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Citi Innovation Insights

Alternative Proteins

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A category with great potential

This is the second *Innovation Insights* report. It explores the economic opportunity in alternative proteins – replacements for milk and meat. Currently most of these come from plants, but it is also beginning to be possible to grow cultured meat and milk in labs.

We think this is a sector with great potential, both economically, and because livestock farming creates many issues, around greenhouse gases, biodiversity and animal welfare. However, it's important to realize that most consumers buy alternative proteins mainly because of the perceived benefits around taste, health and (potentially) price, not for environmental reasons.

Furthermore, if alternative proteins really are successful, they would threaten rural communities worldwide. We therefore believe governments will need to find a way of mitigating the pressures, if there is not to be a considerable political backlash.

We expect alternative proteins to deliver rapid growth . . .

Last year alternative protein's retail sales totaled about $17 billion in North America and Europe as Figure 1 shows. That's about 15% more than the retails sales for sports protein in the same geographies, but about 25% less than sales for reduced risk nicotine products.

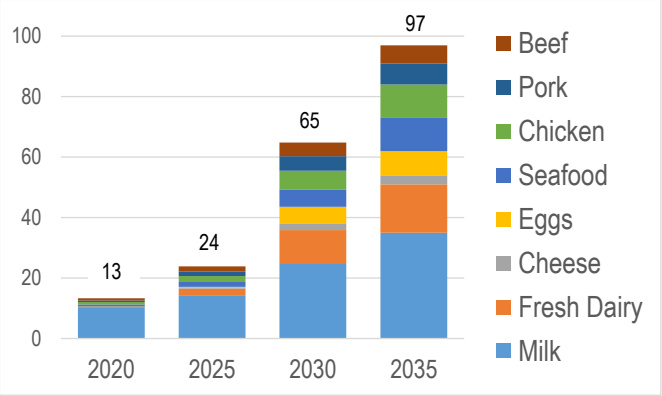
However, there's also the alternative proteins sold in food service, for example burger patties in fast food chains and milk in coffee shops. Most years that adds volumes equivalent to about a quarter of the retail volume, but last year wasn't normal because of Covid, so food service added only 15% to total volumes.

Figure 1. Retail Sales of Alternative Proteins in N America and W Europe, 2020 ($ in billions)

	Retail Sales	Growth	
	2020	**2019**	**2020**
Plant-based meat	3.9	14%	28%
Plant-based milk	6.1	3%	17%
Margarine	6.7	-6%	6%
Total plant-based	**17**	**12%**	**51%**
Sports protein	15	7%	0%
Reduced Risk Nicotine	22	36%	13%

Source: Euromonitor

Figure 2. BCG/ Blue Horizon Base Case Forecast for Alternative Proteins (Millions of metric tons)



Source: BCG/ Blue Horizon

Alternative proteins are growing very fast, especially for meat replacements. Plant-based milk sales in U.S. retail were almost 30% higher in 1Q21 than they were in 1Q19 and plant-based meat sales were more than 60% higher. And we have seen one report which implies the alternative proteins could grow at somewhere between 20% and 40% compound during the next 15 years, depending on the degree of government support[1]. That would still leave alternative proteins accounting for between only 11% and 22% of the total market, however.

[1] The forecast was made in a joint report by Blue Horizon (which is a specialist fund investing in alternative proteins) and Boston Consulting Group.

And we expect good margins . . .

In food, as a general rule, higher margins come to products that are highly processed. We therefore think alternative proteins should be able to deliver good margins over time, unlike the products they are replacing – milk and mass-market meat – which are low-margin commodities.

. . . although that isn't guaranteed

So far scale has not provided lasting competitive advantage. In both alternative milk and alternative meats there has been a pattern whereby a brand grows only to lose share to a newcomer after a year or two. In alternative meats in the U.S., for example, Morning Star Farms was the dominant player but two years ago Beyond started growing rapidly, and now Impossible is growing fastest. In milks, Silk was the most important brand, but now Oatly is growing fast.

This may demonstrate that consumers turn to technically superior products, and that any company that can truly master the technology should end up in a very strong position. But it is possible to look at the same evidence and conclude that the industry is being driven by fads, in common with many other food and beverage categories.

Figure 3. A plant-based burger

Source: Impossible Foods

Important contrasts with digital innovations

There are important contrasts between alternative proteins and digital innovations:

- **Greater capital intensity**: The capital required for alternative protein start-ups is higher, because the companies need to develop genuinely new technologies, especially in cultured products. Early stage VC investments in cultured products have averaged $9.5 million during the last three years, more than double the average across all early stage VC investments[2].
- **Smaller advantages from scale.** We do not expect alternative protein businesses to enjoy the scale advantages seen in many digital businesses. Food and beverages are not winner-take-all markets, and marginal costs are always important. This is quite different from digital businesses like Airbnb (to take one example.) In many digital businesses the No1 or No2 players typically gain a huge advantage from having the most data, and often the marginal cost to serve an additional customer is negligible.
- **Greater political pushback.** Unlike many digital innovations, alternative proteins are designed to directly disrupt an existing industry – livestock and poultry farming – which is the lynchpin of the rural communities. (Figure 6 shows that about 60% of the UK's land area is devoted to cattle and sheep in the UK, for example.) The alternative protein industry is therefore likely to face a greater political backlash. In the EU, for example, it is already illegal to use the word "milk" on the packaging of any plant-based product, and it looks likely that further restrictive laws will be introduced.

But alternative proteins also bring large environmental benefits

If alternative proteins do replace consumption of animal products, there should be considerable benefits despite the opposition we expect from farmers. Livestock farming has a disproportionately heavy impact on the environment, and mass market farming also raises serious issues around animal welfare. Beef, for example, typically contributes almost 100x more greenhouse gas per calorie of food than cereals, and uses about 20x as much water. The expansion of livestock farming is also linked to biodiversity loss – it's responsible for about 40% of tropical deforestation[3]. Figure 5 shows the extent to wild animals have been squeezed, relative to animals used by humans.

The actual drivers are taste, health, and (potentially) price

However, the main reasons consumers actually buy alternative proteins at the moment are that they believe they taste better and are healthier, not for ethical reasons, especially in the U.S.[4] Further sales growth is likely to be driven mainly by (1) improvements in the taste and texture and (2) lower price points. Increased availability in large-scale foodservice chains like McDonald's and Starbucks boosts trial, which is clearly helpful.

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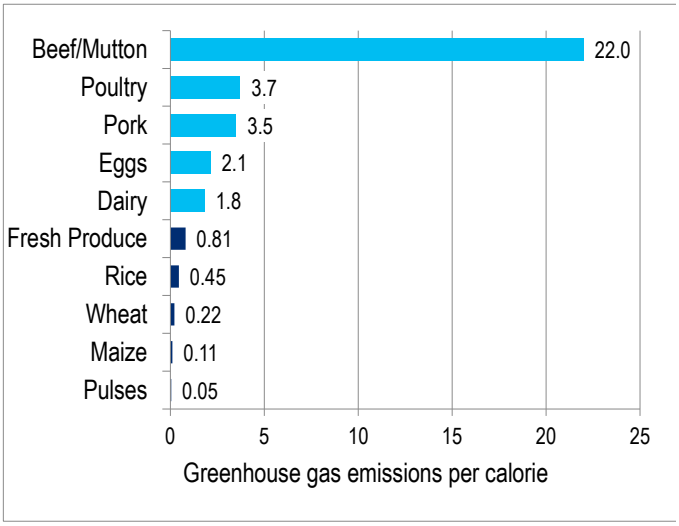
[2] Source: Pitchbook

[3] Sources for this paragraph are Our World in Data, Clarke and Tilman, Water Footprint Network, and Pendrill.

