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Paying for the true costs of our meat, eggs and dairy

The bleak lives imposed on industrially farmed animals are justified by the assertion that this gives us cheap food. But the low cost of animal products is achieved only by an economic sleight of hand. We have devised a distorting economics which takes account of some costs such as housing and feeding animals but ignores others including the detrimental impact of industrial agriculture on human health and natural resources.

Industrial livestock production contributes to impaired human health, overuse of antimicrobials, environmental degradation, greenhouse gas emissions, loss of biodiversity and wildlife and very poor animal welfare.

These various detrimental impacts are referred to by economists as “negative externalities”. They represent a market failure in that the costs associated with them are borne by third parties or society as a whole and are not included in the costs paid by farmers or the prices paid by consumers of livestock products. In some cases the costs are borne by no-one and key resources such as soil and biodiversity are allowed to deteriorate undermining the ability of future generations to feed themselves. When such externalities are not included in prices, they distort the market by encouraging activities that are costly to society even if the private benefits are substantial.[i]

Professor Dieter Helm, chair of the Natural Capital Committee which advises the UK Government points out: “the private costs of farming do not reflect the full social costs”. He continues: “Farmers can avoid costs, by passing on their wastes to others to clean up. Thus fertilisers, pesticides and herbicides can flow into the water supply, for water companies to clean up – and for the water companies to charge their customers accordingly. Slurry and agricultural effluents can leach into the water systems. Land is drained to force off flood waters for others to cope with. Carbon is emitted from the soils without paying a carbon price. Overuse of antibiotics drives up the costs to health care as antibiotic resistance builds up ... biodiversity has been reduced without consequences to the farmers who have caused it.”

The failure to reflect full social costs arguably leads to private gains being viewed as more important than public losses.

Need to internalise externalities is widely recognised

There is increasing recognition that, in order to avoid market distortions and encourage efficient use of scarce resources, these externalities should be internalised in the costs of producing meat, milk and eggs and thus in the price paid by consumers.

A report by the UN Food and Agriculture Organisation (FAO) has said: “In many countries there is a worrying disconnect between the retail price of food and the true cost of its production. As a consequence, food produced at great environmental cost in the form of greenhouse gas emissions, water pollution, air pollution, and habitat destruction, can appear to be cheaper than more sustainably produced alternatives”.[ii]

The FAO has also said: "that "A top priority is to achieve prices and fees that reflect the full environmental costs [of livestock production], including all externalities …economic and environmental externalities should be built into prices by selective taxing and/or fees for resource use, inputs and wastes".[iii]

The UK Foresight report on the future of food and farming said: "There needs to be much greater realisation that market failures exist in the food system that, if not corrected, will lead to irreversible environmental damage and long term threats to the viability of the food system. Moves to internalise the costs of these negative environmental externalities are critical to provide incentives for their reduction."[iv]

It adds: "the food system today is not sustainable because of its negative externalities. These are not included in the cost of food and hence there are relatively few market incentives to reduce them".[v]

The European Commission stresses the need to get prices right.[vi] They point out that markets can only bring about efficient use of resources where the prices match the true cost of the resources used. Prices that do not match true costs lock in inefficient technologies and business structures. The failure to reflect the cost of externalities in prices can lead to unsustainable exploitation of some resources.

The negative externalities of industrial livestock production

The negative health externalities of industrial livestock production arise from several factors:

- The high levels of meat consumption that have been made possible by industrial farming can lead to heart diseases, obesity, diabetes and certain cancers.[vii]
- Free range animals often provide meat of higher nutritional quality - with less fat and higher proportions of the beneficial omega-3 fatty acids - than animals that are reared industrially
- Industrially farmed animals are routinely given antibiotics to ward off the diseases that would otherwise be inevitable when large numbers of animals are kept in crowded, stressful conditions
- Air pollution arising from agriculture
- Exposure to agro-chemicals
- Food-borne diseases such as salmonella and campylobacter.

The negative environmental externalities of industrial livestock production largely stem from its dependence on feeding human-edible cereals to animals. This is inherently inefficient as much of the food value of crops is lost during conversion from plant to animal matter. Studies show that for every 100 calories of cereals fed to animals, just 17-30 calories are delivered to the human food chain as meat. [viii] [ix]

A University of Minnesota paper indicates that the efficiency rates may be even lower for some animal products. It concludes that for every 100 calories of grain fed to animals, we get only about 40 new calories of milk, 22 calories of eggs, 12 of chicken, 10 of pork, or 3 of beef.[x] The paper also looked at the conversion of plant protein to animal protein. It found that for every 100 grams of grain protein fed to animals, we get only about 43 new grams of protein in milk, 35 in eggs, 40 in chicken, 10 in pork, or 5 in beef.

The FAO warns that further use of cereals as animal feed could threaten food security by reducing the grain available for human consumption.

Industrial livestock's huge demand for cereals has fuelled the intensification of crop production. This, with its monocultures and agro-chemicals, has led to soil degradation, overuse and pollution of ground- and surface water, biodiversity loss and air pollution. The relentless need for cereals and soy as animal feed is also driving expansion of arable land into grasslands, savannahs and forests. This leads to loss and fragmentation of wildlife habitats and the release of stored carbon into the atmosphere.

A report by the TEEB (The Economics of Ecosystems and Biodiversity) for Agriculture and Food points out that the same practices that can have adverse ecosystem impacts can also have adverse human health impacts (for example nitrate contamination of groundwater).[xi]

Estimating the costs entailed in negative externalities
The impacts and costs of some of these negative externalities have already been estimated.

Environmental externalities
The Natural Capital Committee (NCC) was established in 2012 to provide independent expert advice to Government on the state of England's natural capital. The NCC's third report *The State of Natural Capital* states that "farming can produce large external costs to society in the form of greenhouse gas emissions, water pollution, air pollution, habitat destruction, soil erosion and flooding. These costs are not reflected in the price of food. As a result, farming is responsible for net external costs to society that have been valued at £700m per annum."

Excess nitrogen in the environment
Industrial livestock production's demand for huge amounts of feed crops has fuelled the intensification of crop production with its high use of nitrogen fertilisers. The *European Nitrogen Assessment* (ENA) reports that 75% of industrial production of reactive nitrogen (N_r) in Europe is used for fertiliser (2008 figure). The ENA points out that the primary use of N_r in crops in Europe is not directly to feed people but to provide feeds to support livestock.

