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研究成果の概要(和文)：本研究では、公共交通機関とシェアード交通システムが存在する都市における人流のモデルを作成した。本研究の主な目的は、これらのシステムが公共交通機関とどのように「競合」または「協調」するかを理解することである。運賃規制のないシェアード交通機関の運営者は、利益を最大化するために、運賃を請求することができる。特に、公共交通機関のサービスが十分に充実していない地域では、シェアード交通機関の運営者は利用者により多くの運賃を請求することができる。このような運賃設定は、公正ではない可能性がある。総合的に見て、シェアード交通機関の運賃にもまた、一定の規制が必要であることを本研究の結果は示唆している。

研究成果の学術的意義や社会的意義

本研究は、モデリング・アプローチに貢献すると同時に、交通計画のためのいくつかの知見を導出している。モデル化に関しては、モデル都市における様々な共有交通システムや公共交通システムの需要を予測するための公式を導き出すことで、「連続的な近似アプローチ」を開発している。さらに、本研究で進められた微視的なシミュレーションのアプローチは、今後の研究においても使用されるツールになることを示唆している。日本ではインフォーマルな公共交通機関や様々な形態のシェアード交通が今後、増加する可能性があるため、本研究は、どのような運賃規制が適切であるかについて、交通計画者に方向性を示す研究となっている。

研究成果の概要(英文)：The research created models of person flows in cities with public and shared transport systems. Different types of shared transport are explored such as feeder, shuttle and carsharing services. A main objective has been to understand how these systems compete or collaborate with public transport. We discuss in particular the role of pricing for this. An unregulated shared public transport operator would charge trips to maximise profit. The prices would then differ significantly over the city area. In particular areas with less public transport service would allow the shared transport operator to charge more. Such pricing is not likely to be perceived as fair. Overall, we suggest hence that certain regulations are required together with a good public transportation system.

研究分野：交通計画

キーワード：Public Transport Shared Transport Pricing

1 . 研究開始当初の背景

Public transport usage is changing with the appearance of new modes such as ride sourcing, carsharing or bicycle sharing. Due to this as well as triggered by “smart ticketing” including tracking of travelers’ routes, fare structures increasingly change from flat, or zonal to distance-based. This results in revenue impacts and “winners and losers” among the population. There is furthermore fear among public transport operators that the additional mobility options will decrease the demand for traditional services such as buses and subway. The rise of “Uber”, “Grab”, “Didi” and other services in various countries all over the world has led already to significant changes in the mobility patterns. In some cities, indeed this has led to fairly significant reductions in public transport. At the same time the pricing of shared services is under discussion. “Surge pricing” has been seen when demand is high and supply low. This has led to complaints by the population. In Japan shared services are still minor and in their initial stages. It is believed, however, that in the future similar problems might arise. In particular if shared autonomous services will become available, then mobility and mode choice patterns might also change in Japan more significantly.

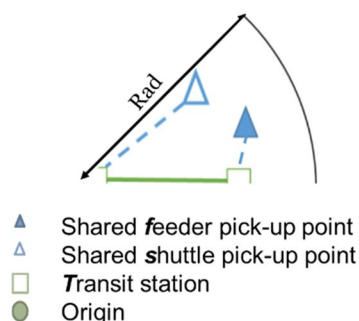
2 . 研究の目的

Therefore this research aims to provide a general understanding as to what are fair fares given changing urban mobility. Furthermore the research discusses whether appropriate fare structures can support the goal of compact cities. A particular focus is given to the competition of public transport with shared transport schemes. In particular the competition versus collaboration problem of free-floating carsharing and bicycles with public transport needs to be discussed. In other words, the research has been aiming to address the question as to whether such shared services increase or decrease the usage of public transport. A decreasing effect can occur if shared transport replaces public transport trips. An increasing effect can occur if shared transport functions as feeder services to public transport and overall private car trips are replaced.

3 . 研究の方法

The research is mostly based on various network modelling approaches.

In the network modelling part we have been looking for efficient ways to reflect complex fare structures as well as ways to model shared transport and public transport so that it allows deriving conclusions for different types of cities. We therefore employed a “continuous approximation” approach as well as a more microscopic modelling approach.