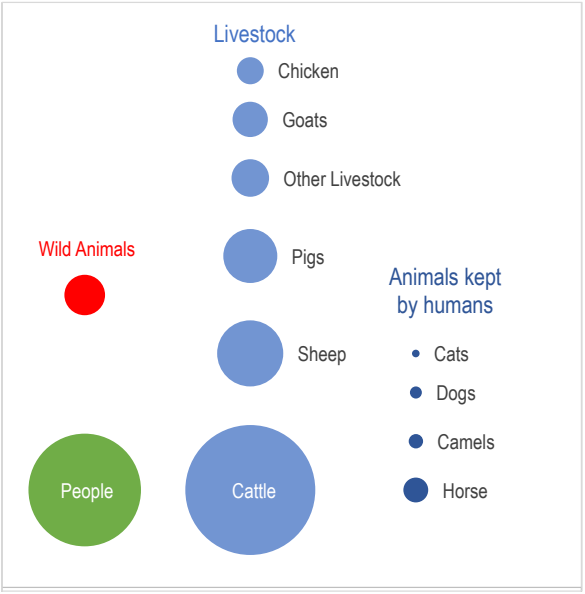
[4] A Mintel survey found the main reasons for choosing plant-based food are taste (52% of those who eat plant based proteins) and health (39%). Concerns about the environment were a driver for only 13% of consumers and concerns about animal welfare for only 11%.

Figure 4. Typical greenhouse gas emissions per calories by food type (gCO_2/kcal)



Note: Our World in Data, Clarke and Tilman (2017), Citi GPS

Figure 5. Wild Animals vs Humans and Animals Used by Humans – Current Biomass Globally



Terrestrial animals only. Source: UK National Food Strategy Plan

What are the risks to the story?

The biggest risk we see is around the perceived health benefits. At the moment plant-based products are generally seen as healthier than animal-based ones, and this clearly helps sales. If that perception changes, however, we'd expect sales to slow and perhaps even reverse.

And perceptions of what constitutes a healthy diet have changed dramatically in the past. Plant-based butter – otherwise known as margarine – used to be widely considered as healthier than butter, for example, but it isn't anymore, and as a result sales are falling globally.

Furthermore there is a tension because consumers increasingly believe "natural" products are healthier than highly processed ones, and alternative proteins do require new technologies, creating tension with the "natural" megatrend.

Another potential problem is that governments may start to discourage the sector's growth. Most farmers (and rural communities) are set to be losers from alternative proteins, but they form a powerful political lobby. Politicians have already started to regulate against alternative proteins in Europe and this could well spread.

Cultured products are entirely new, and therefore need regulatory approval. However there is not yet a clear regulatory pathway in any market. In the U.S. the Department of Agriculture will be involved in their regulation, and may end up being more sympathetic to farmers than to start-ups.

What could cause the growth to accelerate?

On the other hand we see several ways in which growth could accelerate:

- If consumers started to believe there was more of a health benefit than they currently think;
- If governments acted to accelerate the change, perhaps by imposing a carbon price on farmers while simultaneously offering subsidies to switch away from livestock; or
- If there were a cultural change resulting in many more consumers making actual purchase decisions purely on ethical grounds.

To be clear, however, we think there are more votes in protecting farmers and rural communities than there are in promoting alternative proteins, and therefore we think it is more likely that politicians will act as a brake on change, rather than try to accelerate it.

We also think that if mainstream consumers do start to focus on ethical issues more, it is more likely that they will be motivated by animal welfare than by reducing greenhouse gases. After all consumers are spending more and more on pets, but demand for air travel continues to rise, despite its CO_2 emissions.

Some meat processors and dairy companies have taken stakes in alternative protein companies

Clearly meat processors and dairy companies are directly threatened by the rise of alternative proteins. Many have taken stakes in some of the start-ups. Danone, the world leader in yogurts, for example, bought Whitewave, the leader in plant-based milk in the U.S., for $12.5 billion. Cargill is the largest U.S.-based meat processor, and it has invested about $1½ billion in a variety of companies, including two of the leading cultured meat companies – Upside Foods and Aleph Farms.

Farming subsidies will need to change to protect rural communities

Alternative proteins (and aggressive carbon reduction targets) do present a challenge to farmers, especially genuinely commercial famers serving the mass market.

Already many farmers, especially in Europe[5], rely entirely on subsidies and over time, we expect that where subsidies are paid, the emphasis will switch further towards environmental goals and away from production.

But farming animals isn't likely to disappear soon: the most optimistic forecast[6] we have seen is that 45% of the meat market will move to alternative proteins by 2035, although other forecasts suggest it will be closer to 10%.

What's in this report

This report covers a lot of ground. Among other things it analyses

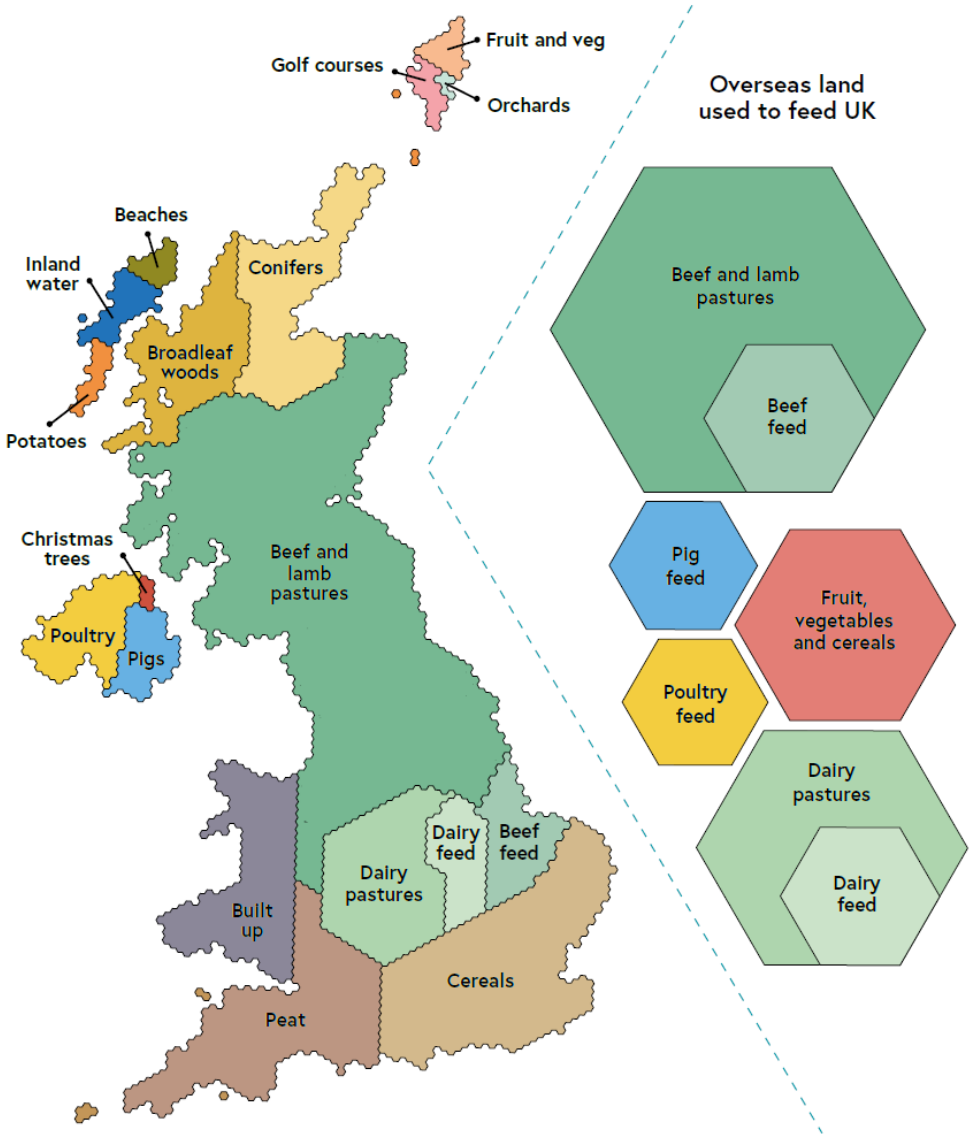
- The benefits of the technology, starting on page 9
- The economic opportunity, with a particular focus on potential margins (from page 14)
- The environmental benefits (page 21)

