Institution: University of Nottingham

Unit of Assessment: UOA17- Business and Management Studies

Title of case study: Reducing food waste and food insecurity through computational social science

Period when the underpinning research was undertaken: 2013-2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s):	Period(s) employed by submitting HEI:
Dr John Harvey	Assistant Professor	2018-present
Professor Andrew Smith	Professor	2003-present,
Dr James Goulding	Assistant Professor	2007-present
Dr Gavin Smith	Assistant Professor	2011-present
Dr Benjamin Lucas	Assistant Professor	2018-present
Dr Bertrand Perrat	Assistant Professor	2018-present
Dr Georgiana Nica-Avram	KTP Associate	2019-present

Period when the claimed impact occurred: 2018-2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

Research undertaken on computational social science analysis of consumer behaviour within the N/LAB of Nottingham University Business School led to a Knowledge Transfer Partnership with OLIO (the world's largest food sharing network). Through a series of multi-year computational research projects this knowledge exchange relationship has helped to secure the financial performance of the platform and has enhanced practice for supporting poverty alleviation. The research influenced policy and practice, particularly in the Greater London area on food poverty, reaffirming the need for improved food insecurity policy and changing the practical implementation of measurement at local authority level.

2. Underpinning research

Prosocial exchange systems are free online services that support peer-to-peer resource sharing. In 2014, research led by Harvey **[1]** found that many people use these services during times of disruption in their lives such as moving to university, getting divorced, or experiencing bereavement. Following **[1]**, Harvey and the research team partnered with a prosocial exchange system, Streetbank, to develop a computational network analysis method for analysing user behaviour at scale **[2]**. Results revealed that reciprocity is rare between people using such systems and that most tend to act either as a donor or as a recipient rather than both. This behavioural split is primarily a consequence of socio-economic differences – those that have resources to share, and those that do not. Research funding from the EPSRC **[G2, G3]** significantly contributed to developing research findings and helped to support the development of methods on other transactional datasets. Though previously unquantified, the newly developed research method enabled the team to show that these services are carrying a massive hidden burden of poverty in the UK.

As a growing number of people in the UK are experiencing 'in-work poverty' and emergency food assistance in the UK has dramatically increased, the research team led by Harvey, turned attention to prosocial exchange systems and redistributed food. In 2017, Harvey, working with colleagues in the Neo-Demographic consumer analytics lab at Nottingham University Business School (N/LAB), a multi-disciplinary team of social and computer scientists, partnered with OLIO. OLIO offer an application that helps people share food surpluses and reduce waste. OLIO is the largest application of its kind in the world with over 2,600,000 registered users and since 2016 has facilitated the sharing of millions of portions of surplus food. The hidden poverty burden is especially acute for services such as OLIO, which help redistribute surplus food. Food waste and food insecurity are pernicious problems at the core of two sustainable development goals. Though often studied separately, if either issue is to be solved, there is an urgent need to understand their relation. Harvey, Smith and Goulding therefore further developed the method pioneered in **[2]** to conduct a massive social network analysis to examine food sharing behaviour at scale **[3]**. The results showed that for OLIO, like other prosocial exchange systems, the majority of users act

either as donors or recipients, and this behavioural split is primarily attributable to socio-economic factors.

The behavioural findings spurred an ongoing research relationship between N/LAB and OLIO to further understand what proportion of people who receive food through prosocial exchange systems are experiencing severe food insecurity and are therefore not adequately captured by existing national deprivation measures. Due to the massive size of OLIO's user base this question required the development of novel computational social science methods combining both network analysis and machine learning techniques. This necessity lead to Harvey and N/LAB partnering with OLIO to successfully apply for an Innovate UK-funded Knowledge Transfer Partnership in 2019 **[G1]**. Through an embedded KTP associate, N/LAB used machine learning on network data to develop a novel approach to model, predict, and visualise food insecurity across the UK **[4, 5]**. This is unprecedented for an area of social research that normally relies upon expensive and time-consuming surveys with small samples. Furthermore, the research approach provides unrivalled insights when compared with standard existing measures such as the Index of Multiple Deprivation, which is only released every few years and does not include a specific measure of food insecurity.