The ENA identifies five key threats associated with excess N_r in the environment: damage to water quality, air quality (and hence human health, in particular respiratory problems and cancers), soil quality (acidification of agricultural soils and loss of soil biodiversity), the greenhouse balance and ecosystems and biodiversity.[xii]

The ENA points out that although the atmospheric emissions of nitrogen oxide from traffic and industry contribute to many environmental effects, these emissions are dwarfed by the agricultural flows of reactive nitrogen.

The ENA estimates that the cost of environmental damage related to N_r effects from agriculture in the EU-27 is €20–€150 billion per year. A cost-benefit analysis shows that this outweighs the benefit of N-fertiliser for farmers of €10–€100 billion per year.

A clear example of the detrimental impact of excess nitrogen in the environment is provided by the extensive algal blooms that affect sections of France's coast line. A paper produced in 2014 by the French Ministry of Ecology, Sustainable Development and Energy states that between 50,000 and 100,000m^3 of algal blooms are collected and treated each year. This cost around €1.7 million in 2012 with a cost of €20/m^3. In addition, algal blooms have a negative impact on tourism and the shellfish industry.[xiii]

The FAO estimates that fertiliser use has adversely impacted marine and riverine ecosystems, producing over 400 aquatic "dead zones" worldwide, covering an area of 245,000 sq.km through eutrophication.[xiv]

Soil degradation
A UK study concludes that "modern agriculture, in seeking to maximize yields ... has caused loss of soil organic carbon and compaction, impairing critical regulating and supporting ecosystem services".[xv] The study's authors point out that depletion of soil organic carbon "in conventional agricultural fields is now thought to be an important factor constraining productivity as many arable soils have suboptimal concentrations".

The European Commission points out that "45% of European soils face problems of soil quality, evidenced by low levels of organic matter".[xvi] Soil biodiversity is under threat in 56% of EU territory with intensive agriculture being a key factor in loss of soil biodiversity.[xvii] In 2006, the Commission assessed that soil degradation in the EU-25 was costing the EU economy some €38 billion per year.[xviii] The consequences of soil biodiversity mismanagement have been estimated to be in excess of one trillion dollars per year worldwide.[xix]

The FAO reports that globally approximately 33% of soils are facing moderate to severe degradation.[xx] The FAO stresses: "the current rate of soil degradation threatens the capacity to meet the needs of future generations, unless we reverse this trend through a concerted effort towards the sustainable management of soils".[xxi] The FAO estimates that worldwide 75 billion tons of soil are lost every year, costing approximately US$400 billion per year.[xxii] Brazil, for example, loses 55 million tons of topsoil every year due to erosion from soy production.[xxiii]

Overuse and pollution of water

Industrial livestock production generally uses and pollutes more ground- and surface-water than grazing or mixed systems.[xxiv] Unabsorbed nitrogen and phosphorus from fertilisers and chemicals from pesticides are key factors in water pollution. Human-induced eutrophication degrades freshwater systems worldwide by reducing water quality and altering ecosystem structure and function. More than 40% of EU rivers and coastal water bodies are affected by diffuse pollution from agriculture.[xxv]

A UK study estimates that the cost agriculture imposes on water companies for cleaning nitrates, pesticides and other treatments from their water was £271 million in 2002/2003.[xxvi] The OECD reports that the annual costs related to water pollution in six EU Member States (Belgium, France, Netherlands, Sweden, Spain, UK) amount to €2.43-€4.75 billion per year.[xxvii]

A U.S. study found that in all U.S. nutrient ecoregions nitrogen and phosphorus concentrations in rivers and lakes exceeded reference values.[xxviii] In 12 out of 14 ecoregions, over 90% of rivers exceeded reference values. The study calculated potential annual value losses in drinking water treatment costs, recreational water usage, spending on recovery of threatened and endangered species, and waterfront real estate. The combined costs were approximately $2.2 billion annually as a result of eutrophication in U.S. freshwaters. The study recognises that a substantial portion of human-induced eutrophication ultimately stems from fertiliser use. The authors point out that their evaluation likely underestimates the economic losses.

A number of papers compare the environmental impact of confinement and pasture-based dairy systems in Europe as regards three factors: eutrophication potential, global warming potential and air pollution from ammonia emissions.[xxix] [xxx] [xxxi] The estimated costs entailed in these various impacts are much higher in high-input confinement systems than in low-input pasture-based systems.

Biodiversity loss

Industrial agriculture is associated with a major decline in Europe's biodiversity.[xxxii] Only 7% of habitats linked to agro-ecosystems have a favourable conservation status, compared to 17% for habitat types not related to agro-ecosystems.[xxxiii]

Farmland birds are considered to be a key indicator of the health of the countryside. Europe's common farmland birds have declined by 30% since 1990; this has been linked to increased intensification as well as habitat loss.[xxxiv] The drive to grow more animal feed has been a major factor in the intensification of cereal production. This has entailed the loss of mixed farming, the erosion of habitat diversity and the development of monocultures all of which result in less diverse opportunities for foraging and a reduction in the insect populations on which birds feed.

Intensive agriculture has also played a major role in the decline in pollinators such as bees through its use of insecticides and herbicides and its contribution to air pollution and habitat deterioration.[xxxv] [xxxvi] The value of insect pollination services to crop agriculture has been estimated at ~ £400 million per year in the UK[xxxvii] and €153 billion globally.[xxxviii] There has also been a dramatic decline in Europe's grassland butterflies of almost 50% between 1990 and 2011 with no sign of recovery.[xxxix] As with birds, butterflies are important indicators of what is going on in the environment.

The European Environment Agency estimates that biodiversity loss reduces global GDP by 3% each year.[xl] Globally food production accounts for 60-70% of total biodiversity loss.[xli] The European Commission states that the livestock sector may be the leading player in the reduction of global biodiversity through its demand on land.[xlii] The contribution of livestock farming to the present global loss of biodiversity is estimated by a Dutch study to be around 30%.[xliii]

EU Member States have identified agriculture (both intensification – including fertilisation and pesticides - and abandonment) as one of the main causes of wildlife loss and habitat degradation.[xliv]

Adverse impact of EU food and farming in third countries

The costs associated with the negative externalities of the EU's industrial livestock sector are not contained within the EU but spread out causing considerable damage in third countries. The EU imports around 30 million tonnes of soymeal each year primarily to feed industrially raised animals. The imported amount corresponds to an area of more than 20 million hectares of cropland.[xlv] Much of the imported soy is grown on land that has been converted into cropland by deforestation or clearing of savannahs. This entails massive biodiversity loss and releases huge amounts of stored carbon into the atmosphere, thereby contributing to climate change.

