Revealing Flows in the Local Economy through Visualisations: Customers, [Clicks/Cliques] and Clusters

Mark Lochrie, Jon Whittle, Bran Knowles
School of Computing and Communications
Lancaster University
Lancaster, LA1 4WA
{m.lochrie, j.h.whittle, b.h.knowles}@lancaster.ac.uk

Jonny Huck, Paul Coulton
Imagination Lancaster
LICA Building, Lancaster University
Lancaster, LA1 4YW
{j.huck2, p.coulton}@ lancaster.ac.uk

Mike Hallam
Lancaster Ethical Small Traders Association (ESTA)
Lancaster
mike@ smallgreenconsultancy.co.uk

ABSTRACT

It is well known by now, that the world has suffered an economic downturn. This has led many governments and organisations to invest resources into researching varying strategies to combat such problem. For some time now, governments have been promoting growth by encouraging local spending; we have witnessed this through 'shop local' campaigns and local currencies. We introduce BARTER a moBile sociAl netwoRking supporTing local Ethical tRading system to tackle this issue, at it's core an information system that encompasses technology, social media and business analytics are brought together to engage customers, traders and citizens to spend locally by featuring the intrinsic and extrinsic motivations of trading local. After situating BARTER at the heart of the community (with varying traders in and around Lancaster, UK) for some time, this paper is a follow on from a "BARTER Visualisations" design concept, reporting on the progression and recent developments in the project. Whilst these systems are in place within the community, further research is being conducted to evaluate if revealing and transforming transaction data in a playful and informative manner will help citizens better understand the flow of money in the local economy.

Categories and Subject Descriptors

H.5.m [Information Interfaces and Presentation]: Miscellaneous

General Terms
Design

Keywords

Visualisations, information systems, revealing flow, geography, game design, nature

1. INTRODUCTION
The BARTER project was conceived to seek an alternative way to overcome the issues of struggling local economies [1, 11]. One of the motivating factors of encouraging local spending was to combat the number of high street stores from closing down (in some areas of the UK this is as high as 20% vacant [2]). Instead of introducing a new local currency or Local Economic Transfer systems (LETS) [3, 8], the BARTER system sits on top of existing currencies (in this case: pound sterling) adding extra data to the money we use everyday. If we look at what money is, we can derive that at its most basic it is an information system [8], it has a value and serves a purpose. However, what it doesn't know is where it has come from and when. The basic idea is simple, the longer the money stays within the local economy the greater opportunity to increase the wealth of that economy. In this sense, BARTER is unlike many personal reward schemes (another way local businesses typically try to improve local spending), instead of presenting the benefits of local spending for the individual, BARTER presents spending information in terms of the benefits to the wider community. It is hoped this focus will produce a greater sense of community within the traders as they see the benefits of locally inter-trading.

2. BACKGROUND
The initial research on this project concentrated on obtaining transaction data, obtained through bespoke NFC cards and integrated mobile terminals setup in local businesses in and around Lancaster, UK [8]. This enables citizens to participate in the scheme through the use of personal cards handed over at the time of purchase and through which the local businesses can offer their own reward schemes. So in essence, the BARTER system records extra information to allow transparency between both parties to share and reveal the transaction data. The system is underpinned by a simple concept: if we can record the money coming in to businesses from the local community (through both business-to-business and business-to-customer transactions), we can reveal information about the money flow within a community [4].

The premise of BARTER is to help visualise the benefits of inter trading between local businesses, in that it can show how the money a business spends within the system may ultimately be 'recycled' back to them through other traders within the BARTER community. The data collected using the system enables BARTER visualisations to be formed, as the recording

of transactions permits others outside the direct transaction to view the connection, it also allows for a wider connection of micro networks (made up of chains, loops that are incomplete). Whilst such information might be readily available for direct business to business trading, when there are multiple businesses involved it becomes a much more complex system, especially as our aim is to reveal this information in real time as transactions happen. For example, if two traders spend with one another they both have a rough understanding of who spent what, when and by who. However, if a third trader enters the mix and money passes through him/her back to the original trader, there is not a clear understanding of where the money has travelled, all the information of each transactions is unknown to all parties involved (for instance only trader 1 knows they spent with trader 2 and that trader 3 spent with trader 1).