[5] In Europe, most livestock farmers make a loss from agriculture, selling their animals for less than then cost of the inputs.

[6] Or the most pessimistic forecast, depending on your point of view

- The true growth drivers (page 24)
- The implications and options for the potential losers here – the existing livestock faming and processing industries (page 29).

Figure 6. Current land use in the UK, including overseas land required to feed the UK



Source: National Food Strategy (based de Ruiter, and Poore and Nemecek)

Understanding the technology: dairy vs. meat; and plant-based vs. cultured and fermented

Alternative proteins can be divided by category: dairy vs. meat

Alternative proteins cover two broad product categories:

- Alternatives for **dairy** (milk, yogurt, ice cream); and
- Alternatives for **meat** and **fish**, especially ground meat and fish, for example for burgers, chicken nuggets and, potentially, fishcake.

In dairy the main focus so far has been liquid milk, although there is momentum in plant-based yogurt and ice cream.

Plant-based butter (in other words margarine) is usually considered separately because it has been common for decades and is now in decline. However, the fact that it is a counter-example to the general success of plant-based products means that it is important not to forget it.

In North America and Europe alternative milks account for 14% of the overall retail market for liquid “milk”. It’s a much smaller percentage for other dairy products like cheese, yogurt and ice cream.

By contrast, meat alternatives account for less than 3% of the overall “meat” market, according to Euromonitor. This means that meat alternatives have more growth potential, at least in theory.

Figure 7. U.S. Retail market size for alternative proteins in millions of dollars

Plant-Based	2020 Retail Sales	Proportion	2020 Growth
Milk	$2,500	36%	20%
Meat	1,400	20%	45%
Meals	520	7%	30%
Ice-Cream	430	6%	20%
Creamer	390	6%	30%
Yogurt	340	5%	20%
Protein Liquids/Powders	290	4%	10%
Butter	270	4%	35%
Cheese	270	4%	40%
Tofu & Tempeh	175	3%	40%
Baked Goods	150	2%	0%
RTD beverages	140	2%	10%
Condiments	80	1%	25%
Spreads/ Dips	60	1%	80%
Eggs	30	0%	170%
	$7,000	**100%**	**27%**

Source: SPINS/ Good Food Institute

They can also be split by technology: plant-based vs. cultured and fermented

It is also useful to divide alternative proteins by underlying technology:

- **Plant-based alternatives**: The aim is use “biomimicry” to create a product that tastes, smells and looks like dairy or meat, but that is much kinder to the environment, animals, and people. Most alternative protein companies focus on plant-based alternatives.
- **Cultured meat and milk** can be thought of as lab-grown. It is “meat” or “milk” produced directly from cells, using the same biological process that occurs when animals build muscles or milk proteins. So far this type of technology is nascent only. Most companies are still developing the technology; only a few have begun to scale up production. In Singapore it is now possible to buy “chicken nuggets” made from a mixture of cultured and plant-based meat from a handful of outlets.
- **Fermentation** uses yeast and other micro-organisms to transform products (for example making beer and yogurt), or to create new ones (e.g. Quorn). Precision fermentation uses fungi to make specific proteins (e.g. insulin), enzymes, flavor molecules, vitamins, pigments, and fats, and these in turn can be used to help improve plant-based or cultured products. In dairy, for example a U.S. start-up called Perfect Day is using fungi to make “milk” proteins, but without lactose.

Figure 8. The cultured ribeye steak made by Aleph Farms

Source: Aleph Farms

These three technologies can be combined. Cultured meats and fats can provide better flavor but plant-based meat provides bulk at lower cost. Hoxton Farms, Future Meat Technologies and Artemys Foods all mix cultured and plant-based in their meats. Impossible Foods uses fermentation to create heme to add flavor and meatiness to its otherwise plant-based meat.

Most of this report focuses on plant-based products because they are the ones in the market currently. However we compare the pros and cons plant-based and cultured products on page 27.

Figure 9. Capital raised in start-ups by type of alternative protein, 2010 to 2020

	Invested Capital		Largest Round		
	2010-20	2020			
Plant-based	$4.4 bln	$2.1 bln	$500 mln	Impossible Foods	Series F
Fermented	$1.0 bln	$590 mln	$300 mln	Perfect Day	Series C
Cultivated	$490 mln	$360 mln	$186 mln	Memphis Meats	Series B

Note: Memphis Meats has been renamed Upside Foods. Source: Good Food Institute

Alternative proteins can be improved in a way that traditional ones can't

One of the advantages of alternative proteins is that they can be changed, to enhance their flavor, nutrients, or other properties. For example, cultured meat can be made with different muscle-to-fat ratios, and to introduce omega-3 fats and other nutrients.

By contrast, a particular breed of cattle or type of chicken doesn't vary over the decades.

How complicated is the technology?

There is a continuum in the technology: At one end of the scale it's possible to make a basic plant-based milk simply by soaking oats or almonds in water, putting them in a food processor and then filtering the pulp.

The process for commercial plant-based diary companies is a bit more complicated than this, however, because they use enzymes[7] to improve their products in terms of taste, nutritional content, "mouth feel".

At the other end is mass-producing a "T-bone steak", with the taste, texture and cooking properties of the real thing. There is still a long way to go until the technology for this is mastered at an acceptable cost. That said, Aleph Farms made a ribeye steak earlier this year, using bio-printing. This proof-of-concept product incorporated "real muscle, fat, and [a] vascular-like system similar to a ribeye from a slaughtered cow" the company said[8].