A study carried out for the Commission states that "EU imports are demanding large areas of fertile cropland in distant regions of the world and EU consumption patterns are contributing to deforestation and land use change elsewhere".[xlvi] In addition, the EU is a net virtual water importer; EU agricultural imports result in the EU having a large water footprint in third countries.[xlvii] [xlviii]

Climate change

The FAO estimates that the livestock sector is responsible for 14.5% of human-induced greenhouse gas (GHG) emissions.[xlix] The international community has agreed to limit the global temperature increase to well below 2°C compared with pre-industrial levels in order to avoid a dangerous level of climate change. However, some studies suggest that 'business-as-usual' will lead to agriculture's GHG emissions being so high by 2050 that they alone will push global temperatures to increase by almost 2°C.[l] [li]

Springmann *et al* (2016a) compared the health impacts in 2050 of a reference diet based on FAO projections with three alternatives: (i) a healthy global diet based on WHO/FAO Expert Consultations and recommendations by the World Cancer Research Fund, (ii) a vegetarian diet and (iii) a vegan diet.[lii] The researchers estimate that, compared with the reference diet, adoption of a healthy global diet would have monetized environmental benefits due to reduced GHG emissions of $234 billion per year. Adoption of the vegetarian and vegan diets would have benefits, compared with the reference diet, of $511 and $570 billion per year respectively.

The environmental costs of feeding cereals to animals
Globally 36% of cereal production is used as animal feed.[liii] As indicated earlier, animals convert cereals very inefficiently into meat and milk. This is a wasteful use not just of these crops but of the land, water and energy used to produce them. In addition, growing these cereals for animal feed (most of which are produced intensively) entails detrimental impacts such as water and air pollution, soil degradation, biodiversity loss and greenhouse gas emissions. As most of the calories and protein contained in the cereals are not converted into meat or milk, a substantial proportion of these detrimental impacts are produced for no purpose in terms of human food supply.

Research funded by the FAO calculates the difference in environmental impacts in 2050 between (i) business-as-usual (BAU) as regards feeding human-edible crops to animals and (ii) ending the use of such crops as animal feed.[liv] This will result in reduced production of meat and milk; the researchers have taken account of the fact that this will necessitate increased production of other foods but these generally will be much less resource-intensive. Table 1 shows the environmental impacts and the associated costs in 2050 of continuing with BAU as compared with ending the use of human-edible crops as feed.

Table 1: Comparison of impacts and their associated costs in 2050 between (i) BAU in use of human-edible crops as animal feed and (ii) ending use of such crops as feed*

Production inputs and environmental outcomes	Reference scenario: FAO BAU projections for 2050	No use of human-edible crops as animal feed in 2050	Extra impact of BAU compared with ending use of human-edible crops as animal feed in 2050	Extra cost of BAU compared with ending use of human-edible crops as animal feed in 2050
Arable land use: million hectares	1630	1200	430	No figure available
GHG emissions: Gt CO2-eq	12.8	10.4	2.4	$271 billion per year
Freshwater use (for irrigation): km^3	2178	1718	460	$575 billion per year[1]
N-surplus: million tonnes N	121.8	65.2	56.6	$17.5 billion per year[2]
P-surplus: million tonnes P	64.0	38.4	25.6	$322 billion per year[2]
Non-renewable energy use: exajoules	26.7	17.2	9.5	No figure available
Pesticide use:**	15.4	12.0	3.4	$38 billion per year[3]
Deforestation: million hectares	7.2	6.5	0.7	$1.1 billion per year[4]
Soil erosion from water: billion tonnes soil lost	36.8	32.2	4.6	$99 billion per year[5]

[1] This figure includes the cost of water use and the impact on water scarcity

2 This figure includes eutrophication impact on both water quality and biodiversity
3 This figure relates to health effects due to pesticide exposure
4 This figure relates to loss of ecosystem services from deforestation; the cost of GHG emissions from deforestation is included in the figure for GHG emissions
5 This figure relates to damage costs on-site and off-site
* Costs are in US dollars (2012)
** Classification of pesticide use per ha by intensity and by crop, legislation by country and access to pesticides by farmers

The costs in the final column of Table 1 have been calculated using the data in Table 2 and elsewhere in the FAO report *Food waste footprint: full cost accounting*.[lv] The Annex to this paper details how the costs in the final column of Table 1 have been calculated.

Table 1 of this paper shows that the projected BAU use of human-edible crops as feed in 2050 will entail costs of $1323 billion (i.e. $1.32 trillion) per year as compared with not using such crops as animal feed. These costs arise mainly due to the inefficiency with which animals convert crops into meat and milk. The calculations presented in Table 1 are inevitably estimates. However, the overall cost may be much greater than $1.32 trillion per year as:

- data was not available to enable this paper to estimate the costs of arable land and energy use
- the above FAO report on food waste also included costs in respect of pollinator loss, the impact of pesticides on biodiversity, and loss of livelihoods and increased risk of conflict due to soil erosion. These aspects have not been included in this paper when estimating the costs arising from the projected BAU use of human-edible crops as feed in 2050 as the data to make reliable calculations is not available.