To better understand how revealing such information helps the citizens of BARTER realise the potential of spending locally, visualisations of the captured data have been designed to depict which traders inter-trade, where money is being spent and how the flow of money affects the local community. First it is important to understand the terminology used within this paper:

- Loops – a loop is formed when 3 or more traders have inter-traded and money has made its way back to the original trader.

- Chains – a chain is basically a loop, which hasn't found its way back to the original trader.

- Recycled Money – this is money that has gone through the loop and been extracted from each node, leaving the remaining monies still in the system ready for new loops. It is easier to think of loops as pipes. If we think of the transaction values being pipe diameter, only a certain amount of water can pass throughout the system, this is 'Recycled Money'.

3. UNDERSTANDING THE SYSTEM

The system is built around web and mobile technologies with a centralised MySQL database serving all users of BARTER. The primary purpose of the database is to store and provide data on the traders, customers and transactions, permitting for real time retrieval of this data. Furthermore, the database has been extended to incorporate the ability to automatically detect chains and loops, and store the routes that they comprise. When a chain is created the route that it has taken is recorded and only when the starting trader of the chain receives a transactions from anyone in that chain a loop is finalised and calculated. This loop then is frozen and cannot be updated or removed.

For instance, when a trader spends with another trader, they use their BARTER cards like any other customer however, the system identifies the cardholder as a trader and that the transaction happening is business to business. At this point as two traders have been involved in a transaction a one-way chain has been completed. Only when the previous selling trader spends with a different trader the chain is appended with new transaction data. Currently, in this example we have a "chain", only when a trader from within the chain spends with the trader who started the chain, a loop can be formed.

To achieves this a BARTER economy state machine is required which effectively holds the current amount of spend between all the traders in the system to track. The state of this machine

changes with each new transaction within the local economy. Further as each transaction occurs the state machine is interrogated to evaluate if any trading loops have been completed and if money has effectively been recycled. One of the key features of a trading loop is that they manifest intrinsic and extrinsic benefits simultaneously. This is performed using a 'breadth-first search' procedure, which runs until either a closed recycle loop is found or the depth of the search reaches the number of traders within the system. To provide a better understanding of this procedure consider Figure 1, which illustrates the particular state of the 'state machine' after a series of transactions, subsequently forming a trading loop. Note that while every transaction represents an amount, date, time and who spent with whom, these diagrams represents the state of the economy after each transaction and is thus not directly driven by time. Additionally, we have not chosen a specific currency unit to make the example applicable to a wider variety of contexts.
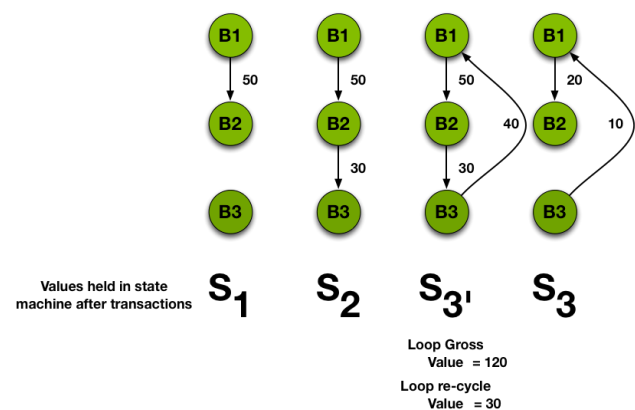

Figure 2. State machine depicting the flow of money between three traders. Forming chains and loops within the local economy.