Plant-based meats lie between the two extremes. There are decent commercial examples already in the market, and they are a long way from anything that is possible to make in a typical domestic kitchen. However almost all the products on the market replicate ground meat, for example burgers, sausages and chicken nuggets. These products aren't as sensitive on either taste or texture as cuts of meat, because they are typically consumed with other strongly-flavored ingredients (e.g. onions) and condiments (e.g. ketchup).

Currently about 40% of beef consumed globally is ground, used in lasagna, nachos, pasta sauces and dim sum/ dumplings, among many other dishes.

[7] Enzymes are biological catalysts that bring about specific biochemical reactions. They are very common too: for example amylase (which is found in saliva) helps turn starch into sugars. The specific enzymes required for improving plant based milk can be developed in-house, or bought off-the-shelf from specialist providers.

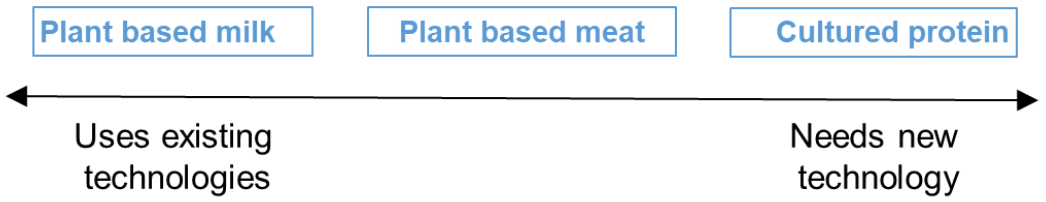
[8] Aleph Farms: We reveal worlds first cultivated ribeye steak

There is a clear commercial implication from Figure 10:

- The more a product is on the left of the scale, the more the business risk revolves around the question: “Can you create and sustain competitive advantage from taste and brand equity?”
- The more the product is on the right, the more the business risk is around the technology: “Can you actually make the product work in the way you want?”

Plant-based meat, sitting in the middle, needs to answer both questions.

Figure 10. Degree of technical innovation required



Source: Citi Global Insights

Milk and meat alternatives are two distinct economic stories

Meat alternatives

With alternatives to meats, consumers generally want products that are as close as possible to the conventional products, in taste, texture, and cooking properties, which means creating good meat alternatives is much harder technically. As a result only 3% of fresh meat sales have migrated to alternatives. This implies, that to the extent the technical challenge can be overcome, there is likely to be more upside, especially if the product can both taste good and be sold at lower prices than conventional meat.

As with all sectors where the underlying product is most important, there is likely to be significant competitive advantage to those with the best product, but with the risk of effective competition from an entrant with a better or cheaper product.

Dairy alternatives

Unlike with meat alternatives, many consumers prefer the taste of certain plant-based milks to animal milk, depending on the occasion. Furthermore it is relatively easy to make plant-based milk. The result is that the technical aspects of the product are less important, and the brand equity is more important. Creating durable brand equity is hard, but if a company can get it right it can be a much more durable driver of margins than technology, as Coca-Cola and Heineken show in soda and in beer.

Figure 11. Plant-based burgers

Source: Impossible Foods

A large economic opportunity

Last year retail sales for milk alternatives were about $6 billion in North America and Western Europe, and meat alternatives were about $4 billion, according to Figure 12. When we include margarine sales, total plant-based protein sales were about $17 billion, up 15% on the year before. Retail sales for milk and meat alternatives are roughly evenly split between Europe and North America, according to Euromonitor, but margarine is biased to Europe.

To put this in context, retail sales for sports protein in the same geographies was about $15 billion last year, and the reduced risk nicotine sales were about $22 billion.

As we say these numbers are for retail sales, and they come from Euromonitor. But there is also foodservice sales – for example meat sales in quick service restaurants and milk sales in coffee shops. According to Euromonitor in 2019, food service added 75% to alternative meat volumes and 11% to alternative milk volumes[9].

Figure 12. Alternative Protein vs. Sports Protein and Reduced Risk Nicotine – Retail Sales in N America and W Europe ($ in billions)

	Retail Sales		Growth	
	2019	**2020**	**2019**	**2020**
Alternative Proteins				
Plant-based Meat				
N America	1.4	2.0	23%	40%
W Europe	1.7	2.0	8%	17%
Total Meat	**3.1**	**3.9**	**14%**	**28%**
Plant-based Milk				
N America	2.7	3.1	2%	14%
W Europe	2.5	3.0	5%	21%
Total Milk	**5.2**	**6.1**	**3%**	**17%**
Margarines				
N America	2.0	2.2	-5%	10%
W Europe	4.4	4.6	-6%	4%
Total Margarine	**6.4**	**6.7**	**-6%**	**6%**
Total Dairy	**11.6**	**12.9**	**-2%**	**11%**
Total Alternative Proteins	**14.7**	**16.8**	**1%**	**15%**
Sports Protein				
N America	12.6	12.6	7%	0%
W Europe	2.2	2.3	6%	2%
Total Sports Protein	**14.8**	**14.8**	**7%**	**0%**
Reduced Risk Nicotine				
N America	11.1	11.4	50%	3%
W Europe	8.1	10.2	20%	27%
E Vapor	16.2	16.3	27%	1%
Heated Tobacco	2.5	4.2	85%	70%
Oral Nicotine Pouches	0.5	1.1	>100%	>100%
Total Reduced Risk Nicotine	**19.1**	**21.7**	**36%**	**13%**

Source: Euromonitor

[9] It's not useful to compare the dollar sales in foodservice to dollar sales in retail.

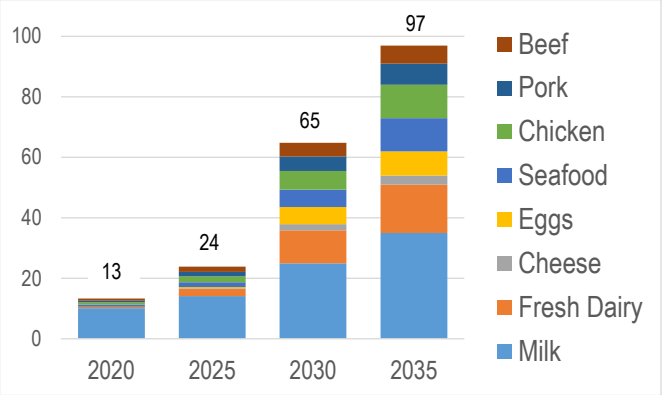
Observers are very optimistic long-term growth, although forecasts vary widely

The category is therefore fairly large, and growing nicely. But what are the long-term forecasts?

We have seen reports by two consultancies, and they both say they expect strong growth in on a 15-year view, but there is a wide range of estimates, which shows just how difficult it is to forecast this category over the long term.

