 buses providing route services in Melbourne and major country towns. The operators vary in size from small 10 bus operations to fleets of over 100 buses. Most fleets are small to medium sized with less than 50 vehicles. Until recently (1993), the government was a major bus operator with a suburban Melbourne operation of about 300 buses, but since this time it has privatised this operation in an attempt to cut the transport budget deficit. It was also in line with a general government trend towards privatisation with the strong belief that private operations were more efficient than public operations. The private bus industry is a $250 million plus operation that is currently costing the government $132 million annually in gross operating subsidies in order to maintain existing service levels. This is partly offset by about $48 million in operating revenue, leaving a net annual subsidy of $84 million.The subsidy is growing at a greater rate than revenue uptake, largely due to the requirements for capital servicing, and is a cause for significant concern as the government seeks to reign in public sector expenditures across not only transport, but also health and education.

2. In an effort to reduce the cash outflow, the government has wanted to tender services in order to stimulate competition and thus lower costs. However, because the private bus industry has existed for over 75 years in Victoria, and had cooperated with government in multi-modal ticket schemes and fare structure changes since 1981, the industry was concerned that the government's continued thrust toward contracting services to the lowest cost operator was not fair treatment, and would ultimately result in poorer customer service. In 1988, the courts ruled in favour of the private bus industry saying that they did in fact have legal rights to their long held route services. There are clearly different objectives between the bus proprietors and the government and this has resulted in difficulties in achieving a negotiated settlement because of divergent requirements.

GAME THEORETIC APPROACHES

3. In situations which may be regarded as a contest involving two or more decision makers, each of whom wants to win, there is a branch of mathematical analysis known as Game Theory which has been applied in a wide range of circumstances over the past fifty years. Game Theory has developed a rich theory in applied economics since its initial creation by Von Neumann and Morgenstern (1944).

4. The essence of game theory is that the decisions made by one player are not independent of the decisions made by a second player (or by a third or fourth player in multi-player games). Each player must decide on not only what their best decision would be in a static situation (where, for example, the other players have already made their decisions known), but what their decision would be in a dynamic situation where the decisions of the other players are either not known or may change over time. In such a situation, each player must make an estimate of what the other players will do and how they will react to the decision made by each player.

5. One of the interesting outcomes of game theory is that many of the rules associated by static choice theory, where decisions are made independently of other players decisions, may not hold in a game theoretic situation. For example, the concept of transitivity, often assumed in choice theory, may not apply. If alternative A is better than alternative B, which in turn is better than alternative C, then it is commonly assumed that alternative A will therefore be better than alternative C. However, it has been shown via game theory that in a three-way contest between A, B and C (where A is stronger (better) than B, which is stronger than C), it is often possible for C to emerge victorious after A and B have effectively neutralised each other (because both A and B adopted strategies to counteract their strongest opponents).

6. Another interesting aspect of game theory is that purely competitive strategies may not be as effective as cooperative strategies. Both players may be better off by aiming for their second-best options (rather than stubbornly pursuing their best options) if the combination of their second-best options is compatible with an overall optimal situation for each player (given the decision made by the other player). A classic example of this situation is the "prisoners' dilemma" game, wherein each prisoner needs to trust that the other one does not make a decision only in their own best interests. If both players trust each other, and aim for the apparent second-best, then they will both be better off than if either, or both, pursues their own apparently best option.

7. This paper uses an elementary game theoretic approach to describe the strategies open to both parties in the negotiations between the government and the private bus industry, and then quantifies the pay-offs and analyses the best strategies for each.

8. In principle, to model the environment of the private bus industry and the government, an n-person cooperative gaming strategy should be employed. This is because there are at least 50 "players" and each is able to share information and form alliances or mergers. However, these models are notoriously difficult to solve because of the huge number of possible alliances and the quantification of the trade-offs. An alternative is to consider the 50 bus operators as a single group (in fact through their association the Bus Proprietors Association, BPA, they are) in "conflict" with just the government. Further let us assume that if the government "wins" then the BPA "loses" so that we have created what is known as a "zero sum game". Under these circumstances it is possible to analyse the strategies and determine if there is a single best strategy for both parties. In order to develop the model, strategies need to be developed and then some form of pay-off matrix is required. The paper first describes the strategies open to both parties and then

estimates the costs associated with them. Finally, the analysis shows that an equilibrium may not exist, and the implications are discussed in the conclusions.