In Figure 1, if we consider three businesses represented as B1, B2, and B3. In the first transaction B1 spends 50 with B2 at the end of which the 'state machine' is in state S1. In the second transaction B2 spends 30 with B3. At this point there is a chain between B1 and B3 through B2, which offers the opportunity for loop to be formed. In the third transaction B3 spends 40 with B1 which we have represented at an intermediate point of S3'. At this point the loop can be considered to have a gross value of 120 with a recycle value for B1 of 30 showing the benefit of being part of inter-trading to the individual trader but also the wider community. The state of the machine is shown as point S3 in which the recycled money has been subtracted from each node edge leaving B1 > B2 with 20, B3 > B1 at 10, and the chain is now broken between B2 and B3. From this state new chains and loops can be formed based on new transactions and the net money continues to be stored within the local economy.

4. BARTER VISUALISATIONS

4.1 BARTER Loops & Flowers
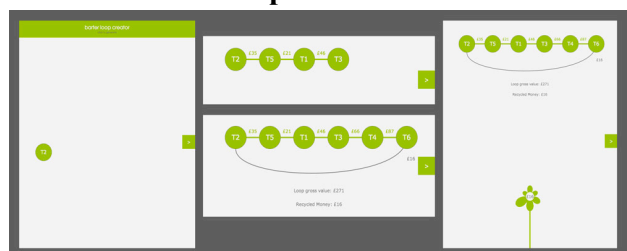
Figure 1. Screenshots taken from the BARTER random loop creator – generating random loops for demo purposes.

In order for the BARTER community to truly understand what data is captured and what it's impact is within the local economy, we drew inspiration from game design, nature and geography to provide visualisations that represent the rhetoric of this approach [6]. The visualisations will subsequently be utilised with the community to better understand if those using the system truly understand the value of spending locally.

It is however, first important to understand if the citizens realise the effectiveness of spending locally and revealing the flow within the community, which actually helps them, better understand. A tool to demonstrate this was developed into a procedural interactive information visualisation. Figure 2 represents snapshots taking from the tool, walking the user through the stages of loop creation. In the first instance the user must click to randomly create a "loop". The system then creates a random loop consisting of a random number of traders within the loop containing random transaction values. The user can then proceed by clicking the arrowed icon to reveal the next part of the chain, leading all the way to when the chain becomes a loop. The tool also demonstrates the amount of recycled money within the loop depicted by the grey line between two nodes. Recycled money can happen anywhere within the loop. It just so happens in the example above it is the last chain where the money is recycled throughout the system.

In order to make spending data and loops understandable to a wider demographic the BARTER flower was conceived. The flower has been inspired by nature; we drew upon the rhetoric of growth of the local economy using the metaphor of flowers. A flower consists of a stem connected to the earth (this would be our local economy), each flower contains petals, and these petals form the basis of our inter-connected traders/transactions. A BARTER 'flower' is generated by completed loops, each flower representing one loop and every petal representing a business in the loop and its contribution to that loop. The larger the petal the greater the transaction value and finally the value printed in the middle is the amount of money that has been recycled within the loop (Figure 3). As a collective these flowers give members of the BARTER community a broad view of the entire system allowing them to visualise inter-trading within the local economy by observing how flowers 'pop up' and fade away over time. Additionally, as each flower contains all the information about the traders and transactions from within the loop, the contents can be further interrogated. This is used to provide extra information to the user such as a greater depth of information about such loop and also real-time alerts sent to individuals who are found within the loop.
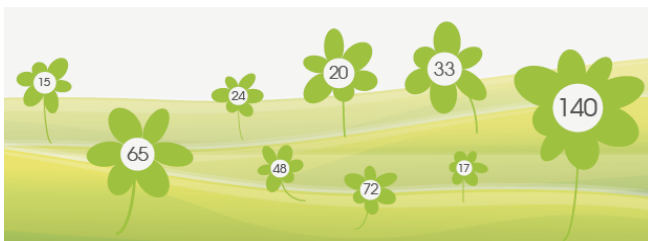
Figure 3. Wider community visualisation of the BARTER loops are represented as 'flowers'

4.2 OD Maps for BARTER Trades

Aside from revealing loops, chains and recycled money within the data, BARTER also permits investigation into the spatial patterns arising from inter-business trades. Such information could be revealed by these visualisations providing invaluable understanding of the dynamics within a local economy, and so to any management strategies relating to its development. Given the large amount and complex nature of data that is expected to be collected from BARTER over time, an effective spatial visualisation requires careful aggregation and presentation in order to reveal patterns in the flow of money in a legible manner. The chosen approach is the 'Origin-Destination (OD) Map' [12], which is a form of spatially ordered treemap that is designed to map flows of given phenomena (in this case money) through geographic space, whilst avoiding many of the issues of clarity that are traditionally associated with such flow maps.

