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Spreading information and developing trust in social networks to accelerate diffusion of innovations

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ABSTRACT

Background: New food technologies developed by producers who want to spread their innovation require potential new adopters to receive information about the innovation as well as to develop trust about the appropriateness and quality of the new technology. Social networks are key for spreading information and for developing trust. In this essay, I will summarize sociological knowledge about how the structure of social networks can accelerate or inhibit innovation diffusion among consumers.

Scope and approach: Innovation adoption is mostly a multistage process in which potential adopters/consumers need to obtain information first. A second step towards adoption is developing appreciation for the advantages of the innovation. A third step is the development of trust that the new product or technology indeed brings the advantages that it promises. I will explain based on existing literature why and in what manner, different structural properties of social networks are crucial for the consumer side of the adoption process.

Key findings and conclusions: While for information diffusion predominantly the number of channels through which information can flow is important, and prevention of redundant information transfers helps to speed up information, the appreciation for the advantages of the innovation will require some redundancy and recurrent confirmation of the success of the innovation. To develop trust, even more confirmation is likely to be important and close social circles in which people repeatedly meet and know each other's acquaintances are known to be especially beneficial to create trust.

1. Introduction

For the introduction and diffusion of many technological developments, the role of the social dimension is often neglected or at least understudied. After producers have developed certain promising innovations, consumers need to be convinced to adopt these innovations. To spread new technologies and certainly technologies related to products that are so close to the human needs as good, healthy and trustworthy food, one cannot neglect the social and psychological barriers for consumers to accept new technologies. It is important to understand how people learn about and decide to accept and embrace a specific new technology. And it would be too easy to expect that standard diffusion models, which are useful but often neglect specific elements as networks in which people operate, would suffice to understand all diffusion processes and that such models can be straightforwardly applied to promote any new technological innovation. While Rogers (Rogers, 2003) dedicates a chapter to the role of networks in diffusion processes in his standard work, this essay elaborates in various ways on this. I will focus on showing why the role of networks can crucially depend on properties of the innovation.

Specific structural features of social networks play a key role in diffusion processes. And how these structural features play a role varies with the type of a diffusion process considered. In this essay, I distinguish three types that often represent different stages for accepting a new technology: information, appreciation and trust. These stages represent that people first need to be informed about a certain new technology or product, then they need to be convinced that the new technology or product can be an improvement over existing options, and finally they need to trust the supplier or producer that the product indeed does what it promises to do. Below I will illustrate some theoretical and empirical work showing that networks work differently depending on each of these three stages of the diffusion process.

But before we can start to understand how networks exactly work, it is important to realize how networks actually look like and then I refer here specifically to human interaction networks. Many theories and models that largely neglect the specific structure of networks assume that any two people interact with some common probability of interaction, which is quite a strong simplification and abstracts away from

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crucial structural features of social networks.

2. Small worlds

Social networks often look like what we call small world networks (Milgram, 1967; Travers & Milgram, 1969; Watts, 2000). One can think about, e.g., a co-author network as Newman (Newman, 2004) illustrated in which the relationships represent co-authorships in scientific articles: most of the relationships are found within disciplines, authors who have joined co-authors might also become more likely co-authors themselves creating clusters of co-authors. Less commonly, there are co-authorships between disciplines. Therefore, the networks are relatively dense and clustered within disciplines, while they are sparse between disciplines. Still, there are enough relations between disciplines such that each discipline can reach another discipline in a few steps, creating a small world indeed.

Similarly, people have most ties within their own social circles and people who have friends in common are more likely to become friends as well, while there are only incidental relationships with people more at a distance (socially or geographically). Still, Milgram (Milgram, 1967) showed with an inventive experiment already in the 60s that these networks have the feature that any two people in the United States can be connected by a rather low number of relations. He showed that in the US an arbitrary person could send a package to another unknown person by sending the package to an acquaintance and this acquaintance to an acquaintance of that person and so on. On average the package reached the target person in about six steps, which became known as the "six degrees of separation" (see also Barabási, 2002; Watts, 2003). This is where the term small-world networks comes from. Every person is connected in relatively few steps to every other person. Watts and Strogatz (Watts & Strogatz, 1998) showed later that adding only a few long-ranging relations to a network in which people only have local relationships creates such a small-world network in which local clustering is very strong, while distances are small.