THE STRATEGIES

9. Cox and Love (1992), describe five basic service structure models that a government may employ for the bus industry:
   - Public Monopoly, usually a unit of government designing and operating public transport services;
   - Private Monopoly, where private companies hold franchises over particular routes or areas;
   - Competitive Tendering, where a government body designs the system and then requests tenders from private companies;
   - Free Market Deregulation, in which there is minimum government intervention; and
   - Threatened Competition, where private monopoly operators are required to meet certain service standards and costs or have their route licences revoked.

10. In addition to the above five models, it is possible that a single private operator could cover the whole metropolitan operation. We call this a Private Operating Agency.

11. In Victoria, a combination of public and private monopolies existed until recently. The government is now seeking to move towards a strategy of Competitive Tendering where service standards and fares are set and monitored by government and private enterprise bids for licences which may be held for a period of several years. This is clearly a movement from the Private Monopoly strategy which has existed for over 50 years. While the Victorian Government has signalled its preference to move to Competitive Tendering, the private bus operators see that Threatened Competition could achieve similar competitive pressures without the destabilising effects of an ongoing tendering process.

12. The BPA, acting as the other player in the game, has a range of possible strategies available:
   - Maintaining the status quo of private monopolies;
   - Voluntary cost reductions through better planning or service rationalisation;
   - Mergers and service rationalisation; and
   - Withdrawal of Services altogether.

13. It needs to be stated that the use of the word "private monopoly" is true only in a spatial sense. Operators have licences which entitle them to operate services along routes and in areas of a town or city. Usually these areas have no other bus operator's services, or at most restricted services, so that competition is indeed limited. However, there has been a continual movement in the structure of the private bus industry as companies merge or take each other over naturally. It is fair to say that there has been a movement toward fewer larger operations as smaller,

weaker operators sell out in order to maximise their returns on investment or minimise losses in the face of tougher financial constraints. It is clear that there has been competition between the 50 operators within the regulatory framework imposed by the government. As a group, the BPA prefers to maintain the status-quo in preference to risk losing licences in a competitive tendering process. But it is unfair to say that competitive forces are not at work in the private bus industry, even though there are long standing route franchises that effectively are spatial monopolies.

14. Adopting the game theoretic framework, a table can be constructed with the BPA and Government Strategies outlined in pay-off matrix format as shown in Table 1. In Table 1, the existing situation is shown with the intersection of the government strategy column of Private Monopoly and the BPA strategy row of Private Monopoly. The preferred government strategy of tendering (the Competitive Tenders column) would be optimised by the BPA choosing a merger strategy (the Mergers row) since changeover costs would be minimised for the government if there were fewer operators. However, in the short run, if a single private agency operated the whole system (the Private Operating Agency column), and the BPA adopted a withdrawal strategy (the Withdraw Services row), the government would minimise its changeover costs because all operating costs would be born by a single private operator. However, in the long run, without competition, this situation would likely deteriorate because of the lack of competitive pressures (Stopher, 1988). The worst case for the government would be if it tried to operate some public services (the Public Monopoly option) and if the BPA operators withdrew all services. This would force the government to operate all services and incur the highest cost to the public purse. Of course the public transport unions might see this as preferable, but it all depends on the players' objectives and in this case, the objective is to minimise the expenditure by the government.

TABLE 1: GOVERNMENT AND BPA STRATEGIES

	GOVERNMENT STRATEGIES					
BPA STRATEGIES	Public Monopoly	Private Monopoly	Competitive Tenders	Free Market Deregulation	Threatened Competition	Private Operating Agency
Private Monopoly		Existing situation				
Voluntary cost reduction						
Mergers			Govt. Preferred			
Withdraw Service	Govt's worst case					Short term best Govt' option

DEVELOPING THE PAY-OFF MATRIX, COST ESTIMATES

15. A study reported by the Industry Commission (1994) indicated that the average cost of operating a metropolitan route bus in Victoria was, on average, about $2.25 per kilometre. Given that there are approximately 46 million bus-kilometres of services

operated annually by BPA operators (Ryan 1995), this suggests a total operating cost of about $105 million dollars annually. The actual 1994 government outlay was $132 million for metropolitan services (Ryan 1995). The difference can be attributed to variations in operation costs about the, PTC overheads in the administration of the subsidies, and payments to non-BPA operators.