3. References to the research

1. Harvey, J.; **Smith, A.**; Golightly, D. (2014), "Giving and sharing in the computer-mediated economy", *Journal of Consumer Behaviour* https://doi.org/10.1002/cb.1499
2. **Harvey, J., Smith, A.**, Golightly, D., **Goulding, J.** and Gallage, S., (2020) Prosocial exchange systems: Nonreciprocal giving, lending, and skill-sharing, *Computers in Human Behaviour* https://doi.org/10.1016/j.chb.2020.106268
3. **Harvey, J., Smith, A., Goulding, J.** and Illodo, I.B., (2020) Food sharing, redistribution, and waste reduction via mobile applications: A social network analysis. *Industrial Marketing Management*. https://doi.org/10.1016/j.indmarman.2019.02.019
4. **Nica-Avram, G., Harvey, J., Goulding, J., Smith, A., Smith, G.** (2020) Identifying food insecurity in food sharing networks through machine learning, *Journal of Business Research* https://doi.org/10.1016/j.jbusres.2020.09.028
5. **Nica-Avram, G., Harvey, J., Goulding, J., Lucas, B., Smith, A., Smith, G.** and **Perrat, B.**, 2020, April. FIMS: Identifying, Predicting and Visualising Food Insecurity. In *Companion Proceedings of the Web Conference 2020* (pp. 190-193). https://doi.org/10.1145/3366424.3383538

Funding that facilitated the research:

Funding body	*Investigators*	*Title*	*Dates*	*Amount*
G1. Innovate UK	**Harvey, J., Goulding, J., Smith, A., Smith, G.**	Knowledge Transfer Partnership Funding in partnership with OLIO	2019-2021	GBP169,077
G2. EPSRC	**Smith., A. Goulding, J.** Meng, X, et al.	Neo-demographics: Opening Developing World Markets by Using Personal Data and Collaboration	2014-2016	GBP612,744
G3. EPSRC	McAuley, D., **Goulding, J. Smith, A.** et al.	From Human Data to Personal Experience	2015-2021	GBP4,062,954
G4. ESRC	**Harvey, J., Goulding, J.**	'Modelling Food Poverty across the UK from Food-Sharing Network data'	Sept 2018 & Feb 2019	GBP9987
			Approx. TOTAL:	GBP4,856,000

4. Details of the impact

Since 2018, Harvey and colleagues from Nottingham University Business School, through a Knowledge Transfer Partnership (KTP) have collaborated with OLIO to share knowledge surrounding food redistribution, food insecurity and how to best use and understand the data, which OLIO collects from its users **[G1]**. OLIO is a mobile and web-based service that helps people share food surpluses and reduce waste. It is the largest application of its kind in the world. OLIO summarise that they intend to 'help create a world in which nothing of value goes to waste, and every single person has enough to eat – without destroying our planet in the process' **[B].**

OLIO's registered users generate an enormous amount of data which can be interpreted to understand how and why people redistribute food through the app. This work has informed the way that Olio operates. OLIO state that 'Harvey and the N/LAB team [have] significantly helped OLIO to understand the data we collect from our users and how to best interpret it. Specifically, Harvey's research on reciprocity helped enable us to understand how people use our app. For example, we discovered that 15% of our users both donated and received food items. The remaining 85% only engaged in one mode of behaviour. This new understanding helped inform strategic decisions regarding the direction of OLIO and contributed to key decisions regarding how to best use data to ensure a viable business model, without negatively affecting our most vulnerable users' **[B].**

Informing OLIO's strategy to protect vulnerable users

OLIO is still in the early stages of monetisation and is cautious about charging users that may be vulnerable to food insecurity. OLIO is currently developing a freemium model of revenue generation designed so that the application can remain free whilst also offering a core group of users premium features at a cost. The initial market segmentation research produced by N/LAB demonstrated unequivocally that there is a behavioural split between users on the platform who tend to act primarily as donors or recipients. A social network analysis quantified reciprocity on the platform and provided OLIO with behavioural insights of peer-peer food sharing at scale **[1, 2, 3]**. This behavioural segmentation provided the initial managerial insight necessary to recognise that the platform is inadvertently carrying some of the hidden hunger burden in the UK and demonstrated that OLIO's data had the ability to map and highlight food insecurity.

OLIO faces a continual problem of user classification in terms of identifying those users who can act as a source of revenue, and those who are unsuitable to charge given their exposure to food insecurity. Therefore, the company began to examine other sources of revenue, which made use of their valuable data and Harvey's research, which demonstrated how to best understand and interpret it. To be more specific, food insecurity is hard to identify using traditional demographic approaches as poorer users can be in the same postcode as affluent users, which renders orthodox geo-demographic techniques inappropriate.