Human health externalities

Non-communicable disease

The high levels of meat consumption that have been made possible in the western world by industrial farming are having an adverse impact on human health. EU citizens on average consume around 40% more saturated fat than the recommended maximum dietary intake proposed for Europe by the World Health Organisation (WHO) and almost 50% more red meat than the maximum level advised by the World Cancer Research Fund.[lvi] A range of studies show that overconsumption of animal products can lead to heart diseases, obesity, diabetes and certain cancers.[lvii] [lviii] [lix]

A report by the World Economic Forum and the Harvard School of Public Health states that 63% of all deaths worldwide currently stem from non-communicable diseases (NCDs) – chiefly cardiovascular diseases, cancers, chronic respiratory diseases and diabetes.[lx] The report stresses that "NCDs have a large impact, undercutting productivity and boosting healthcare outlays". A key message from the report is that "NCDs already pose a substantial economic burden and this burden will evolve into a staggering one over the next two decades". The WHO identifies four major risk factors for NCDs: unhealthy diet, physical inactivity, tobacco use and harmful alcohol use.[lxi]

A study published in *The Lancet* concluded that a 30% decrease in intake of saturated fats from animal sources in the UK and São Paulo city could reduce the total burden from ischaemic heart disease by 16% and 17% respectively.[lxii] It may well that the UK figure would be similar for the EU as a whole.

The total annual cost of all coronary heart disease related burdens in the UK in 2003 was €11.13 billion.[lxiii] This figure includes costs to the UK health care system, informal care and productivity losses. As a 30% decrease in intake of saturated fats from animal sources could reduce the total burden from ischaemic heart disease by 15% in the UK, it would appear that such a decrease could save the UK economy around €1.67 billion per annum.

The annual global economic impact from obesity is estimated to be roughly $2 trillion, or 2.8% of global GDP, nearly equivalent to the global impact from smoking or armed violence, war, and terrorism.[lxiv] The World Health Organization (WHO) reports that the global cost of diabetes is $825 billion annually.[lxv]

As indicted earlier, Springmann *et al* (2016a) compared the health impacts in 2050 of a reference diet based on FAO projections with three alternatives: a healthy global diet based on WHO/FAO Expert Consultations and recommendations by the World Cancer Research Fund, a vegetarian diet and a vegan diet.[lxvi] The researchers estimate that adopting the healthy global diet rather than the reference diet would produce health related cost-savings of $735 billion per year. Adoption of the vegetarian and vegan diets would result respectively in savings of $973 and $1067 per year. These benefits arise principally from reduced consumption of red meat, increased consumption of fruit and vegetables and limiting excessive energy intake.

These figures are calculated using a cost-of-illness approach. A value-of-statistical-life approach led to much higher estimates of the economic benefits associated with dietary change. In this case the researchers estimate that the monetized value associated with diet-related changes in mortality (as compared with the reference diet) amount to $21 trillion, $28 trillion and $30 trillion per year respectively for the healthy global diet and the vegetarian and vegan diets.

Antimicrobial resistance
The use of antimicrobials in human medicine is the main driver of antimicrobial resistance. However, the WHO has stressed that over-reliance on antimicrobials in intensive livestock farming is also a significant contributor to the emergence of antimicrobial-resistant bacteria that affect human health.[lxvii] A Scientific Opinion by the European Food Safety Authority (EFSA) concludes that it is "of high priority to decrease the total antimicrobial use in animal production in the EU". [lxviii] The WHO states that worldwide approximately half of current antibiotic production is used in agriculture, to promote growth and prevent disease as well as to treat sick animals.[lxix]

The link between intensive farming and high levels of antimicrobial use is highlighted by the fact that the Veterinary Medicines Directorate's data show that around 83% of all UK farm antibiotic sales are for pigs and poultry, the two most intensively farmed species.[lxx]

Each year 25,000 patients die in the EU from an infection caused by resistant micro organisms with extra healthcare costs and productivity losses of at least €1.5 billion per year.[lxxi] A recent study commissioned by the UK Government shows that a continued rise in resistance by 2050 would lead to 10 million more people dying worldwide every year than would be the case if resistance was kept to today's level and a reduction of 2-3.5% in Gross Domestic Product.[lxxii] The study estimates that between now and 2050 the world can expect to lose between 60 and 100 trillion USD worth of economic output if antimicrobial drug resistance is not tackled.

The U.S. Centers for Disease Control and Prevention estimates that at least 2 million people are infected with antibiotic-resistant bacteria every year in the U.S. with at least 23,000 people dying every year as a direct result of these infections.[lxxiii] This incurs annual treatment costs of around $20 billion on top of costs to society for lost productivity that are as high as $35 billion a year, totalling $55 billion per annum.[lxxiv]

Air pollution
Agriculture is a key source of three major air pollutants: ammonia, particulate matter and nitrous oxide. The UK Department for Food, Environment and Rural Affairs estimates that the cost of

the damage caused by these three pollutants emanating from agriculture is £816 million per year.[lxxv]

Air pollution is a serious problem for human health as it contributes to conditions such as bronchitis, asthma, lung cancer and congestive heart failure. The related costs are considerable. A study has analysed the impact of Danish emission sectors on health-related costs arising from air pollution in Europe.[lxxvi] Emissions in Denmark cause health-related costs in Europe of €4.9 billion per year. The study found that agriculture is the main Danish sector contributing to health-related costs arising from air pollution in Europe; agriculture's contribution (43%) outweighs those of road traffic (18%) and major power plants (10%). A study for the US suggests that a 10% reduction in livestock ammonia emissions can lead to over $4 billion annually in particulate-related health benefits.[lxxvii]

A 2015 report by the French Senate concludes that the total cost of air pollution in France is between €68 and €97 billion per year.[lxxviii] This includes the medical costs of treating ill health resulting from air pollution such as certain cancers, asthma, bronchitis and cardiovascular problems. It also includes the costs of lost production as well as placing an economic value on loss of life and years of life spent in poor health. The study states that air pollution is mainly caused by four sectors: agriculture, transport, industry and residential. It does not provide an indication of the proportion of overall costs attributable to agriculture.

Exposure to agro-chemicals

Recent research explores the health impacts of pesticides as 'endocrine disrupting chemicals' (chemicals that interfere with hormones). A report by the TEEB for Agriculture and Food states that in the EU, of all endocrine disrupting chemicals, "pesticide exposure causes the highest annual health and economic costs at roughly $127 billion, almost four times as high as the second highest category (plastics)".[lxxix] [lxxx]

Foodborne disease

A U.S. study estimates the cost of foodborne illness in the U.S. is $152 billion a year. This figure includes medical costs (hospital services, physician services and drugs) and quality-of-life losses (deaths, pain, suffering and functional disability).[lxxxi]

A University of Florida study ranked the top 10 pathogen-food combinations and concluded that campylobacter in poultry was the most damaging in terms of both cost of illness and loss of Quality Adjusted Life Years (QALYs), a measure of health-related quality of life.[lxxxii] Salmonella in poultry was the fourth most damaging. The study found that contaminated poultry has the greatest public health impact among foods. It is responsible for over $2.4 billion in estimated costs of illness annually and loss of 15,000 QALYs a year. Nearly all U.S. chickens are produced industrially.