16. Local studies by consultants, and international experience, suggests that with a tendering system for a network the size of Melbourne's, savings of the order of $10 million p.a. are possible (Ryan 1995). It is not known precisely how much the Threatened Competition strategy would reduce the costs to Government. The BPA claims that it would be as effective, economically, as the Competitive Tenders strategy. However, the government clearly believes that this would not be the case, even though they may accept that it might be more efficient than the current situation. Therefore, a half-way point has been assumed, with savings of $5 million p.a. assumed in comparison to the existing situation.

17. Furthermore, it has been arbitrarily assumed that the existing operators could make voluntary cost reductions of $10 million p.a., while mergers could reduce operating costs by a further $10 million p.a.

18. In order to complete the matrix, it is necessary to estimate the costs of a total government buy out of the private system. If we assume about $100,000 as the current book-value of an average bus and 1,000 buses in the system, then capital costs for just the vehicles are of the order of $100 million. Some multiple of the annual operating cost needs to be added to this amount so that operators would be indifferent between staying in, or leaving, the industry. If operators were not satisfied with the buy-out price, then litigation would follow and they would not participate in the buy-out. Let us arbitrarily suppose that operators would be willing to take the equivalent of one year's costs, in addition to the value of the vehicles, to leave the industry. It follows that a buy-out by government would cost about $200 million or on average, about $4 million per operator. Given the strength of the industry, and the length of time over which these businesses have been successfully developed, these costs do not appear to be commercially unreasonable.

19. Given the above assumptions it is possible to develop an estimate of the government's pay-off matrix as shown in Table 2. The government's strategy of selecting a Single Operating Agency and the BPA's Withdrawal of Services strategy are not considered here because they would involve the inclusion of a third-party to operate the services, and hence cannot be easily handled as part of a zero-sum game. The addition of these two strategies requires a more complex analysis and is not taken further in this paper. In the current circumstances, they are also unlikely to be played by either party. The option of Free Market Deregulation is also excluded because the government has clearly signalled an intention to maintain an involvement in the regulation of bus services to ensure that Community Service Obligations are met by the operators.

20. Table 2 presents the two players' strategies in a classic pay-off matrix. Because it has been assumed that the situation can be represented by a "zero-sum" game, the total game can be represented by the pay-offs to either one of the players; the other player's pay-offs are simply the negative of those shown in the table. In reality, it is

known that the existing situation is not truly a "zero-sum" game because there are other players who will be affected by the decisions made by the government and the BPA operators (and vice-versa). For example, there are other bus operators outside the BPA who could bid for services or otherwise participate in the game; there are suppliers to the industry who would be affected by reductions in the costs of providing services; and there are the users of the services, who will be affected by the government and BPA decisions and whose decisions about usage will affect the operators and the government.

21. For the moment, however, a simple "zero-sum" game will be explored to illustrate the major points to emerge from such a game theoretic approach.

TABLE 2: GOVERNMENT'S ESTIMATED PAYOFF MATRIX

	GOVERNMENT STRATEGIES			
BPA STRATEGIES	Public Monopoly	Private Monopoly	Government Tenders	Threatened Competition
Private Monopoly	-$200M	-$84M	-$74M	-$79M
Voluntary cost reduction	-$200M	-$74M	-$64M	-$69M
Mergers	-$190M	-$64M	-$54M	-$59M

22. The principle of dominance can be used to reduce the size of the matrix because the government is clearly better off not using the Public Monopoly strategy since that involves greater expenditure than the existing situation of Private Monopoly, no matter what the BPA may do. Thus, a reduced 3x3 matrix can be created in Table 3.

TABLE 3: GOVERNMENT'S REDUCED PAYOFF MATRIX

	GOVERNMENT STRATEGIES		
BPA STRATEGIES	Private Monopoly	Government Tenders	Threatened Competition
Private Monopoly	-$84M	-$74M	-$79M
Voluntary cost reduction	-$74M	-$64M	-$69M
Mergers	-$64M	-$54M	-$59M

23. Using the minimax procedure to identify if a saddle point (equilibrium) exists, we find the smallest value in each column and take the largest of these (-$74 million for Government Tenders and Private Monopoly) and then pick the largest value in each row and pick the smallest of these numbers (-$74 million, Government Tenders and Private Monopoly). Since these two values coincide, it suggests that there is a saddle point or equilibrium situation which defines the strategies which both players should play. The government is selecting the best of the worst outcomes from the

BPA's decisions, while the BPA is selecting the best of the worst outcomes that might be created by the government's decisions. Each player is taking a pessimistic view of what might occur.