3. Information diffusion in networks

Given that we can expect small-world networks and thus that social networks are rather far from a random interaction pattern, what does this imply for the possibility to spread new technologies and products among consumers? To answer this question, it is important to dive deeper into how network structure accelerates or inhibits the diffusion process. I start with insights on straightforward information diffusion: which network features facilitate information diffusion. Together with Kazuo Yamaguchi (Buskens & Yamaguchi, 1999), I developed a model for information diffusion resembling existing models such as models related to social influence (Friedkin & Johnson, 1990) and epidemiological models in which it is not information, but a disease that spreads (Kretzschmar & Morris, 1996; Morris, 1993). Although already various related models existed, most models either neglected specific complexities in the network structure (the references above were the exceptions) or considered the diffusion of information more as a package that travels through a network (cf. Yamaguchi, 1994). This obscured the crucial feature of information that it accumulates in more and more people in the network.

Every network relation creates the possibility that people exchange information and as soon as you have received the information, you have a probability yourself that you pass it along. And in each subsequent period, you can again pass it on to other people. We show in addition to the obvious that with more relations information spreads faster, also that clustering hinders fast information spread and incidental connections between dense clusters inhibit information spread (holding constant the amount of relations in the network). This implies that small-world networks are not optimal for information spread because both unattractive features are rather common in small-world networks. This implies that, e.g., in an information diffusion strategy, if one wants to inform a population about a new product, it is important to reach different clusters that are not so well connected in the first place. In that way, the information diffusion process becomes less dependent on the incidental bridges between different clusters that hinder fast information diffusion. More in general one would like to know, giving the network structure, which are the most influential nodes that can be targeted first to spread the information most quickly, but exactly determining the most influential nodes in large networks is a hard computational problem and many subsequent models have been working on finding efficient algorithms to find such influential nodes (see, e.g., Kimura & Saito, 2006).

As a side-note and to related this to prominent sociological theories in general: there are some well-known theories about "weak ties" (Granovetter, 1973) and "structural holes" (Burt, 1992) claiming that people who are on the bridges between clusters have information advantages over people that have only relations within clusters, because they will not only know sooner information from their own cluster but also from other clusters. There is indeed considerable empirical evidence that these network position can help the people at these positions: they make faster promotions, they find better jobs etc. But note that this does not imply that information spread is in general through these networks better than in networks in which the clusters are connected to each other through more relations. The individual advantages do not translate to advantages for the network as a whole per se.

4. Appreciation diffusion in networks

This brings me to the second aspect that is important for new technology to be diffused in a

Population: people do not only need information about the technology, but they also need to become convinced that the technology is worthwhile and appreciate that it is an improvement over the existing situation. Damon Centola and Michal Macy (Centola & Macy, 2007; see also Centola, 2010, 2018) have initially set up the theoretical argumentation that especially for technologies for which people feel uncertain about the improvement, they do not need to hear this only once, but they need to get reconfirmed by different people before they take the step to innovate themselves. The most important insight from this was that optimal network characteristics for information diffusion are different from optimal network characteristics for what I call here appreciation diffusion. This is what they call complex contagion. For appreciation diffusion, there needs to be some clustering in the network (which is not needed for information diffusion), because otherwise diffusion will quickly stop since no reconfirmation is established. In addition, for complex contagion, multiple connections between different clusters are even more crucial than for simple information diffusion, because if only one person can inform a new cluster, the connected person in the new cluster will not become convinced and will not spread the technology further into the cluster. Thus, for diffusion of appreciation, it is even more important to ensure that the necessary information to start adopting reaches different clusters and that not only one person, but multiple persons within a cluster who are themselves not too distant in the network are convinced that the new technology is an improvement. Guilbeault, Becker, and Centola (Guilbeault et al., 2018) reviewed recently the complex contagion evidence of the last decade showing the predictive power of the idea, but also identifying challenges that lay ahead such as how to account for individual heterogeneities in the extent of reconfirmation different people need to start appreciating a certain behavior or innovation.

One interesting application that also appears in this review is an experimental and modelling study by, among others, the 2019 Nobel prize winners in economics Banerjee and Duflo about adoption of microfinance in India (Banerjee et al., 2013). In the experiment, they study the optimal placement of opinion leaders in the network of a village and the results illustrate that the optimal placement should not only consider the information diffusion process, but also appreciation (or as they call it the endorsement step). They illustrate this based on a combination of network relations that represent information diffusion, but also relations to friends who have already adopted the innovation. So this article does not only relate to complex diffusion, it also corroborates the distinction between the two types of diffusion processes explained so far.

5. Trust in networks

Especially in the case of new food technologies the adoption by people requires a considerable amount of trust in the new product as well as in the producer. Many consumers might be willing to buy more environmentally friendly food if they trust that it is indeed produced in a more environmentally friendly manner, the claims on the label of the product are genuine, and so on. Trust can be generated in networks especially through the possibilities to obtain and spread information about potential good and misbehavior of a supplier of a certain product via trusted others. In my book on social networks and trust (Buskens, 2002), I analyze game-theoretic models on trust in networks and show that especially density of the network and clustering help to generate trust within clusters.