A 2015 study by the U.S. Department of Agriculture estimates that foodborne illnesses impose over $15.5 billion in economic burden annually in the U.S.[lxxxiii]

Campylobacter

The UK Food Standards Agency estimates that campylobacter costs the UK economy about £900 million a year. It says that about four in five cases of campylobacter poisoning in the UK come from contaminated poultry. [lxxxiv]

The European Food Safety Authority (EFSA) estimates that there are approximately nine million cases of human campylobacteriosis per year in the EU27. The disease burden of campylobacteriosis and its sequelae in the EU is 0.35 million disability adjusted life years per year and total annual costs are € 2.4 billion.[lxxxv]

There is no doubt that poultry is a major source of campylobacters.[lxxxvi] EFSA identifies poultry meat as a major source of campylobacteriosis and states that broiler meat may account for 20% to 30% of cases of human campylobacteriosis, while 50% to 80% may be attributed to the chicken reservoir as a whole (broilers as well as laying hens).[lxxxvii] Around 90% of EU broilers are reared industrially.

Salmonella

EFSA states that over 100,000 human cases of salmonellosis are reported each year in the EU. EFSA has estimated that the overall economic burden of human salmonellosis could be as high as €3 billion a year.[lxxxviii] EFSA points out that salmonella is most frequently found in eggs and raw meat from pigs, turkeys and chickens.[lxxxix] Most poultry and pig production in the EU is industrial.

An EU study of laying hen flocks detected salmonella in 30.8% of the laying hen holdings in the EU. It found that cage production was associated with a higher risk of positivity than for the other investigated laying hen production types.[xc] A study of salmonella incidence in British laying hen flocks found that non-cage systems were associated with a reduced risk. [xci]

Animal welfare

Industrial livestock production generally results in low standards of animal welfare. A Dutch study seeks to quantify and value the adverse impact of pork production on pig welfare.[xcii] Based on willingness-to-pay research, the Dutch study suggests that the animal welfare related costs of producing 1kg of fresh pork are between €1.10 and €4.60 for conventionally produced pork and between €0 and €3.50 for organic pork. Taking the lower of these figures for conventionally produced pork and assuming that at least 90% of EU pigs are farmed intensively, the animal welfare costs of the EU pig sector are €19 billion per year.

All the above costs are set out in Table 2:

Table 2: Costs of negative externalities

Negative externality	Estimated cost	Source
UK impacts attributable to farming: GHG emissions, water pollution, air pollution, habitat destruction, soil erosion and flooding	£700 million per year	Natural Capital Committee
EU: environmental damage related to Nitrogen effects from agriculture	€20–€150 billion per year	European Nitrogen Assessment
EU: soil degradation	€38 billion per year	European Commission
Global: soil loss	$400 billion per year	FAO
UK: cleaning nitrates, pesticides etc from water	£271 million per year	O'Neill
US: eutrophication in freshwaters	$2.2 billion per year	Dodds *et al*
Belgium, France, Netherlands, Sweden, Spain, UK: water pollution	€2.43-€4.75 billion per year	OECD
Global: biodiversity loss	Globally food production accounts for 60-70% of total biodiversity loss	PBL Netherlands Environmental Assessment Agency
Global: Climate change	$100-$250 billion per year	DARA & the Climate Vulnerable Forum and Springmann *et al* (2016a)
Global: Feeding cereals to farm animals in 2050	$1323 billion per year	Schader *et al* (2015); FAO, *Food waste footprint: full cost*

		accounting & author's calculation
Global: non-communicable diseases (NCD)	$735 billion per year using a cost-of-illness approach; $21 trillion per year using value-of-statistical-life approach	Springmann *et al* (2016a)
UK: ischaemic heart disease	30% decrease in intake of saturated fats from animal sources could reduce the total burden from ischaemic heart disease by 15% in UK. This would save £1.67 billion per year	The Lancet & author's calculation
EU: ischaemic heart disease	€7.3 billion per year even if the savings are only 50% of those achieved in UK (see above row)	Author's calculation based on Lancet figure for UK
EU: antimicrobial resistance	€1.5 billion per year	European Commission
US: antimicrobial resistance	€55 billion per year (includes treatment costs & lost productivity)	U.S. Centers for Disease Control and Prevention
Global: loss of economic output due to antimicrobial resistance between now & 2050 on BAU basis	$1710-$2860 billion per year	Study commissioned by UK Government
Denmark: health related costs of air pollution	€2.1 billion per year	Brandt *et al*
France: total cost of air pollution	€27-€41 billion per year (on assumption that, as in Denmark, 43% of air pollution costs are attributable to agriculture)	French Senate
EU: exposure to pesticides	$127 billion per year	TEEB for Agriculture & Food
US: foodborne disease	$15.5-$152 billion per year	Scharff USDA
EU: campylobacter	€2.4 billion per year	EFSA
EU: salmonella	€3 billion per year	EFSA
EU: animal welfare costs of intensive pig sector	€19 billion per year	Van Drunen *et al* & author's calculation

The need to internalise the negative externalities of livestock production
Our economic system is generally poorly equipped to take into account the impact of agriculture on factors that are not owned by anyone and for which there is no, or only a partial, market. These factors include for example clean air, animal welfare, climate stability, good dietary health and the need to leave sufficient and good quality water, soil and biodiversity for future generations. Such factors do not have to be paid for by farmers and consumers of food and so, in the absence of some form of intervention, are vulnerable to receiving insufficient attention.

An economic system that arbitrarily takes account of some of the costs of producing food while ignoring others is inefficient and produces undesirable outcomes such as poor levels of dietary health, erosion of agriculture's core factors of production (soil, water, biodiversity) and low standards of animal welfare. This capricious failure to take certain costs into account has produced a food system that makes unhealthy, environmentally damaging food cheaper than food that is nutritious and respects the environment and animal welfare.

