Food system challenges

We are all increasingly familiar with the challenges facing the food system and in particular the need to massively increase the amount of food that is available to consumers over the next 20 years. At the moment, UK agriculture is not really doing its bit. Figure 1 compares productivity in the UK with that of some of our European competitors and for all countries in the world. It is evident that we have been falling behind for much of this century.

It is also apparent that our toolbox is becoming rather dated in tackling this challenge. The number of active chemicals and pharmaceuticals available for the control of pests and diseases is reducing rapidly, we are potentially approaching the limits of improving the genetic potential of our crops and livestock through conventional breeding and the size of machines that we currently use for farming practices is having a worrying impact on the soil.

These conventional methods of improving productivity are a bit one dimensional. We see a problem that is caused by a particular pest and produce a chemical that is effective against it. Over time, the pest evolves to develop a resistance to the chemical and we in turn develop a new chemical. In addition to these ‘arms races’ we often find that solving a problem in one part of the system causes a new problem elsewhere. The potential

Richard Tiffin of Agrimetrics, one of four Agri-Tech Centres set up by Government to inspire new business, greater efficiency and improved profits for the UK agrifood sector, explains the challenges in establishing a data marketplace for the sector to help it find, manage and monetise agri-food data.

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for widespread use of insecticides to reduce populations of pollinators is one example.

**Complexity and resilience**

Whilst the ability of the food system to meet the demands of future generations (its sustainability) is of concern, we are increasingly worried about its ability to recover from shocks (its resilience). There are two reasons for this: the first is that the magnitude and frequency of the shocks will increase as a result of climate change and the second is that the growing complexity of the food system makes it more vulnerable to shocks. The relationship between the vulnerability of an ecosystem and its complexity is well documented. For example, Haldane and May argue that ‘a random assembly of N species, each of which had feedback mechanisms that would ensure the population’s stability were it alone, shows a sharp transition from overall stability to instability as the number and strength of interactions among species increases’. Thus, even in an entirely natural system where the population of a single species might be self-regulating in relation to the availability of food, when that species is seen as part of a complex food web, there are likely to be feedback loops that effectively break the self-regulatory mechanism. Intuitively, introducing humans to this food web does nothing to change the argument, we are just another species. However some commentators argue that the additional complexity that we have introduced to the food system worsens the situation further.

Since the 2008 financial crisis, some have argued that complexity theory from ecology offers insights into the crisis. The dominant paradigm of economics is one of equilibrium, be that a static equilibrium, which exists at a point in time, or a dynamic equilibrium, which may evolve through time. In both cases the equilibrium is an ‘attractor’ to which the system will return following a perturbation. In this way resilience is almost ‘baked in’ to economic thinking. However, some scenarios clearly show this view to be flawed. One example is the phenomenon of a bubble where a perturbation, such as a false expectation of increased profit, causes a stock price to diverge from its equilibrium. The attractor theory would suggest that the invisible hand will come into play and re-establish the equilibrium, with the rise in prices discouraging some potential purchasers of the stock. In reality what often happens is that investors see the price rise as a sign of things to come and pile into the market. This fuels further price rises and a positive feedback loop contrary to the re-establishment of equilibrium, is formed.

Ecological complexity theory might also provide some warnings about how the food system works. For example, the total factor productivity growth in selected countries and the world is shown in Figure 1.

![Figure 1: Total factor productivity growth in selected countries and the world](source: USDA)
system, an ecosystem with humans being just one of the species, might respond to future shocks. In some cases, feedback loops that are characteristic of a complex system can threaten the productivity of the food system. The American dustbowl is one such example in which a drought lead to crop failure which in turn caused soil instability and subsequent erosion. The end result being that the temporary shock of a drought became a permanent shock to productivity.

Understanding complexity is hard, but massive increases in the volumes of available data can help. By using artificial intelligence and sophisticated statistics we can identify patterns in data that will reveal the type of insight necessary to continue raising productivity whilst increasing resilience and sustainability.

**Tackling complexity in practice**

If we are to improve productivity and resilience, the people who matter are those who make decisions day-to-day as they go about producing and retailing our food. The complexity of the food system, represented by complexity in data, needs to be translated into actionable insight for these decision makers. The problem is that the complexity means that the data, which describes the food system, is fragmented. The data within a business will not, on its own, provide insights that reflect the interdependencies inherent in complexity. It is therefore critical that data is shared within the sector.