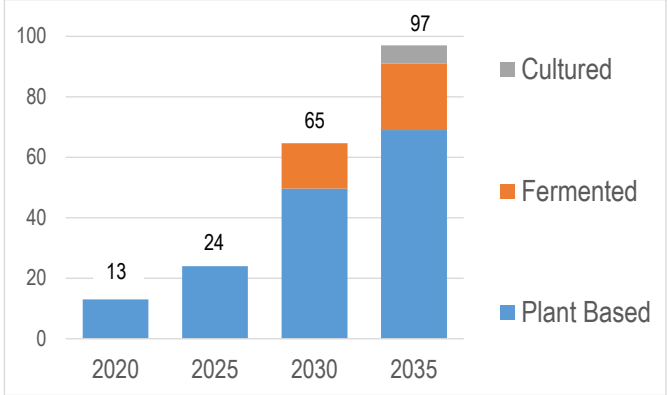
- Figure 13 shows the base case forecast from BCG and Blue Horizon (which is a specialist fund investing in alternative proteins). They forecast that by 2035, about 11% of all protein consumption will come from alternatives. Of this total, they forecast that 56% of the volume (by weight) will be dairy products but that meat and seafood will be growing faster. This forecast equates to about $290 billion in retail sales, implying about 20% compound growth during the next 15 years. Figure 14 cuts the same forecast by technology, and what is striking is that these companies expect cultured products to contribute only 6% of total volumes in 2035.
- However BCG and Blue Horizon say that with government support for alternative proteins and with environmental charges levied on conventional farmers, total volumes could be double their base case in 2035, equivalent to 22% of all proteins consumed.
- A separate report by Kearney focusing only on meat gives quite a different outlook, because it says that by 2035 cultured meat will effectively generate the same sales as plant-based meat, with the combination representing about 45% of the global meat market.

Figure 13. BCG/ Blue Horizon Base Case Forecast for Alternative Proteins (Millions of metric tons)



Source: BCG/ Blue Horizon

Figure 14. BCG/ Blue Horizon Base Case Forecast for Alternative Proteins (Millions of metric tons)



Source: BCG/ Blue Horizon

Demographic trends support growth

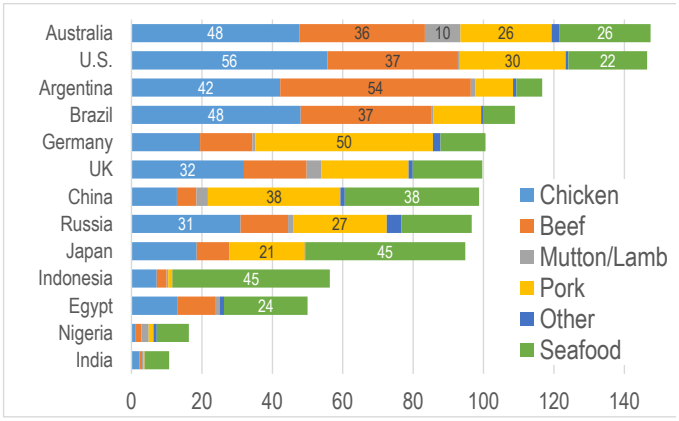
One reason to be optimistic about alternative proteins is that young people consume more than their elders. About 75% of 15-29 year olds are willing to eat alternative meats, whereas more than half of those aged 60+ say they never eat meat alternatives[10]. And the numbers are increasing: 23% of consumers said in the 2021 survey that they are trying to reduce their consumption of traditional meat, up from 21% in 2019. (By contrast 15% said they are trying to limit their intake of traditional dairy products.)

[10] Euromonitor global survey on health and nutrition, 2021

Demand is likely to vary by market

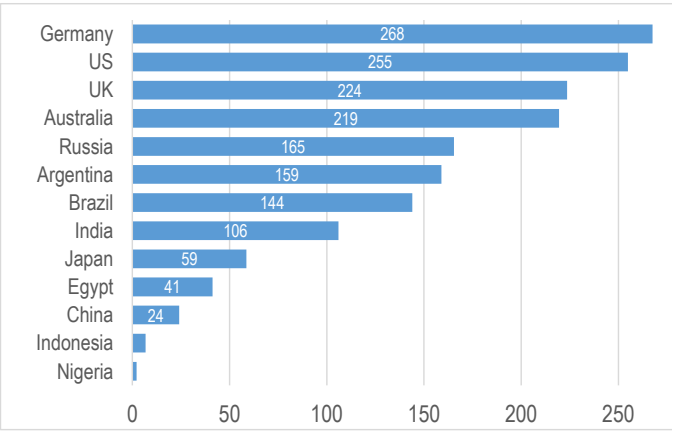
Currently per capita consumption of meat and milk varies considerably, as the charts below show, so it is likely that demand for protein alternatives will also vary.

Figure 15. Consumption of different types of meat – selected markets (kg per person per year, 2017)



Source: Our World in Data

Figure 16. Milk consumption (liters per person per year, 2017)



Source: Our World in Data

We expect the category to generate good margins

The category's economic potential also depends on margins, of course, and currently the EBITDA margins of the quoted alternative protein companies are quite low, relative to established food companies. We don't worry about this because these companies are in an expansion phase and their gross margins are in the 30s. (In fact it would be worrying if their EBITDA margins were too high, as that would imply the companies weren't investing much in growth.)

Figure 17. Selected Food Companies – Sales Growth and Margins

	Sales				Gross margin		Adj EBITDA margin		Capex
	Abs $ MM	Growth							Abs $ MM
	2000	2020	2021	2022	2019	2020	2019	2020	2020
Alt Protein									
Oatly	421	106%			33%	31%	-15%	-11%	134
Beyond	407	37%	42%	40%	33%	33%	8%	3%	58
Other Food									
Simply Good Foods	817	56%	15%	5%	42%	41%	18%	19%	2
Kellogg	13,770	1%	0%	2%	34%	34%	17%	17%	505
Campbell	8,691	7%	-3%	0%	33%	35%	21%	20%	299
JM Smucker	7,801	0%	3%	-3%	38%	38%	20%	22%	269
Post Holdings	5,699	0%	4%	4%	32%	31%	21%	19%	235

Source: Company reports and Citi Research Estimates

For the long-term, it is possible to be quite pessimistic, because real milk and mass marker meat are low-margin commodities. However, we think that this will turn out to be the wrong comparison, because alternative proteins are processed foods, not agricultural commodities.

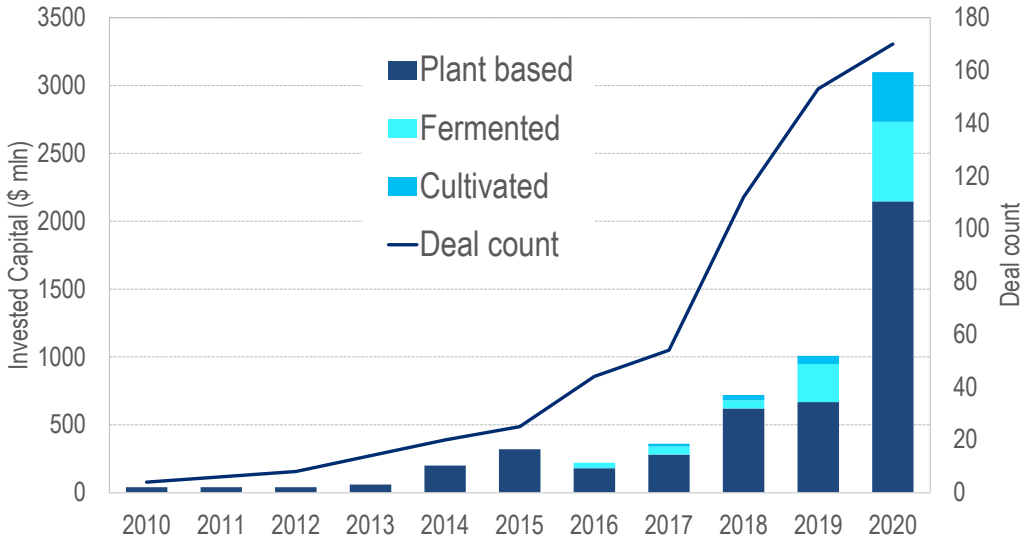
In dairy gross margins can range from the low double digits, up to 40% or more, according to a report published by Cédric Besnard, Citi's European Food analyst[11]. In general the more processing that's done, the higher the margins tend to be.