The consequence of unhealthy food being cheaper in the West than healthy food is that poorer members of society find themselves having to rely on poor quality food. For example, the Faculty of Public Health states that "in the UK, the poorer people are, the worse their diet, and the more diet-related diseases they suffer from".[xciii] Olivier De Schutter, former UN Special Rapporteur on the right to food, stresses that "any society where a healthy diet is more expensive than an unhealthy diet is a society that must mend its price system." [xciv] This applies equally to a society where environmentally damaging, low animal welfare food is cheaper than food that respects natural resources and animals' well-being.

Mending our food price system
A principal objective of internalising negative externalities is to achieve a better alignment between an individual's incentives and societal objectives.

A wide range of measures can be used to internalise both positive and negative externalities. Legislation, fiscal measures, codes of practice and standards set by food businesses can all internalise external costs. Taxes can be used to internalise external costs and/or to encourage or discourage certain production or consumption decisions.

A report by the Europe region of the World Health Organisation (WHO) points out that taxation specialists recognise that the purpose of the tax system is not just to raise revenue but that it plays a role in supporting policy objectives such as health gains and health care cost savings.[xcv] It stresses that "consumers can be highly responsive to food prices and that taxation and subsidies are an effective means of influencing consumption of targeted foods".

Internalising the societal costs of unhealthy food and promoting healthy diets
The UN advocates the use of fiscal measures to promote healthy diets. The UN *Political Declaration on Non-Communicable Diseases* (NCDs) identifies unhealthy diets as a key risk factor for NCDs.[xcvi] It urges Governments to advance interventions to reduce the impact of unhealthy diets on NCDs through, *inter alia* "fiscal measures". In his 2011 report on NCDs the UN Secretary-General identifies food subsidies and taxes as a cost-effective way of promoting healthy diets.[xcvii] Countries could, for example, place a tax on unhealthy foods and use the income generated to subsidise healthy foods.

Research shows that a tax on unhealthy foods, combined with the appropriate amount of subsidy on fruits and vegetables, could lead to significant health gains.[xcviii] A Danish study concluded that taxes on "unhealthy" and subsidies for "healthy" food products can improve public nutrition.[xcix] U.S. research found that small price differences at the point of purchase can be highly effective in shifting consumer demand from high calorie milk to healthier low calorie alternatives.[c] It reports that low income consumers who are at higher risk for obesity are particularly responsive.

The WHO report referred to earlier points out that without government intervention the prices of fruit and vegetables at point of purchase are likely to exceed the socially optimal price, and the quantity sold will be below the level needed for the maximum benefit to society.[ci] The report emphasises the effectiveness of subsidies in increasing the purchase of healthy foods and of taxes in decreasing the purchase of unhealthy foods. It states that the potential for positive effects might be amplified if a targeted food tax were combined with a subsidy on fruit and vegetables or other healthy foods with the subsidy being funded by the revenue raised by the tax.

Brazil has made commitments on ending obesity that include "fiscal measures (subsidies, tax reductions etc) in order to reduce the price of healthy foods, as fruits and vegetables".[cii]

Preventing regressivity
Taxes on food must be designed so as to avoid having an unfair impact on poorer people as a tax-related price increase will place a greater burden on them than on wealthier consumers. This can be mitigated by subsidies on healthy food so that the overall price of food does not increase.

The WHO points out that for poor socioeconomic groups a food tax may lead to dietary shifts and so to improved dietary health provided that untaxed, healthy alternatives are available; such health gains may contribute to reducing health inequalities.[ciii] The OECD has concluded that, of all actions to prevent obesity “fiscal measures are the only intervention producing consistently larger health gains in the less well-off” across the countries studied.[civ]

Impact of tax or charge can go beyond its monetary value
The WHO points out that taxation may result in consumers becoming more aware of the unhealthy properties of certain products because of the price increase, thereby amplifying the effect of the price increase and enhancing the market for healthy products.[cv]

It may be that a similar mechanism is operating in respect of the charge on plastic carrier bags in England. A charge of 5 pence per bag has been in place since October 2015; this has led to a reduction of over 80% in the number of bags used.[cvi] This change may not have been brought about just by shoppers wishing to avoid the relatively modest charge of 5 pence per bag. It may be that the fact that a charge has been imposed has brought home to people the detrimental environmental impacts ensuing from huge numbers of discarded bags. A shift in attitudes has perhaps been affected that goes beyond the monetary impact of the charge.

Internalising the societal costs of farm use of antimicrobials
The O’Neill report examined the case for placing a tax on the use of antimicrobials in the livestock sector.[cvii] It advised that this would ensure that farm use takes into account the societal cost of antimicrobial use and would increase the economic incentive for farmers to use alternatives such as improved husbandry and vaccination. It said that the tax should be set at a level that discourages growth promotion (which is still used in many countries), and unnecessary prophylactic use, but that does not stop farmers from adequately treating their sick animals.

Vagsholm and Hojgard (2010) argued that antimicrobial resistance is a negative externality in that it undermines the public good of bacterial sensitivity to antimicrobials.[cviii] They suggested that if bacterial susceptibility is to be managed as a finite natural resource, the incentive to use antimicrobials might be reduced through taxation.

Internalising negative environmental externalities and promoting sustainable agriculture
Environmental taxes are in operation in certain countries, for example, carbon/energy taxes, sulphur taxes, leaded and unleaded petrol tax differentials, landfill taxes, pesticide taxes and fertiliser taxes. Such measures are designed to internalise the external costs of certain activities.

A paper by the UN Development Programme (UNDP) examines how taxes on pesticides and fertilizers can correct certain market failures (e.g. the failure to incorporate in the price of the pesticide/fertilizer its social and environmental costs) and can forestall increases in the use of the most harmful pesticides and fertilizers.[cix] Such taxes can lead to savings in health budgets (including lost productivity) and reduced expenditure in restoration of degraded land and natural resources.

The UNDP paper states that from an economic perspective, a differentiated tax that takes account of the damage to the environment and human well-being caused by different types of pesticides/fertilizers is the preferred solution, since it provides more targeted price signals to the market and more adequately reflects marginal damages.

The paper points out that the revenue generated by such taxes could be earmarked to mitigating the environmental impacts of pesticides and fertilizers, adopting more sustainable agriculture practices and otherwise contributing to the achievement of a country's sustainable development goals. It stresses that these taxes are "more appropriate where the objective is to facilitate a smooth transition to more sustainable practices through market mechanisms".

