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The Economic Value of Personal Data: An Introduction

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1 Introduction

Three concepts related to information are often confused: the cost of production, the quantity and the value of information. If cost is generally proportional to the amount of information exchanged, there is seldom a direct link between the amount of information and its value. Consider two examples of smart, connected products involving highly sensitive personal data: home automation data and health data. Nest (acquired by Google in January 2014 for $ 3.2 billion) manufactures smart thermostats to control temperature in the different rooms of a home based on environmental parameters such as the number of people in each room. Withings started by selling smart scales but now also sells activity trackers, blood pressure indicators, smart watches, sleep monitors and surveillance cameras. These are information services that produce information through sensors and transmit them via the Internet of Things. The cost of installing these sensors is not very high. The amount of information to be communicated and stored on servers costs more. But none of these quantities is directly related to the value of information. Indeed, a single bit of information indicating with certainty that a fire is about to break out in your home while you are away has a much greater value than the gigabytes of data corresponding to daily variations in the number of people in every part of your home during years. Similarly, a single bit of information indicating with certainty that you are suffering from a rare disease has much more value than the hundreds of gigabytes corresponding to the measurements of your heart rate or the number of your daily steps over several years.

The theory of information in economics experienced a sporadic development in the past five decades since the pioneering work of Jacob Marschak. The difficulty arises from to the early attempts to analyze information as a homogeneous good with a single market value. It is now clear that information is a differentiated economic good.

2 Information: a product unlike any other

If information is an economic good with an exchange value, some of its features are unusual and their combination unique.

2.1 An experience good

We often do not know the value of an information service before having used it. This is illustrated by the paradox of Arrow (1969) on the transfer of new technologies. The buyer of a new technology requires detailed information on what this technology does and how it fits

into the existing production system to determine its value. But if he/she gets these details, he/she does not need to buy it: he/she can develop it him/herself.

2.2 A public good

Information has common features with public goods. Firstly, it is costly to produce, but cheap to reproduce. Secondly, it is both non-rival (the acquisition of information by one person does not prevent another person to acquire it at the same time) and non-excludable (it is difficult to exclude users from its acquisition). This is illustrated by the paradox of Grossman and Stiglitz (1980) on financial markets. If asset prices reflect the information of all investors, according to the efficient market hypothesis, what are the incentives for an investor to spend time and resources to actively search for information?

2.3 Consequence: informational externalities

Information often generate strong externalities. For instance, users of Amazon post recommendations on products that they have purchased that other users can read before making a purchase. Similarly, a user of a smart, connected product can benefit from databases constructed from personal health data of all users to better understand his/her own health status. However, these informational externalities are not always positive. For example, a server containing sensitive personal data can be hacked, which can lead to data loss, identity theft, spam and harassment, or bank fraud.

3 Willingness to pay for an information service

The value of an information service for a decision-maker for depends on several factors: its usefulness, an priori distribution and the initial knowledge, the quality of the information provided. Information intuitively depends on what he/she has to do and what he/she gets in return. Most importantly, information is only useful with an appropriate level of knowledge. Indeed, Withings smart, connected products detect symptoms of a rare disease, but these measures will only have value after consulting a specialist, who diagnose the disease with theses measures.

The value of information is the difference between the value of an activity or action before and after receiving this information, on average. We can determine the maximum price that a buyer is willing to pay for an information service by subtracting in each state of nature, the amount he/she is willing to pay for the service. This amount is obtained by equating the expected utility of the service and the expected utility without using it. For example, the user of Nest smart thermostats can reduce utility costs by optimizing the temperature according to the number of people in each room. The maximum price that he/she is willing to pay is the difference between the energy bills before and after buying smart thermostats.

The value of the information also depends on the quality of the received signal. One can compare the value of two information services of different qualities in two particular cases. First, an information service will have more value if it generates a finer partition than another of the states of nature. For example, a thermostat with a sensor that can distinguish the specific number of persons in a room will have more value than a thermostat with a sensor that can only determine whether there is fewer or more than two people in the room. Second, it is possible to compare the quality of two information services that generate the same partition of states of nature if the first state is a kind of "garbling" of the second. This result

is due to in Blackwell (1953) and was extended by Marschak and Miyasawa (1968). In general, it is very difficult to rank different information services in terms of value. This is where market equilibrium can provide some insights.

4 Equilibrium between the supply and the demand for personal information

The value of information is very heterogeneous. Information is a differentiated economic good, which does not have a unique exchange value. Each decision-maker has preferences on personal information characteristics. This determines the demand for personal information. Each individual shares more or less information by leaving traces on the Internet or by posting personal information on forums, and by contributing to social networks, etc.: he/she is a producer of personal information. By aggregating these individual behaviors, we can determine the supply function of personal information. The market equilibrium results from the equilibrium between supply and demand.

4.1 The supply of personal information

The offer of information depends on socio-economic factors:
- The context and the social norm;
- The factors influencing the contribution economy (warmglow, sense of community, efficacy, altruism, career-concern);
- Behavioral factors;
- The risks associated with negative externalities (identity theft, spam, harassment, bank fraud).

4.2 The demand for personal information

The demand for personal information depends on actions that are often very heterogeneous:
- Targeted advertisements (eg Criteo retargeting technology);
- Matching product and consumer (eg Compass Coffee optimizes each step of coffee processing based on parameters determined by personal preference, using industrial sensors);
- Customized recommendations (these algorithms are well developed at Spotify, Deezer or Netflix);
- Understanding the spread of disease (scientific community, insurers, governments);
- Targeting voters during a campaign (political parties);
- Improving the quality of transport and infrastructure (local authorities);
- etc.

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