As described by Wood [12], an OD map is constructed by the division of geographic space into a grid, permitting the representation of a flow by two cells – the origin cell and the destination cell. By nesting the destination grid cells within the origin grid cells (so that each cell contains a grid identical to the one of which it is a part), both of these locations may be displayed within a single 2D matrix whilst preserving both the spatial relationships and the flow relationships between the cells [12].

Typically, OD Maps, as with other forms of spatially ordered treemap and OD matrices, will rely upon the generalisation of existing administrative boundaries for the formation of a grid (e.g. a map of the UK divided into counties, whereby each county is represented by one cell in the grid). Such an approach may, however, fall foul of 'cartogram effect', whereby smaller (generally urban) administrative areas are under-represented in comparison to larger areas (generally rural) areas. The latter issue in particular would have a negative impact on this work, as it would be expected that the bulk of trade within an economy would typically take place in more urban areas. As such, this work will follow the solution proposed by [10], and divide the study area into a regular grid of __km^2. Whilst this approach reduces the information carrying capacity of the cells (by fixing their size), removed reliance upon arbitrary administrative areas and also gives a more spatially consistent layout than other approaches, permitting the visualisation to be more effectively overlain onto a base-map.

As BARTER is still a work in progress, and sufficient 'real' data has yet to be collected through the BARTER project to fully illustrate the benefits of a visualisation such as this, a spatially weighted pseudorandom number generator (PrNG) was created in order to generate a sample dataset with an inherent spatial pattern. In this way, an illustrative dataset has been created in which directional patterns are evident, allowing the effective demonstration of the below visualisations. For the purpose of illustration, the resulting visualisation is shown in Figure 4.

The sample data Figure 4 demonstrates the flow of money from origin (the outer cells) to their destination (the nested cells). This shows that money in the BARTER system is generally flowing towards the city of Lancaster from all areas of the study area (as evidenced by the dark patch of nested cells in the upper left of centre of each outer cell), and that there is more activity in and around the city itself than in the peripheral areas (as evidenced by the greater number of darker nested cells per outer cell closer to the city centre}.

Obvious patterns have been induced here using the spatially-weighted PrNG in order to make this illustrative figure useful as

a demonstrative OD map [9] with the visualisation of the flows of money through a local economy. When based upon real data, however, this visualisation will provide the user with a simple and legible illustration of how money is moving spatially through the BARTER economy.
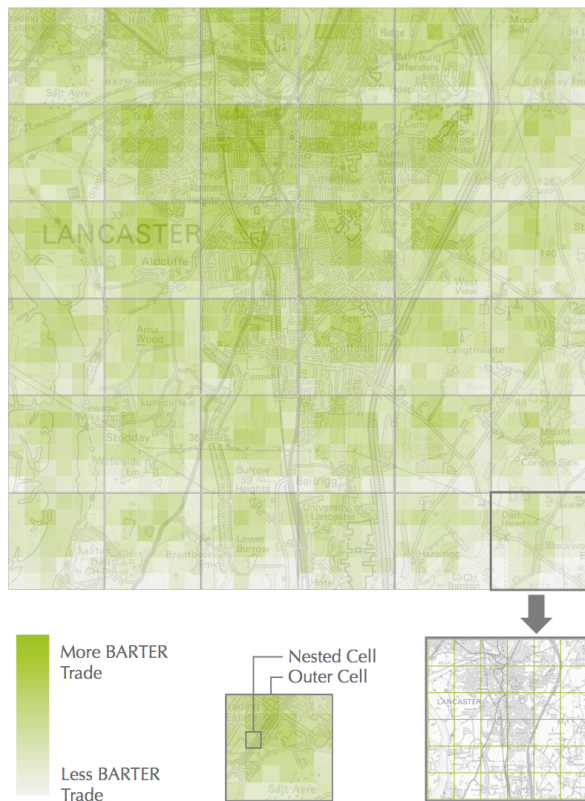
Figure 4. An illustrative OD map of spatially-weighted random BARTER trades around Lancaster, UK.