Such taxes should be seen not as a substitute for legislation but as complementing regulations. The UNDP paper states: "an example is seen in France where a combined system is in place in which a reduced tax rate is imposed on pesticides that are allowed in organic farming, while the regular tax rate is imposed on other pesticides, and a total ban is imposed on some widely used pesticides that are considered to harm bees."

Joint health and environmental benefits of taxing certain foods

Many studies show that a dietary pattern higher in plant-based foods and lower in animal-based foods would be beneficial for the environment and public health and would reduce greenhouse gas (GHG) emissions. [cx, cxi, cxii]

Springmann *et al* (2016b) show that levying GHG taxes on food commodities could, if appropriately designed, both lower GHG emissions and promote health in high-income countries, as well as in most low- and middle-income countries.[cxiii] However, taxes on food must spare food groups that are beneficial for health from taxation and use the tax revenues for health promotion and subsidising the consumption of fruit and vegetables.

The UN Standing Committee on Nutrition states that policies to make diets healthier and sustainable with low environmental impacts include economic incentives.[cxiv] They say this could involve taxing unhealthy food and subsidising or providing economic incentives for the consumption of healthier food.

Internalising the societal costs of the production and consumption of animal products

Similar approaches could be taken in the field of livestock production. One approach to internalising the externalities of meat production – i.e. including them in the price of meat – is the introduction of a Pigouvian Tax that reflects the cost of the negative externalities.[1] Such a tax would correct the market failure due to externalities. The Dutch study referred to earlier states that the average rate of the Pigouvian Tax should be at least €2.06 for 1kg of conventionally produced pork, which is 31% of the consumer price in the Netherlands at the time of the study.

A Swedish study considers three meat products, cattle, chicken and pork, and three pollutants generating environmental damages: greenhouse gases, nitrogen, and phosphorus.[cxv] The study examines taxes on meat products corresponding to the environmental damage caused by the different products; these amount to 28%, 26%, and 40% of the price per kg of beef, pork, and poultry respectively in 2009. The study calculates that a simultaneous introduction of taxes on all three meat products can decrease emissions of GHGs, nitrogen, phosphorus and ammonia by at least 27%.

[1] Wikipedia describes a Pigouvian tax as a tax levied on a market activity that generates negative externalities. The tax is intended to correct the market outcome. In the presence of negative externalities, the social cost of a market activity is not covered by the private cost of the activity. In such a case, the market outcome is not efficient and may lead to over-consumption of the product. A Pigouvian tax equal to the negative externality is thought to correct the market outcome back to efficiency

Taxes on meat should not apply to all meat but only to that which is produced industrially as it is this meat that is responsible for most of the sector's adverse environmental impacts and most of its use of antimicrobials and that generally is of lower nutritional quality than free range meat. Moreover, the industrial livestock sector has inherent severe deficiencies for animal welfare. In contrast, extensive indoor systems and outdoor rearing have the potential, if well-designed and well-managed, to deliver good welfare outcomes. Accordingly, taxes should not be placed on meat from well-managed pasture-based herds, integrated rotational crop-livestock systems or extensive indoor or free range systems.

Revenue raised from such taxes should be used to subsidise healthy foods such as fruit and vegetables, legumes and whole grains as it is crucial from the viewpoint of social equity that the overall price of food does not increase.

Using fiscal measures positively

Tax measures should be used not just to reflect the cost of negative externalities but the revenue raised should be used to lower the costs of particular farming practices and certain foods. They should be used to make healthy food produced to high environmental and animal welfare standards economically attractive for both farmers and consumers.

Supporting farmers

Farmers producing to high environmental and animal welfare standards could be compensated for the extra costs involved by subsidies and tax breaks. When calculating net profits for tax purposes, more generous capital allowances could be given to investments for high quality farming. Governments already uses differential capital allowances to reward activities that they wish to encourage; for example, enhanced capital allowances are given in some countries for businesses that use environmentally beneficial technologies. Moreover, an extra tranche of farmers' taxable income could be tax-free when they employ specified animal welfare or environmental practices. These tax breaks could be paid for by the revenue raised from placing taxes on the inputs of industrial agriculture such as chemical fertilisers and pesticides.

Payments for environmental services (PES) can be made to farmers or landowners who agree to take certain actions to manage their land or watersheds to provide an ecological service. Such payments can be a useful market-based mechanism for encouraging the conservation and restoration of natural resources.

Supporting consumers

Taxes should be placed on unhealthy, inhumanely produced food with the revenue raised being used to subsidise the price of healthy food produced to high environmental and animal welfare standards. In countries which charge VAT on food, the price paid by consumers for such food could be reduced by placing a lower or nil VAT rate on such food.

Studies show varying results as to how effective fiscal measures can be in influencing consumer behaviour. However, a report by Chatham House and the Food Climate Research Network (FCRN) stresses that "lack of evidence should not be used as an excuse for policy inaction. Indeed policy inaction leads to a paucity of empirical evidence. Trials and experimentation particularly based on some of the more politically challenging fiscal and regulatory approaches discussed are essential. As noted, robust monitoring and evaluation processes need to be in place so that impacts in the short, medium and longer term can be understood. In this way the evidence base is built and policies progressively refined and improved."[cxvi]

Fiscal measures cannot on their own reshape our food system into one that delivers high quality food. They must be implemented in conjunction with other strategies and policies that aim to improve our food system including regulation, voluntary initiatives by food businesses, supportive public procurement and consumer information.

The report by Chatham House and FCRN stresses that while they have important roles to play, the restructuring of our food system cannot be left to "industry goodwill or enlightened self interest".[cxvii] The report highlights the need for governments' non-interventionist approach to be replaced by a willingness to set a strong policy, regulatory and fiscal framework. It emphasises that governments must govern and must be prepared to step in and lead. It points out that "a supportive policy environment ... enables more voluntary approaches and agreements to actually deliver on their intended results".

Conclusions

Livestock production, in particular industrial production, produces a wide range of negative externalities. These include pollution and overuse of water, soil degradation, greenhouse gas emissions, biodiversity loss, increased levels of disease in humans and very poor animal welfare.

