**VIP: HMO Caps in St Andrews**

Individual Reflective Report

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1. **Calibration of Parameters in Python**

My most significant contribution to the project was developing a framework and conducting accurate calibration of the parameters using optimisation libraries in python. The calibration framework is the core process in the binomial logit model for St Andrews. Without it, the results that the model predicts in the null state and various situations described in the counterfactual analysis are arbitrary, insignificant, and not relevant in the St Andrews housing market. Therefore, the focus of this report would be on evaluating the accuracy of the current calibration framework.

The current calibration process is numerical and is based on the scipy. minimise python package, where the program attempts to estimate the eight parameters (Alexander et al., 2022) of the modelbased on hard-coded constraints and boundaries which it must abide by and an objective function for which it tries to reduce the error as much as possible using a least-squares approach. Our current objectives comprise seven theoretical moments (Alexander et al., 2022) based on the synthetic data set and past literature relevant to St Andrews. Due to this, the estimates for the parameters are not arbitrary and allow us to assess counterfactuals to make inferences about the impact of HMO license and other factors on the St Andrews housing market.

Another positive aspect of the current calibration model is that it only introduces necessary constraints, such as ensuring WTP for high-income groups is higher than for low-income groups, and probability values are between 0 and 1. It shows that the calibrated values are reasonable without excessive external intervention. Furthermore, the framework is very flexible since it can easily accommodate more parameters, changes in objectives' weights, or an increase or decrease in constraints and theoretical moments.

It is a very sophisticated initial attempt; however, there are flaws in the framework. Based on the sensitivity analysis results, WTP parameters and calculated elasticity of demand are quite sensitive to an increase in *M\_c, E\_c and P\_c* (Alexander et al., 2022),indicating high uncertainty and the possibility of inaccurate standardisation of the errors. Another drawdown is that some theoretical moments are arbitrary since moments about proportions are based on a synthetic data set, and a rough approximation for first-order derivatives is used when calculating elasticity.

This calibration framework was the third method I tried. Initially, the idea was to get an analytical expression for each parameter of interest using the sympylibrary in python. I attempted to code this in python, but it resulted in several errors and no solution, possibly because there was not a relevant analytical expression. Due to this limitation, I tried a numerical approach using fsolve. The aim was to find a solution for the parameters using a system of equations formed by the theoretical moments. Unfortunately, the code resulted in no solution to the system of equations and the closest results from inbuilt Jacobian iterations led to unreasonable values for the parameters such as negative probability and WTP values.

I had expected us to go through with the fsolve procedure, as I believed if we could come up with more independent theoretical moments, we could permutate various combinations for the system of equations until we got a solution. However, after discussing this with Luc, I realised that it would be unreasonable to expect any more independent theoretical moments due to our lack of empirical data. Hence I coded the minimum distance calibration method, as described previously.

My willingness to try several approaches without being discouraged was a significant factor in the progress of the calibration framework. In addition, Luc's advice and guidance throughout the process were constructive, as I had regular meetings with him after team meetings to discuss any issues I faced while coding. He would occasionally send relevant maple code for an outline process, which helped better understand.

1. **State of the Project**

There has been significant progress this semester. A working binomial logit model with a flexible calibration framework in python has been implemented. It predicts significant results such as the proportion of each student bin and the respective proportion of each group that lives in St Andrews, Equilibrium Rent, WTP and Elasticity of Demand. This further allows for detailed sensitivity and counterfactual analysis to be conducted, which can later be used to infer the housing market and possible policy decisions to mitigate the impact of HMO caps. As an inspiration from the VIP conference, there even is a causal analysis of the environmental impact caused by HMO caps. Collectively we have reached most of our goals and even exceeded them in some areas.

The prospects for continuation are excellent as this semester, a lot of the work led to creating a solid base for the project. From here on out, there are many directions to explore. For example, a multinomial logit model can be explored as the current assumption of the homogenous housing stock is not reasonable. Data Collection can be conducted, so more independent theoretical moments are generated. Detailed sensitivity analysis can be done using partial derivatives so that the uncertainty in parameters is reduced and a dynamic model can be explored in the long term future.

The best way to manage a large group project is to have clear internal deadlines, detailed responsibilities for every team member, and balanced subdivisions of groups. Another consideration while forming a team is the desired skill set. This semester, I feel a lack of members with coding experience led to slower progression throughout the semester.

1. **Personal Growth**

As the head of the coding sub-team, I have experienced noticeable growth in my technical skills and leadership ability.

Overall, due to my extensive coding responsibilities, I gained a profound understanding of econometric model building and parameter calibration procedures. In specific, I gained extensive knowledge about various optimisation packages and libraries in python. Working extensively on calibration also gave me insights into clever mathematical tricks such as weights, standardisation, and numerical approximations. I even learned good coding practices as I regularly shared code with Lu and members of the coding team.

As the head, I learnt the importance of delegation of work and active collaboration and communication with teammates. For example, Essia had trouble early in the semester participating. However, by encouraging her to join the coding team, I was able to help her find tasks to contribute to the team effectively. For instance, she created the map and code displayed at the conference and actively contributed to the causal analysis of the environmental impact of HMO caps.

**References**

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