Also through a variety of empirical studies, we confirm that especially the reception of positive information through trusted third parties induces trust. In a review article (Buskens & Raub, 2013) we collect experimental as well as field studies, also about buyer-supplier relations and interorganizational networks. And although not all these studies have very detailed information about the structure of networks, there is considerable evidence for the importance of networks to create trust. For example, in online markets positive information from many other buyers can increase trust in suppliers. And while we ignore in the theoretical models also for reasons of parsimony that confirmation of information is crucial, the strong evidence that we have that positive information from own experiences and on top of that positive information from third parties all add up to the extent to which people trust each other (e.g. Barrera & Buskens, 2009; Buskens, Raub, & Van de Veer, 2010) suggests that trust builds up with continuing positive information on a certain partner or product.

While I focus in this paper on the importance of social networks to promote the adoption of new technologies, I do not want to claim that other social science related knowledge is not important for the diffusion of new technologies. Clearly, one should also consider the more psychological elements that play a role, because at the individual level people have likewise hurdles to switch to new technologies. On the other hand, people can be influence by subtle changes, for example, in the presentation of products. I cannot dive into the details of these, but the individual processes have been extensively studied in, e.g., psychology, marketing, and behavioral economics. A recent popular proponent of these theories is related to nudging as popularized by Thaler and Sunstein (Thaler & Sunstein, 2008). They indicate subtle ways to reduce hurdles at the individual level. Still I insist that the potential of these individual strategies can be improved if the network is used in an effective way. While convincing people at the individual level to start using a new product is a challenge in itself, if one succeeds in doing this, networks can help to multiply these effects because people are often more effective to convince their peers to change through social influence than that outsiders are able to do this. And, a fast innovation adoption needs the bandwagon effects that social networks can bring and will not fly on convincing each individual personally.

6. Conclusion

Summarizing, it is crucial for producers of new technologies in general and food technologies in particular to realize the three main lessons from the social network literature on innovation diffusion among consumers. First, social networks play a crucial role in all types of diffusion processes and are therefore key for the successful spread of an innovation. Second, I have shown that the most effective networks depend on what type of diffusion process is most applicable given the stage of the technology and the diffusion. When information diffusion only is sufficient to spread the innovation, trying to reach an as diverse as possible group of people to start the information diffusion in many different places in the network is a reasonable strategy. However, if the new technology requires more convincing and thus the diffusion process is probably more like a complex diffusion process, then initial targets cannot be too dispersed because then they cannot reconfirm each other and the diffusion process can get stuck due to lack of reconfirmation. This becomes even stronger, if a relatively high level of trust is needed: pockets of positive experiences are then important to form an initial basis for the innovation. These pockets can then slowly be extended layer by layer to more people who need to be convinced to trust and adopt the new technology. So it is important in these last cases that one first tries to build up some critical mass in a rather small number of selected areas and give that innovation the opportunity to build up further from these groups. The groups who did already innovate should then have the possibility not only to inform other groups, but also to reconfirm through various channels the beneficial features of the innovation.

Theoretically, this all sounds straightforward, but clearly there are still many challenges in these theories to be addressed. I will mention some examples. I have already discussed the individual level challenges, but clearly individuals are not the same in their tendencies to adopt innovations. Some are much more prone to change than others. If people who adopt quickly are at the more bridging positions in the network, then these bridges are more easily crossed by the innovation than if very reluctant people are at the bridges. Second, measuring networks is a challenge in itself but knowledge on the network is of course crucial to use the network well. Therefore, it would be good if we could establish a limited amount of information about the networks that would be sufficient to apply the network theories for diffusion enhancing interventions. Third, networks are not static and some innovations might even foster relations or put relations under pressure. If you think people should eat vegetarian food, relations with friends who enjoy eating large amounts of meat might come under pressure and changing food habits might therefore lead to different friendship networks that can inhibit the spread of new types of food. Such network dynamics might cause that innovations get stuck into pockets of supporters, if the innovations push away others and causes relationships to break.

Related to this, my advice to use this knowledge for concrete food technology innovation are the following. First, it is for many innovations not obvious beforehand whether the diffusion will just unfold after informing people or whether the appreciation and trust levels need to be build up beforehand for the more complex diffusion processes. Therefore, some investigation on how easily people adopt certain innovations would be useful.