24. However, the saddle point in Table 3 is clearly not a desirable outcome from the BPA's point of view. They have stated that they do not favour a open tendering situation because of the instability that would create in the industry; it may also not be the most profitable outcome from their point of view. One can understand this situation by relaxing the constraint that the game is necessarily a two-person "zero-sum" game. While the game may still be zero-sum, it is not necessarily the case that it is only a two-person game. In the simplest extension of the game, one can consider the suppliers of goods and services to the bus industry. Whatever the government pays to the bus operators for the provision of services is actually split between the operators (as retained profits) and the suppliers (via the costs of operating the services). Clearly, what the bus operators want to do is to maximise the profits, rather than maximise the revenue.

25. For example, suppose that the cost to the BPA operators of operating the existing services was $70 million, that the cost could be reduced to $50 million by voluntary cost reductions, and that a further $5 million could be cut from the costs by mergers, then the profit payoff matrix from the BPA point of view would be as shown in Table 4.

TABLE 4: BPA'S PROFIT PAYOFF MATRIX

	GOVERNMENT STRATEGIES		
BPA STRATEGIES	Private Monopoly	Government Tenders	Threatened Competition
Private Monopoly	$14M	$4M	$9M
Voluntary cost reduction	$24M	$14M	$19M
Mergers	$19M	$9M	$14M

26. Applying the minimax criterion to Table 4 shows that a saddle point exists where both players adopt the Private Monopoly strategy and the payoff to the BPA is $14 million. However, this is different to the saddle point obtained from the government's payoff matrix in Table 3. This partly explains why no easy negotiated compromise has so far eventuated since each party has a different optimal solution from their own point of view.

27. If, however, both parties adopted a cooperative approach it can be seen that there exists a solution in which both players are better off compared to either the existing situation or to the best situation obtained through the competitive minimax solutions. This occurs when the government adopts a Threatened Competition strategy and the BPA adopts a Voluntary Cost Reductions strategy. In this case the cost to the government is $69 million (compared to the current $84 million, the payoff of $74 million to the government from the government's minimax solution

or the payoff of $84 millionto the government from the BPA's minimax solution) while the profit to the BPA is $19 million (compared to the current $14 million, the payoff of $14 million to the BPA from the BPA's minimax solution or the payoff of $4 million to the BPA from the government's minimax solution). The added payoff to both the BPA and the government comes about by reducing the share of the government expenditure which goes to the suppliers of goods and services to the bus industry.

CONCLUSIONS

28. While the specific numbers used in the paper are indicative only, the game theoretic approach confirms the problem that both the BPA and government face. If both parties adopt a two-person zero-sum game approach, where they assume that their wins are the other party's losses, then each comes to a different solution which imposes costs on the other party. However, if the BPA and the government could agree to cooperate, then a successful resolution is possible where each of these parties is better off (at the expense of a third party). It demonstrates rather clearly the value of cooperation and trust that would mutually benefit both parties. Strategies to increase cooperation should be used by both parties so that a meaningful dialogue can begin. The use of common cost data bases to identify areas of improvement in cost efficiency, and marketing strategies designed to increase patronage should be explored as areas of common interest. If this can occur, and a relationship of trust developed, both parties would benefit.

REFERENCES

Aumann R. and Hart S. (1992). Handbook of Game Theory with Economic Applications, Volume 1, North Holland.

Cox, W. and Love, J. (1992). "International Experience in Competitive Tendering", In Antti Talvitie, David Hensher and Michael Beesley. (Eds.). The 2nd International Conference on Privatization and Deregulation in Passenger Transportation". Auranen Ltd, Forssa: Finland, pp. 23-36.

Industry Commission (1994)."Urban Transport", Industry Commission Report No. 37, AGPS, Canberra.

Luce R D. and Raiffa H. (1957). Games and Decisions: Introduction and Critical Survey. John Wiley, New York.

Render, B. and Stair, R. (1988). Quantitative Analysis for Management, Third Edition, Allyn and Bacon.

Ryan, S. (1994). "Victorian Private Bus Industry, Future Direction of Government Involvement", Unpublished RMIT Term Paper for LM459, Department of Marketing, Logistics and Property, RMIT University, Melbourne.

Stopher, P.R. (1988). "Privatisation of Urban Mass Transport: A Dissenting View". 13th Australasian Transport Research Forum, Volume 1, pp. 19-33.

Von Neumann J. and Morgenstern O. (1944. Theory of Games and Economic Behaviour. Princeton University Press, Princeton, New Jersey.