This is far easier said than done. Data is sensitive stuff, and it is valuable. The fact that it is valuable, however, is the key to achieving the goal of shared data. Most businesses are aware that the data they collect is valuable, otherwise why collect it? But most, if not all, businesses do not currently realise the full value in their data. The insights that can be obtained by pooling data are much richer if the data is accessible to specialised analysts and if it can be contextualised with data from other businesses. However, although there are good business reasons for data sharing to occur, it does not happen because of the understandable fear that the benefits of sharing will not accrue equitably. This has given rise to the so-called FAIR data principles, which refer to the need to make data findable, accessible, interoperable and reusable and to emphasise that this can only be achieved when everyone benefits.

The key to achieving the goal of data sharing in which everyone benefits is to establish a mechanism through which data transactions can take place. Data recipients could pay for the data they obtain but equally they could provide a service based on the data that allows the data provider to improve profitability. A marketplace needs infrastructure, however, and it may also require regulation. There are four fundamental requirements to establish a data marketplace:

- **Data standards**
  Data is unlike other commodities in being very heterogeneous. Streamed data from a drone based sensor is very different from maps of soil geology. Different data-sets, which relate to the same thing, have different structures, formats and terminology. We already have quite a lot of standards though and there is a danger that standardising the standards will create yet another standard. An
alternative is to make the standards talk to one another. In a sense this is what the world-wide-web did for information and documents. Before the web, if you had a Mac it was really difficult to access the information that was stored on an MS-DOS computer. Even when Windows came along, the problem persisted. Now you can access information on the web with any device, whatever the system used to store it.

- **Business models**
  How exactly will a user see the value in data? Sometimes it will be in the form of an enhanced insight, for example a better forecast of an outbreak of disease or a market insight that allows supply and demand to be better matched. But in some cases, people will want to see a benefit in the bottom line and for this to happen we will need detailed information on when and how data is being used.

- **Trust**
  There are two important aspects to trust. The first is that data users need to know something about the suitability of the data for their purposes and the second is that suppliers of data need to know how the data they have provided is being used and, where necessary, that they will get the financial benefit due to them. In addition to annotating data to provide meaning, it can be annotated to describe its source. This provides traceability to understand how the data is used and provides information on how it was created.

- **Enabling technology**
  A conventional market needs physical infrastructure to function. A data marketplace is no different. There needs to be a way in which data can be supplied into the market as well as a means by which buyers and sellers can interact. Overcoming these challenges is an issue for the whole sector. It is unlikely that a single business or institution will be able to resolve them alone. In the case of the world-wide-web, a range of different businesses and institutions came together facilitated by a common set of protocols that allowed documents to be linked and presented across many different platforms. The same protocols have been extended to cover data and it is now increasingly possible to link data that is stored in different formats and different locations so that it appears to be a unified data-set.

It is easy to see how interoperability might work with fully open data or with data dispersed within a single business. Work would still be needed to annotate the data so that it can be linked, but that is achievable. This work entails the identification of relationships between concepts in the different data sets and using the appropriate protocols to encode them. Where data is not open, making progress will be harder because we will need to develop the necessary business models and trust. Of course, business models already exist to support data transactions. Data can be licensed from a range of providers including the Met Office and the Ordnance Survey. In these different sources so that their analytical needs can be achieved as rapidly as possible. This is precisely the need that gave rise to conventional marketplaces: you can get all of the ingredients that you need in a single location with an interoperable currency removing the need for bartering. A data marketplace fulfils exactly the same requirements in a digital domain and as such provides the institutional setting in which the challenges to data sharing outlined above can be addressed.

Creating a working data marketplace therefore goes beyond establishing data interoperability and the additional requirements are likely to stretch the interests of an individual business. This is particularly the case for trust. Establishing trust in a physical market is comparatively straightforward because the goods tend to be excludable and visible. In a digital marketplace, where the data is invisible and very easy to copy, trust is much more ephemeral and is likely to require a mechanism by which independent scrutiny of the data marketplace is possible.

**Conclusions**
It is relatively easy to make the case for data sharing as part of the solution to the challenges of the food system. However the difficulties in achieving this should not be underestimated and currently amount to a market failure; we have a plentiful supply of data and demand for the insights that this data can provide but, as yet, much of this demand is unfulfilled.

This was the situation acknowledged when the UK Government launched its Agritech strategy in 2013 in which the establishment of a centre for innovation in ‘big data’ was mandated. Agrimetrics was established with the mission of accelerating the agri-food sector’s ability to maximise the value trapped in its data. It has been working to put in place the national infrastructure to bring about transactional data sharing within the food system. This needs to happen if we are going to feed an expanding population in a more risky environment and do so sustainably. It also means that the sector will grow, improve its productivity and pull its weight in the post-Brexit UK economy.

Responding to the massive increase in demand for food that we will see over the next 30 years means that we have both a tremendous opportunity and responsibility to do things differently. Unlocking the value in data demands that we work together to create a data ecosystem that is fair and equitable benefiting every business, every farmer and every food consumer.