The low cost of industrially produced animal products is achieved only by an economic sleight of hand. We have devised a distorting economics which takes account of some costs such as housing and feeding animals but ignores others including the detrimental impact on human health and natural resources of industrial agriculture. This results in market failure as the costs associated with livestock's negative externalities are borne by third parties or society as a whole and are not included in the costs paid by farmers or the prices paid by consumers. In some cases the costs are borne by no-one and key resources such as soil and biodiversity are allowed to deteriorate undermining the ability of future generations to feed themselves.

An economic system that arbitrarily takes account of some of the costs of producing food, while ignoring others, is inefficient and produces unwanted outcomes, mainly in the public sphere. It also leads to private gains being viewed as more important than public losses.

The UN Food and Agriculture Organisation stresses that: "In many countries there is a worrying disconnect between the retail price of food and the true cost of its production. As a consequence, food produced at great environmental cost ...can appear to be cheaper than more sustainably produced alternatives."

A number of studies have stressed the importance of internalising the negative externalities of livestock production in order to avoid market distortions and provide incentives for their reduction. The Foresight Report warns that these market failures "if not corrected, will lead to irreversible environmental damage and long term threats to the viability of the food system".

Some of the damage caused to natural resources and our health by industrial agriculture has been costed and is set out in Table 2. More efficient decisions would be made by policy makers, producers and consumers if these 'hidden' costs were internalised and so paid for by farmers when deciding on farming methods and by consumers when buying food. Society cannot make sound judgments about the proportion of animal products in our diets - and how these should be produced - if we do not take these wider costs into consideration.

Legislation, fiscal measures and standards set by food businesses can all internalise external costs. Olivier De Schutter has said that: "any society where a healthy diet is more expensive than an unhealthy diet is a society that must mend its price system". This applies equally to a society where environmentally damaging, low animal welfare food is cheaper than food that respects natural resources and animals' well-being.

Tax measures should be used not just to reflect the cost of negative externalities but in a positive manner to lower the costs of particular farming practices and certain foods. They should be used to make healthy food produced to high environmental and animal welfare standards economically attractive for both farmers and consumers.

Taxes should be placed on unhealthy, inhumanely produced food with the revenue raised being used to lower the price of healthy food produced to high standards of animal welfare. Farmers producing to high environmental and animal welfare standards could be compensated for the extra costs involved by subsidies and, in their tax affairs, by generous capital allowances and an extra tranche of tax-free income. This could be paid for by placing taxes on the inputs of industrial agriculture such as chemical fertilisers and pesticides.

The costs of making good the adverse impacts arising from industrial livestock production will in the years to come be massive. In some cases they may even not be capable of being made good, for example the loss of soil through erosion. It would in the medium and long term be much cheaper to move to sustainable forms of livestock and crop production than to have to meet the escalating costs of dealing with diet-related disease and repairing the damage to natural resources that arise from industrial agriculture. An analogy can be found in the Stern review on *The Economics of Climate Change* which concluded that "the benefits of strong, early action considerably outweigh the costs".[cxviii] Here too action now to halt the depradations of industrial agriculture will deliver huge savings for future taxpayers.

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Annex: how the costs in the final column of Table 1 were calculated

The first two columns are drawn from Figure 1 in Schader *et al* (2015).[cxix] The third column subtracts the figures in the second column from those in the first column.

The final column calculates the costs arising from the detrimental impacts that are quantified in the third column. These calculations have been made using the data in Table 2 and elsewhere in the FAO report *Food waste footprint: full cost accounting*.[cxx]

GHG emissions: Table 2 of the FAO report suggests a figure of $113/tonne CO2e. 2.4 Gigatonnes CO2e of emissions entails a cost of $271 billion per year.

Freshwater use (for irrigation): Table 2 of the FAO report suggests a figure of $0.1/m^3 for water use and $1.15/m^3 in respect of water scarcity making a total of $1.25/m^3 (see pages 41-42 of the FAO report). 460 km^3 of freshwater use entails an annual cost of $575 billion.

Nitrogen-surplus: Table 2 of the FAO report suggests a figure of $0.286/kg N leached in respect of eutrophication impact on water and $0.0245/kg N applied in respect of eutrophication impact on biodiversity. The annual N surplus of 56.6 million tonnes entails a cost of $17.5 billion per year.

Phosphorus-surplus: Table 2 of the FAO report suggests a figure of $12.32/kg P leached in respect of eutrophication impact on water and $0.26/kg P applied in respect of eutrophication impact on biodiversity. The annual P surplus of 25.6 million tonnes entails a cost of $322 billion per year.

Pesticide use: The paper by Schader *et al* does not specify a unit for measuring pesticide use. However it shows that pesticide use would be much higher in 2050 under BAU than if the use of cereals as feed was ended. The FAO paper on food waste estimates the adverse health effects due to pesticide exposure attributable to the production of food that is then wasted to be $153 billion per year.

The FAO paper estimates that approximately one-third of food produced for human consumption is lost or wasted. Studies show that for every 100 calories of cereals fed to animals just 17-30 (an average of 23.5) calories enter the human food chain as meat.[cxxi] [cxxii] The effect of this is that 76.5% of cereals fed to animals are lost due to animals' poor conversion of cereals into meat. 36% of global cereal production is fed to animals; 76.5% of this is lost. This means that 27% of global cereal production is lost by being used as animal feed.

To sum up, 33% of food is lost or wasted in the conventional sense (e.g. post harvest losses, food discarded by consumers). A roughly similar figure - 27% - of global cereal production is lost by being used as animal feed. The FAO estimates the adverse health effects due to pesticide exposure attributable to the production of food that is then wasted to be $153 billion per year. A substantial proportion of pesticides are used in cereal production. This paper takes a cautious approach and presumes that if the pesticide impact on health of growing food that is then wasted is $153 billion per year, the pesticide impact on health of that proportion of cereals used as animal feed that does not produce meat is $38 billion per year (25% of $153 billion).

Deforestation: Table 2 of the FAO report suggests a figure of $1611 per hectare of forest lost for loss of ecosystem services from deforestation. The annual loss of 700,000 hectares of forest entails a cost of $1.1 billion per year.

Soil erosion from water: Table 2 of the FAO report suggests a figure of $21.54/ton of soil lost by water erosion. The annual loss of 4.6 billion tonnes soil entails a cost of $99 billion per year.

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