In response to the challenge of identifying food insecure OLIO users, Harvey and the research team developed an entirely new method of food insecurity prediction using machine learning on behavioural network data. This work **[4, 5],** which summarises firstly, the machine learning approach used and secondly, the development of a first-of-its-kind food insecurity prediction digital map for the UK (as shown in Figure 1) is now deployed by OLIO in practice. The approach provides a mechanism to help protect the welfare of vulnerable users. The aggregated anonymised results are now used by OLIO to study food insecurity in real-time across the UK and offer support to those most at risk. As OLIO's marketing manager notes:

"N/LAB's machine learning approach to modelling food insecurity has been fundamental to our understanding of the problem and ensuring the social welfare of our users. For example, in the UK alone, as of April 2020, 8% of a sample of 93k transactional users in the UK were identified as food insecure...The research has enhanced our ability to support food insecurity alleviation." **[B]**

Preventing food waste and building relationships with external partners

Furthermore, Harvey's research **[3]** enabled OLIO to better understand user behaviour on the platform and inform a strategy of engaging with 'external partners such as supermarkets who could share surplus food with our users and therefore prevent food waste. For example, we have now partnered with Tesco across the UK to redistribute directly from stores' **[B]**.

Tesco state that this partnership aims 'to help reduce food waste in stores across the UK' and that a successful six-month trial in 2020 at 250 Tesco stores resulted in nearly 195,000 portions of food being saved, nearly 4,200 people being fed and the equivalent of 93,000 meals being saved' **[F]**. Therefore, Harvey's research helped inform OLIO's ongoing business strategy and their commercial partnerships which led to a prevention of food waste in 2020. OLIO notes that this provided 'enormous social and environmental value' **[B]**.

Informing OLIO's business model and monetisation

According to OLIO, Harvey's research and the subsequent analysis and understanding of OLIO's data encouraged the organisation to 'begin seeking new funding streams to ensure we could keep providing OLIO's service to vulnerable users without having to charge them' **[B]**. As the Covid-19 pandemic took hold in 2020, the UK's food system endured sharp and profound supply and demand shocks. These shocks exacerbated food insecurity as panic buying, social distancing, and furlough schemes all created challenges for the emergency food assistance services. It quickly became apparent that OLIO's ability to estimate the prevalence of food insecurity across the UK could be of enormous value to policymakers dealing with the economic consequences of the virus. This situation presented an opportunity to develop the food insecurity prediction approach as a commercial data product, and support income generation for the organisation without charging those most at risk. The approach developed by N/LAB was therefore leveraged by OLIO to secure income, develop the service, and support the financial longevity of the organisation.

"N/LAB's research was integral to helping ensure OLIO's long-term viability through our recent funding success from Innovate UK's 'The Sustainable Innovation Fund: SBRI phase 1' worth approximately £47,000." **[B]**

Informing policy surrounding food insecurity

In 2020, the machine learning approach to predicting food insecurity caught the attention of policymakers too and OLIO were asked to contribute to food insecurity policy debates by the Mayor of London's team. OLIO's CEO participated in a London Assembly policy debate on food insecurity and introduced N/LAB's approach **[4,5]** which is transcribed as follows.

"What I have heard you saying is that currently there is not enough data and when there is, it is done by a survey which is a one-off, it is expensive and it is a single point in time. Perhaps there is some stigma also. …. We recently partnered with Nottingham University and have built a highly predictive model that is able to demonstrate food poverty down at a local ward level over time for the whole of the UK but also specifically for London. We could contribute this data to help solve the measurement challenge … I know the Mayor of London had a survey of about 6,000 people. We have a data set which is over 55,000 people, which is available real-time and which has none of the expenses of a survey and is based on people's behaviour rather than what they are putting their hand up and saying … The other point I would say as well is that our data is showing that the correlation between food poverty and overall deprivation is 0.4, so there is some correlation but it is not an exact correlation. That, for me, reinforces the fact that we need specific measures for food poverty, because it is a very unique thing."