Second, given the crucial position of the social networks, it is necessary to have information about the actual network structure of a target population of an innovation. Determining this structure can be done by measuring the network, e.g., through surveys or observing online interaction structures. Alternatively, one can model where clusters and links between certain clusters might be, based on other data available from the target population that provide information on the likelihoods of existing relations between people with certain characteristics. We recently did a detailed measurement of a small population in a municipality to investigate the network and attitudes towards energy transition related innovations (Ligterink et al., 2019). Clearly such an approach is really intensive and especially useful if one thinks that a specific subpopulation needs a tailor-made approach. Otherwise, it might be sufficient to have estimates about which groups form clusters and which types of people are more likely to be on bridges between clusters.

The information derived from the data collections suggested above should provide insights on how and whom to approach. Clearly, it would be good to add more individual knowledge about which look and feel of a product individuals are more likely to appreciate. Most likely, then different strategies to diffuse information and trying to convince certain people will seem reasonable given uncertainties about the population, network characteristics and appeal of the innovation. Therefore, small scale experimental studies on the effectivities of different diffusion strategies should be done and evaluated to obtain empirical comparisons for the success of the different strategies. These experiments provide insight in the network structure as well as on how difficult the innovation diffuses. Based on the results than more large scale interventions can be developed.

Declaration of competing interest

None.

References

Banerjee, A., Chandrasekhar, A. G., Duflo, E., & Jackson, M. O. (2013). The diffusion of microfinance. *Science, 341*(6144), 1236498.
Barabási, A. L. (2002). *Linked: The new science of networks*. New York: Plume.
Barrera, D., & Buskens, V. (2009). Third-party effects. In K. S. Cook, C. Snijders, V. Buskens, & C. Cheshire (Eds.), *eTrust. Forming relationships in the online world* (pp. 37–72). New York: Russell Sage Foundation.
Burt, R. S. (1992). *Structural holes: The social structure of competition*. Cambridge, MA: Harvard University Press.
Buskens, V. (2002). *Social networks and trust*. Boston: Kluwer.
Buskens, V., & Raub, W. (2013). Rational choice social research on social dilemmas: Embeddedness effects on trust. In R. Wittek, T. A. B. Snijders, & V. Nee (Eds.), *Handbook of rational choice social research* (pp. 113–150). Stanford, CA: Stanford University Press.
Buskens, V., Raub, W., & Van der Veer, J. (2010). Trust in triads: An experimental study. *Social Networks, 32*(4), 301–312.
Buskens, V., & Yamaguchi, K. (1999). A new model for information diffusion in heterogeneous social networks. *Sociological Methodology, 29*(1), 281–325.
Centola, D. (2010). The spread of behavior in an online social network experiment. *Science, 329*(5996), 1194–1197.
Centola, D. (2018). *How behavior spreads: The science of complex contagions*. Princeton, NJ: Princeton University Press.
Centola, D., & Macy, M. (2007). Complex contagions and the weakness of long ties. *American Journal of Sociology, 113*(3), 702–734.
Friedkin, N. E., & Johnsen, E. C. (1990). Social influence and opinions. *Journal of Mathematical Sociology, 15*(3–4), 193–206.
Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology, 78*(6), 1360–1380.
Guilbeault, D., Becker, J., & Centola, D. (2018). Complex contagions: A decade in review. In *Complex spreading phenomena in social systems* (pp. 3–25). Cham: Springer.
Kimura, M., & Saito, K. (2006). Tractable models for information diffusion in social networks. In *European conference on principles of data mining and knowledge discovery* (pp. 259–271). Berlin, Heidelberg: Springer.
Kretzschmar, M., & Morris, M. (1996). Measures of concurrency in networks and the spread of infectious disease. *Mathematical Biosciences, 133*(2), 165–195.
Ligterink, J., Kleijwegt, J., & van de Rijt, A. (2019). De mobiliseerbaarheid van huurflatbewoners voor de energietransitie. *Mens en Maatschappij, 94*(1), 91–115.
Milgram, S. (1967). The small world problem. *Psychology Today, 1*(1), 60–67.
Morris, M. (1993). Epidemiology and social networks: Modeling structured diffusion. *Sociological Methods & Research, 22*(1), 99–126.
Newman, M. E. J. (2004). Coauthorship networks and patterns of scientific collaboration. *Proceedings of the National Academy of Sciences, 101*(suppl 1), 5200–5205.
Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.
Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. Boston: Yale University Press.
Travers, J., & Milgram, S. (1969). An experimental study of the small world problem. *Sociometry, 32*(4), 425–443.
Watts, D. J. (2000). *Small worlds: The dynamics of networks between order and randomness*. Princeton, NJ: Princeton University Press.
Watts, D. J. (2003). *Six degrees: The science of a connected age*. New York: Norton & Company.
Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of 'small-world' networks. *Nature, 393*(6684).
Yamaguchi, K. (1994). The flow of information through social networks: Diagonal-free measures of inefficiency and the structural determinants of inefficiency. *Social Networks, 16*(1), 57–86.