"This follows the general pattern you see in the food industry – it's usually the case that the more a product has been transformed and processed, the better the gross margins are," Cedric says. "If I had to guess about margins in 2035, I would say alternative meats could see gross margins perhaps in the high 30s, or even 40s and I think that maybe the more processed alternative dairy products could be in the mid-40s."

There was a sharp increase in capital raised last year

Like most other new industries, alternative proteins is attracting more and more capital, as Figure 18 shows. This seems to have continued into 2021: Pitchbook data show the capital raised in the broader FoodTech sector totaled $16 billion by mid-June -- 86% of 2020's total.

Figure 18. Capital Raised in Alternative Protein, 2010 to 2020



Source: Good Food Institute

It appears the capital required for start-ups is higher in alternative proteins than in many other sectors, perhaps because the companies need to develop genuinely new technologies, especially in cultured products. Pitchbook reports that early stage VC investments in cultured products have averaged $9.5 million during the last three years, vs an average of $3.9 million across all industries.

[11] See Danone – Deep Dive (13 May 2020)

Brand dynamics – incumbency has not proved to be an overwhelming advantage

One of the things that is striking about alternative proteins is that brand leadership has changed several times. The sector is quite different from many digital industries, where the No1 and No2 players can gain a large competitive advantage by gathering more data, more quickly.

- **In alternative milk,** U.S. retail was dominated by Silk and Blue Diamond, but these are falling rapidly due to Oatly and "All other brands" as Figure 19 shows. In the UK, Oatly has risen from 7% share at the start of 2018 to 27% in at the end of 2020. In Germany, Oatly has risen from 0% in 2018 to 23% now.
- **In alternative meats** in U.S. retail, Morning Star is also falling rapidly, with the major growth coming first from Beyond and then from Impossible.

Figure 19. Alternative Milk Brands – Market Share in U.S. Retail

Brand	Owner	2017	2018	2019	2020	YTD21
SILK	Danone	39.3%	36.4%	34.6%	31.0%	29.1%
BLUE DIAMOND	Blue Diam'd Growers	28.2%	29.1%	28.5%	27.8%	25.9%
CALIFIA	Califia Farms	4.8%	5.1%	5.4%	5.8%	6.2%
OATLY	Oatly	0%	0.2%	1.5%	3.4%	4.4%
SO DELICIOUS	Danone	2.7%	3.1%	2.1%	1.7%	1.4%
RICE DREAM	Hain Celestial	2.2%	1.9%	1.6%	1.4%	1.1%
PRIVATE LABEL	Various	15.5%	15.9%	16.8%	16.1%	15.7%
All other brands	Various	22.7%	24.2%	26.3%	29.0%	31.9%
		100%	**100%**	**100%**	**100%**	**100%**

Note: Reddish shading = rising share; bluish = falling share.
Source: Scanner data

Figure 20. Alternative Meat Brands – Market Share in U.S. Retail

Brand	Owner	2017	2018	2019	2020	YTD21
MORNINGSTAR FARMS	Kellogg	40.8%	38.9%	35.2%	30.0%	29.5%
BEYOND MEAT	Beyond	5.3%	8.9%	16.7%	20.6%	19.8%
IMPOSSIBLE	Impossible Foods	0%	0%	0.3%	3.1%	7.0%
GARDEIN	ConAgra	7.5%	7.8%	6.8%	6.3%	5.9%
LIGHTLIFE	MapleLeaf Foods	7.1%	7.0%	6.2%	5.9%	4.9%
BOCA	Kraft Heinz	6.7%	5.3%	4.6%	3.7%	3.1%
FIELD ROAST	Field Roast	2.9%	3.9%	3.6%	3.0%	3.0%
QUORN	Monde Nissan	3.4%	3.5%	3.0%	2.5%	2.4%
PRIVATE LABEL	Various	3.8%	4.0%	4.4%	4.9%	5.2%
All other brands	Various	22.7%	20.7%	19.3%	20.0%	19.3%
		100%	**100%**	**100%**	**100%**	**100%**

Note: Reddish shading = rising share; bluish = falling share.
Source: Scanner data

But does the rapid growth recently of brands like Impossible and Oatly (and the correspondingly loss of share of certain other products) show that this category is driven by fads, or does it show genuinely better products can build and sustain a competitive advantage?

Fads are certainly common in the food and beverage industries. Hard cider is an example of a category that grew very fast for a couple of years and appeared quite durable, partly because of its “natural” and “no gluten” claims, but it eventually declined almost as quickly as it came. The Atkins diet was also very popular for a while; but now has almost entirely disappeared.

At this stage it is impossible to know for sure, but we think the answer may be different in the two categories.

As we have said, creating a new type of milk is easier technically than creating a new type of meat, and consumers often prefer a taste that’s slightly different from conventional milk.

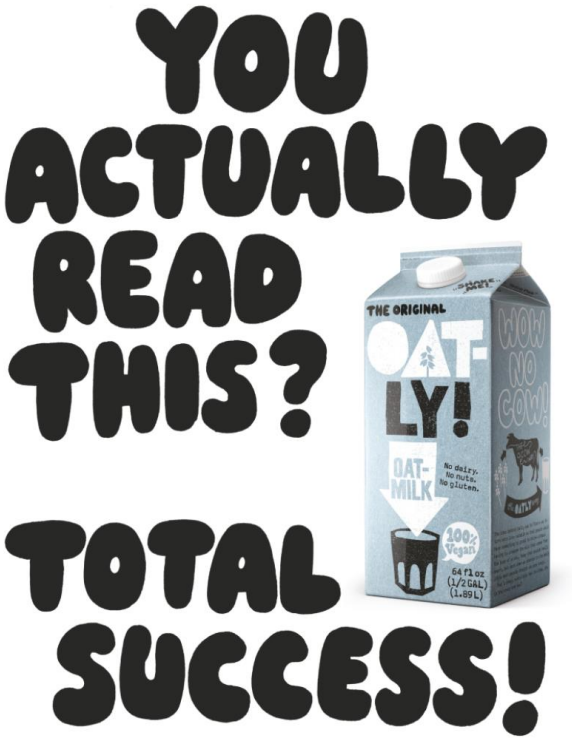
There’s another point that comes out of Figure 19 and Figure 20: almost half of all milk alternatives sold in the U.S. are either private label, or very small brands, but it’s only about a quarter of all meat alternatives. Does this mean there is lots of room for the big brands to grow in milk alternatives? Or does it mean that it is really hard to sustain brand equity?