Such a visualisation could be used to identify those areas that are attracting money effectively within the local economy, and those that are not; which is valuable information that may not be obvious from traditional data sources (which would likely be skewed by the effect of non-local traders within the wider economy). Such patterns may then be exploited by councils or local trade associations in order to boost local economies with spatially targeted action plans, such as the adjustment of business rates in certain areas; as well as allowing lessons to be learned from those areas that are doing well, but which would not normally be expected to, such as an outlying farm shop that attracts more business than would be expected.

5. FURTHER WORK & CONCLUSIONS

This paper presents the design and recent developments of an alternative method in promoting growth through encouraging local spend by revealing hidden transaction data. Due to the nature of displaying transaction information being considered in its raw form somewhat meaningless, varied playful visualisations have been developed to secure better understanding of the nature of trading within a local economy, through the exploration of both, the formation of trading loops, and spatial patterns in the trades that comprise them.

Although in their current states (beta) the visualisations have been developed with the traders and customers in mind, they have yet to be released in the BARTER system. This is due to a concurrent study-taking place that is evaluating the validity amongst the community to investigate whether trading loops and visualisations depicting the flow of money better helps citizens understand what is happening in their local economy.

6. ACKNOWLEDGMENTS

7. REFERENCES

[1] American Express, Small Business Saturday UK: encouraging consumers to think small. The Guardian [//theguardian.com/small-business-network/2013/nov/30/small-business-saturday-consumers-uk] (30 Nov 2013).

[2] BBC. High street vacancies still stubbornly high, says report. BBC News Business [//bbc.co.uk/news/business-24025297] (10 Sept 2013).

[3] Brixton Pound [//brixtonpound.org/] (05 Aug 2014).

[4] Gradinar, A, Coulton, P, Lochrie, M, Knowles, B, Whittle, J & Hallam, M 2013, 'Designing a mobile service as a facilitator for capturing local trade data'. in AcademicMindTrek '13 Tampere, Finland, 1-3 October.

[5] Kelly, M., Slingsby, A., Dykes, J. & Wood, J. (2013). Historical Internal Migration in Ireland. Paper presented at the GIS Research UK (GISRUK), Apr 2013, Liverpool, UK.

[6] Knowles, B, Coulton, P, Lochrie, M & Whittle, J 2014, 'Wicked persuasion: a designerly approach'. Persuasive Technology: 9th International Conference.

[7] Knowles, B., Lochrie, M., Coulton, P., and Whittle. J., 2014. BARTER: promoting local spending behavior. In Proceedings of the extended abstracts CHI EA '14. ACM.

[8] Knowles, B, Lochrie, M, Coulton, P & Whittle, J 2014, 'BARTER: a technological strategy for local wealth generation' IEEE IT Professional, vol 16, no. 3, pp. 28-34., 10.1109/MITP.2014.27.

[9] Shneiderman, B., (1991) Tree visualization with Tree-maps: A 2-d space-filling ap- proach, ACM Transactions on Graphics, 11, 92–99.URL http://dx.doi.org/10.1145/102377.115768

[10] Slingsby, A., Dykes, J., & Wood, J. (2009). Configuring hierarchical layouts to address research questions. *Visualization and Computer Graphics, IEEE Transactions on*, *15*(6), 977-984.

[11] Spennymoor – Shop Local campaign. Facebook Page [//facebook.com/pages/Shop-Local-Spennymoor/325492404188891] (05 Aug 2014).

[12] Wood, J., Dykes, J., & Slingsby, A. (2010). Visualisation of origins, destinations and flows with OD maps. *The Cartographic Journal*, *47*(2), 117-129.