OLIO CEO speaking at London Assembly public policy debate on Food Insecurity **[C]**

The outcome of this policy debate led to firstly, a recognition of the need for distinct food insecurity policy measures from Greater London Authority **[D],** because the prevalence of hunger is not properly accounted for through standard deprivation measures such as the *Index of Multiple Deprivation.* Additionally, the debate led to a change in policy direction for London local councils such as Havering Borough **[E]** who have now actively partnered with N/LAB and OLIO to implement localised food insecurity prevalence maps which are now being practically used for emergency food assistance intervention planning **[Figure 1].**

The pandemic demonstrated the fragility of food access for millions of people in the UK and highlighted the urgent need for robust policy of food insecurity measurement at scale. As the Principal Social Policy Analyst at Greater London Authority suggests:

"We are highly supportive of N/LAB's work, as it helps to confirm the policy need for food insecurity measurement in the country and supplements previous work done by the GLA on this issue… We know that there are disadvantages in using survey methods to assess food security, social desirability biases being one, as well as in using proxies like the existing Index of Multiple Deprivation, which is updated only very infrequently, so we welcome innovative methods that use behavioural and/or real-time data to provide other views of how many Londoners are affected by food insecurity, especially since the onset of the coronavirus pandemic." **[D]**

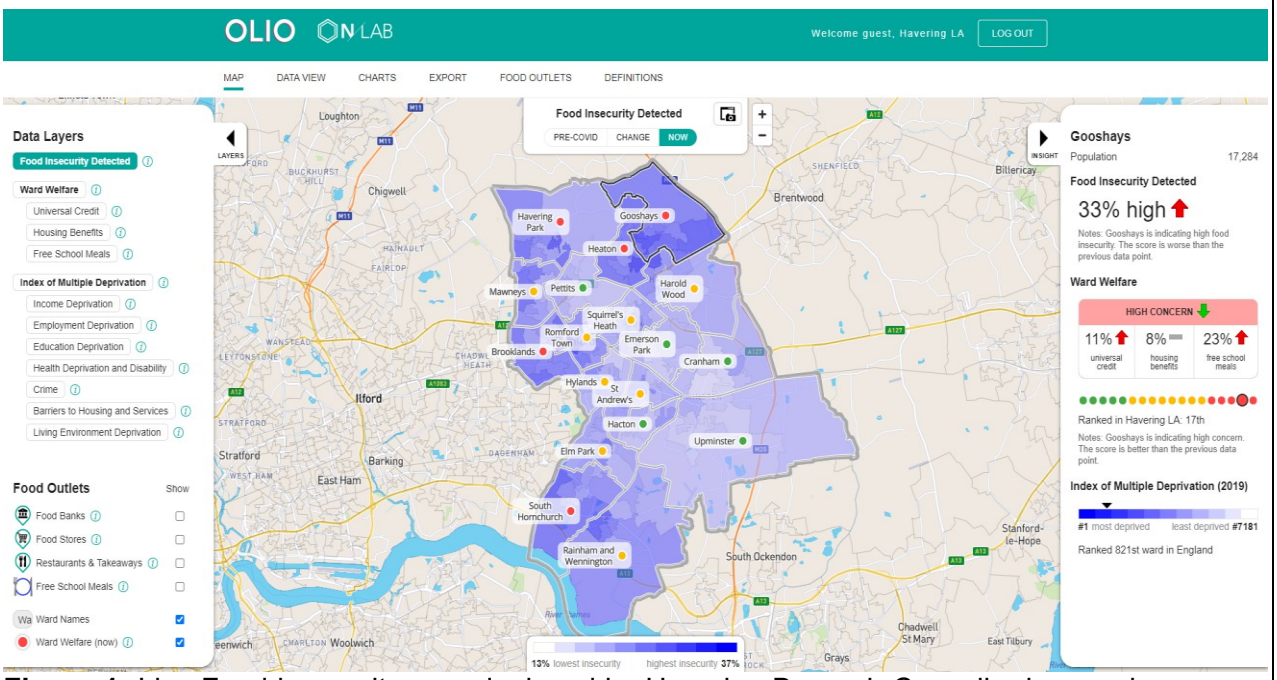

Figure 1: Live Food insecurity map deployed by Havering Borough Council – image shows pre- and post-Covid-19 food insecurity prevalence estimates at ward level, identifying areas at greatest risk. Live demonstration of the map in action can be accessed via https://foodinsecuritymap.uk/

Sources to corroborate the impact

A. KTN webpage: https://ktn-uk.co.uk/news/knowledge-transfer-partnership-helps-the-worlds-only-neighbour-to-neighbour-food-sharing-app-olio-reduce-food-waste

B. Testimonial from OLIO's Marketing Manager

C. London Assembly Economy Committee – 12 February 2020: Transcript of Item 5 - Food Insecurity

D. Letter of support from Principal Social Policy Analyst (Greater London Authority)

E. Letter of support from Transformation Programme Manager (Havering Borough Council)

F. Tesco PLC announcement via webpage (17 September 2020)