Either way we believe that brand image is the most important driver in milk alternatives, and this hasn’t always been stable over time. Oatly has done well in the past few years – we think its marketing campaigns are very striking. It will be interesting to see how its brand equity develops in future.

Figure 21. Oatly marketing

Source: Company reports

Figure 22. Oatly marketing



Source: Company reports

Building a really convincing replacement for meat is the greater technical challenge, and therefore we assume that having a really good product is a bigger competitive advantage there. It is noticeable that in Figure 20 only Beyond Meat and Impossible have been able to sustain market share gains, and their products retail at a very significant premium to brands like Morning Star[12].

But if that is the case, we would assume that, just as in tech, there will be waves of innovations that change the industry dynamics. It is possible to view the success first of Morning Star, then Beyond, and now Impossible as illustrating this.

Furthermore some of the largest traditional food companies are now muscling in, thanks to the combination of their financial power, R&D facilities, consumer understanding and worldwide distribution muscle.

We believe global scale is an advantage in foods. Beyond seems to agree, because earlier this year it announced global partnership deals with both PepsiCo and McDonald's, two much larger companies with worldwide reach.

The large food mega-caps have traditionally stressed their ESG credentials, science-driven product development and global reach. Will they be able to succeed in this space? Or have the investment in intellectual property made by Oatly, Beyond Meat and Impossible created sufficiently strong barriers to entry that other players will be locked out?

[12] Impossible's products retail at an average of about $10.40/pound, Beyond's at about $10.40, and Morning Star at $6.60.

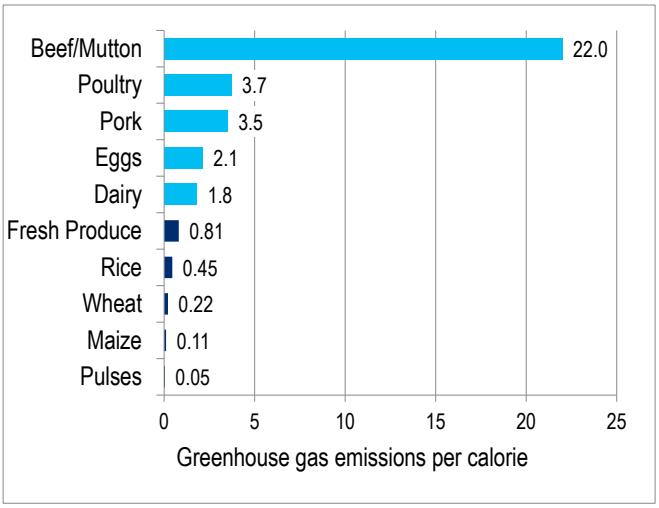
Plant-based proteins bring important enviromental and animal welfare benefits

The traditional livestock industry has serious issues

As our colleagues Jason Channell, Ying Qin and Anita McBain have discussed[13], the livestock industry is responsible for:

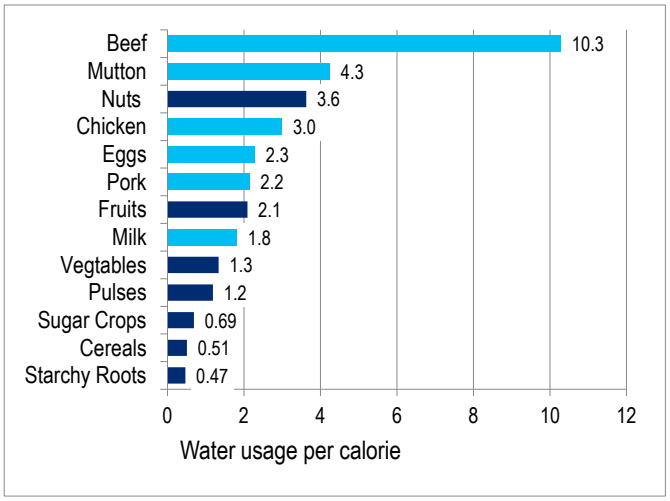
- **A disproportionate amount of greenhouse gas emissions and water usage** as shown in Figure 23 and Figure 24.
- **Deforestation and biodiversity loss:** The expansion of pasture land for cattle accounts for about 40% of tropical deforestation which is around 2.1 million hectares a year.[14] Figure 25 shows just how much wild animals have been squeezed by humanity.
- **Serious ethical concerns about animal welfare:** The cheapest meat comes from intensive farming that encourages rapid weight-gain through growth hormones and non-traditional foods. Large-scale feed-lot farms contain 1,000s of animals held in pens that prevent them from moving freely, thereby accelerating the weight gain.
- **Zoonotic diseases:** Intensive farming increases the risk of disease developing in livestock or poultry, and then spreading to humans. All parties have become much more concerned about this issue as a result of the Covid pandemic.

Figure 23. Typical greenhouse gas emissions per calories by food type (gCO_2/kcal)



Note: Our World in Data, Clarke and Tilman (2017), Citi GPS

Figure 24. Typical water usage by food type (liters per kcal)



Source: Water Footprint Network, Citi GPS

[13] Please see Jason's first Sustainable Tipping Points report and the recent Biodiversity Citi GPS report.

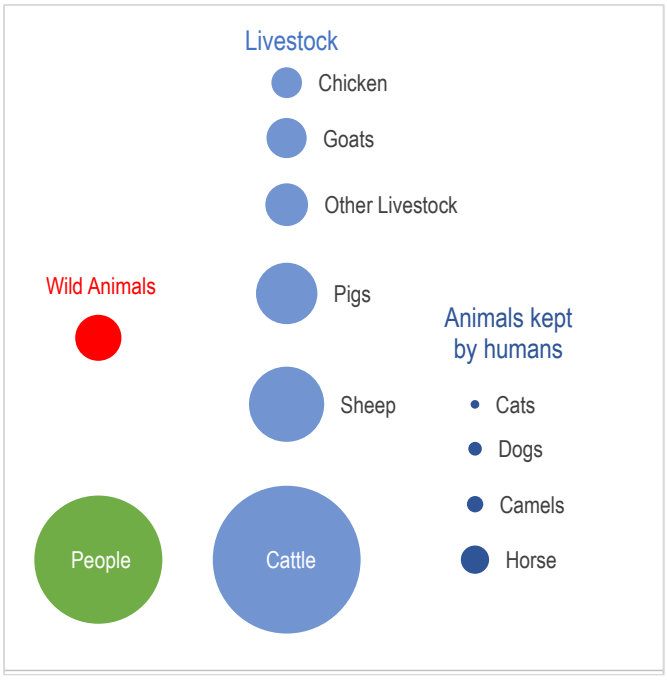
[14] Global Environmental Change, 2019. Pendrill, F. et al. Agriculture and forestry trade drives large share of tropical deforestation emissions.

Different forms of agriculture contribute to these problems in different ways.

As a side point, it's important to note that different types of livestock agriculture contribute to these issues differently, and there is clearly a tradeoff between greenhouse gas emissions and animal welfare.