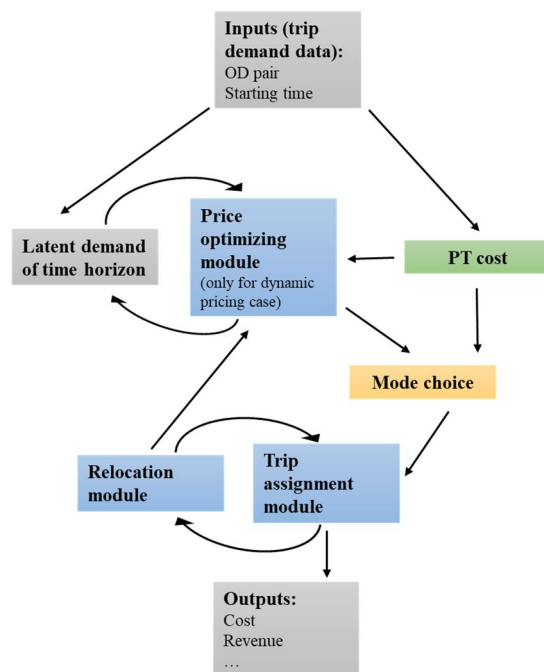


The left hand figure shows some parts of the CA approach. For a radial city with demand focused on the city center we assume that there is a fixed transit line and flexible locations for feeder and shuttle services. We then developed an optimization approach to find the optimal location as well as fares for the feeder and shuttle services.

In the microscopic simulation part of this research we used an existing simulation framework and advanced it by modelling the competition between public transport and shared transport.

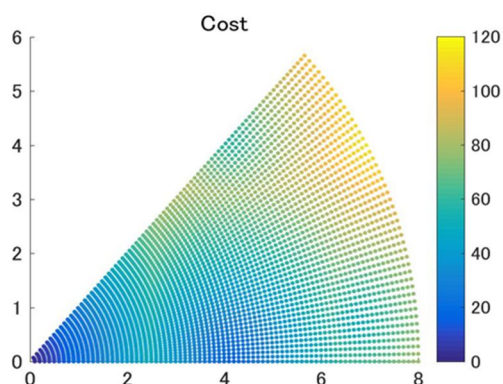
The right hand figure shows the conceptual framework. The focus of this research has been the pricing optimization module in the center of the framework.

In addition to these network modelling approaches we have been advancing some of the approaches developed in previous research (Kaken, 26289174) as well as have been using econometric modelling with data from a carsharing scheme.



4 . 研究成果

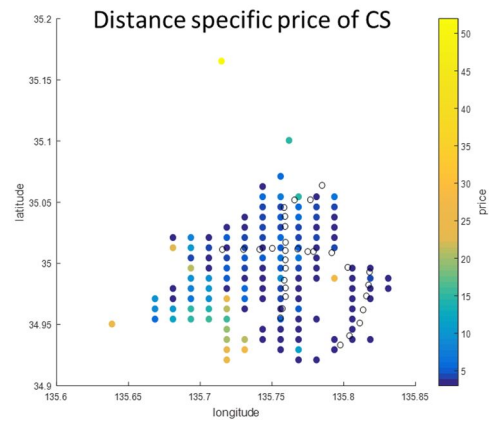
With the CA network modelling approach we have been able to show the changing accessibility and resulting modal share between public transport and shared services. The right hand figure shows an illustration of the resulting spatial distribution of the travel costs in the radial city shown above. Compared to scenarios without feeder service we could show how especially the travel costs from the corners of the area are reducing with the introduction of shared transport.



Overall we have been discussing in the resulting research papers how depending on city size and population density competition and collaboration occur as in below figure. On the x-axis the demand city is shown and the y-axis describes the size of the radial city. We suggest that only for larger cities feeder and shuttle services are suitable and that there is a risk that public transport will lose demand to the shared services. In dense small cities with limited public transport, however, feeder services can support public transport.

With the microscopic modelling of carsharing and public transport we also obtained the spatial distribution of prices for an actual case study. We modelled the trip patterns of Kyoto city based on available spatial statistics from a mobile phone service provider. We fixed the public transport price to current prices in Kyoto and allowed the assumed provider of the carsharing service to set prices that maximize its revenue. The carsharing operator will hence choose prices that are slightly below the general costs that people encounter if they have to use public transport. This means that carsharing prices will be larger in areas with less public transport service. Below figure shows an

illustration of the carsharing prices. Note the high prices (yellow) in some of the southern areas of Kyoto that are far from the subway lines. This might not be perceived as fair. In general we conclude, however, that carsharing can reduce the costs of the population significantly. We suggest that our results indicate that regulated pricing for carsharing is needed in combination with good public transport to provide improvements and “fair” mobility solutions to all stakeholders.



5. 主な発表論文等

〔雑誌論文〕 計3件（うち査読付論文 2件／うち国際共著 2件／うちオープンアクセス 0件）

1. 著者名 Jin, Z., Schmoecker, J.-D. and Maadi, S.	4. 巻 79
2. 論文標題 On the interaction between public transport demand, service quality and fare for social welfare optimisation.	5. 発行年 2019年
3. 雑誌名 Research in Transportation Economics	6. 最初と最後の頁 1-12
掲載論文のDOI（デジタルオブジェクト識別子） 10.1016/j.retrec.2019.05.005	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 該当する

1. 著者名 Maadi, S. and Schmoecker, J.-D.	4. 巻 12
2. 論文標題 Route Choice Effects of Changes from a Zonal to a Distance-based Fare Structure in a Regional Public Transport Network.	5. 発行年 2020年
3. 雑誌名 Public Transport	6. 最初と最後の頁 535-555
掲載論文のDOI（デジタルオブジェクト識別子） 10.1007/s12469-020-00239-9	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 該当する

1. 著者名 Zhang, C., Schmoecker, J.-D., Kuwahara, M., Nakamura, T. and Uno, N.	4. 巻 136
2. 論文標題 A diffusion model for estimating adoption patterns of a one-way carsharing system in its initial years	5. 発行年 2020年
3. 雑誌名 Transportation Research Part A: Policy and Practice	6. 最初と最後の頁 135-150
掲載論文のDOI（デジタルオブジェクト識別子） 10.1016/j.tra.2020.03.027	査読の有無 無
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 -

〔学会発表〕 計6件（うち招待講演 0件／うち国際学会 6件）

1. 発表者名 Maadi, S., Schmoecker, J.-D. and Hong, J.
2. 発表標題 Non-additive Fares within Congested Frequency-based Transit Assignment
3. 学会等名 99th Annual Meeting of the Transportation Research Board（国際学会）
4. 発表年 2020年

1. 発表者名 Jin, Z. and Schmoecker, J.-D.
2. 発表標題 Shared and Mass Transit Operational Strategies in Radial Cities with Many-to-One-Demand
3. 学会等名 3rd International Symposium on Multimodal Transportation (国際学会)
4. 発表年 2019年

1. 発表者名 Yao, Z. and Schmoecker, J.-D.
2. 発表標題 Equilibrium Assignment Issues with free-floating bicycles
3. 学会等名 3rd International Symposium on Multimodal Transportation, Singapore (国際学会)
4. 発表年 2019年

1. 発表者名 Schmoecker, J.-D., Maadi, S. and Fonzone, A.
2. 発表標題 Optimal non-additive distance-based public transport fare structures
3. 学会等名 9th Int. Symposium on Travel Demand Management (国際学会)
4. 発表年 2019年

1. 発表者名 Lai, Y., Schmoecker, J.-D. and Yamada, T.
2. 発表標題 Marginal increasing pricing to mitigate the negative impacts of autonomous vehicles
3. 学会等名 9th Int. Symposium on Travel Demand Management (国際学会)
4. 発表年 2019年

1. 発表者名 Yao, Z. and Schmoecker, J-D.
2. 発表標題 Equilibrium Assignment Issues with free-floating bicycles
3. 学会等名 3rd International Symposium on Multimodal Transportation, Singapore (国際学会)
4. 発表年 2019年

〔図書〕 計0件

〔産業財産権〕

〔その他〕

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6. 研究組織

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7. 科研費を使用して開催した国際研究集会

〔国際研究集会〕 計0件

8. 本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関
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