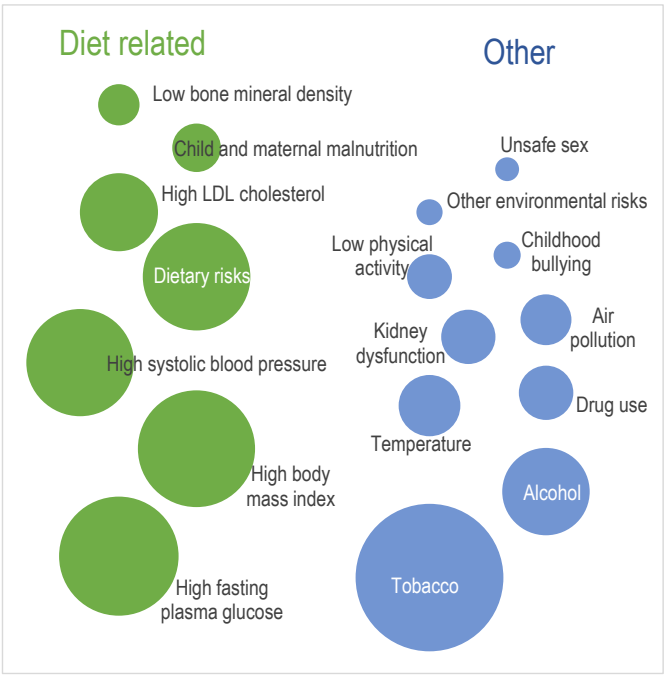
- To minimize greenhouse gas emissions and to reduce the threat of deforestation, it is best make livestock farming as intense as possible.[15]
- However this type of farming reduces animal welfare and increases the risk of disease.

Figure 25. Wild Animals vs Humans and Animals Used by Humans -- Biomass



Source: UK National Food Strategy

Figure 26. Years lost to avoidable ill health /death in UK



Source: UK National Food Strategy

[15] Figure 23 and Figure 24 imply that all beef farms, for example, produce the same amount of CO_2 equivalents and water usage per calorie, but this is not at all true. In fact, the range is massive. Beef in Paraguay averages about 200 kg of carbon per 1 kg of meat, whereas Danish beef emits less than 15kg. This is driven by whether forest is cleared to create pasture, the suitability of land for pasture, and whether dairy cattle are subsequently used for beef.

Alternative proteins ameliorate these issues, but they can cause others

With alternative proteins, by contrast, there isn't a trade-off between greenhouse gases and animal welfare: to the extent that alternative proteins can reduce consumption of milk and meat, then both will be improved. (There is a trade-off with the well-being of rural communities, however, and we discuss it more on page 29.)

This does not mean, of course, that all plant-based protein's environmental footprint is without problems. In the U.S., about 65% of plant-based milk is now made with almonds, but almonds require Mediterranean climates like California's Central Valley and Spain, and they need intense irrigation, which can cause extreme water stress. This year there have been numerous reports of farmers cutting down almond trees in California because of the drought there[16].

Using more pea-based protein would help solve this, because peas like cooler climates that are more similar to those that serve dairy farming best, and require less water anyway. Peas have the added advantage of fixing nitrogen in the soil.

An even better solution from an environmental perspective would be cultured meat and milk. This could (in theory) be manufactured in factories anywhere, helping with food security for countries and regions where environmental conditions are not conducive to agriculture, for example in city states like Singapore.

[16] See Bloomberg; Bloomberg: California drought is withering almond farms and Gizmodo: California's drought is so bad farmers are ripping up almond trees6993225 and WSJ: Almonds swept California then the water ran out. 80% of the world's almond crop comes from California.

But the biggest growth drivers are actually taste, and health, and (potentially) price

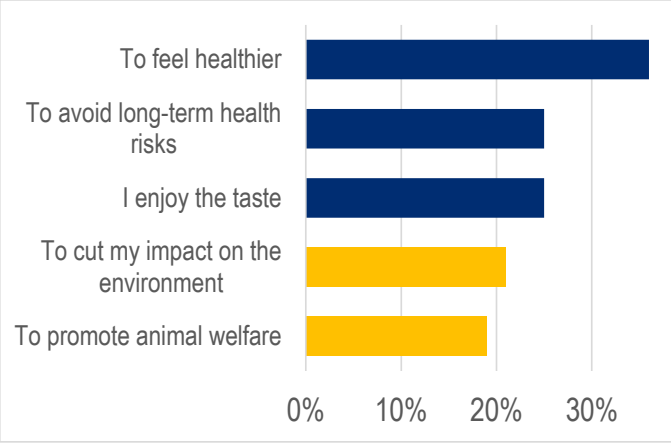
As we've just said, if alternative proteins replace consumption of animal products, there should be considerable benefits to the environment and around animal welfare. However, it's vital to realize that these benefits motivate only a small minority of consumers to buy the product.

Growth has to come from mainstream consumers, and they are generally motivated most by what they believe benefits them: in this case health, taste, and (potentially) cost.

According a global Euromonitor study this year, about 36% of consumers buy plant based meat because it makes them feel healthier, vs. about 20% who do so to reduce their environmental footprint or to promote animal welfare. (See Figure 27.)

In the U.S. specifically, it seems that environmental and animal welfare issues are less important motivations than in Europe, because a Mintel survey of U.S. consumers[17] found that concerns about the environment were a driver for only 13% of those who eat plant based proteins and concerns about animal welfare were a driver for only 11%. In the U.S., the main reasons for choosing plant-based food are clearly taste (52%) and health (39%), according to the Mintel survey.

Figure 27. Top 5 reasons to consume plant-based meats



Note: Survey conducted in Jan-Feb 2021. N=14,197.
Source: Euromonitor

Figure 28. Beyond's revenue per pound of product in the U.S., vs the wholesale price of meat

	2016	2017	2018	2019	2020
Beyond Sales / Pound					
U.S. Retail			5.81	6.06	5.78
U.S. Foodservice			5.82	5.94	5.60
Average	**$4.07**	**$5.13**	**$5.81**	**$6.02**	**$5.74**
Wholesale Price of Meat					
Beef	$3.17	$3.21	$3.29	$3.41	$3.66
Poultry	$0.74	$0.86	$0.79	$0.77	$0.67

Source: Citi calculations based on Beyond reports, and USDA data

Wendy Nicholson is Citi Research U.S. Consumer Staples analyst, and she supports this point: "Time and again I've seen companies introduce brands that are better for the environment, but in the end almost all American consumers buy products to suit themselves," she says. "One example is diapers – almost every mom believes that disposable diapers are terrible for the environment, but almost nobody uses cloth diapers. They're just too yucky."

There is also substantial confusion over the true environmental impact: 44% of U.S. consumers belief plant-based meat is better for the environment, 38% believe it is the same, and 23% believe it is worse[18].

[17] Mintel survey

[18] See Citi Consumer Survey on Plant Based Meat.

Motivations in emerging markets are likely to be different. In China, modern alternative proteins have struggled to gain traction, according to Euromonitor, possibly because environmental concerns are more focused on air quality than on greenhouse gases, and because animal welfare is less of a concern for most consumers.

Further growth is likely to be driven mainly by improvements in the taste and texture, and lower price points.

Of course the major companies are aware of the importance of taste, health and price. Beyond, for example, said in its latest conference call that it has three main initiatives to drive growth:

- **Improving taste**: It has just launched is 3.0 burger to improve the taste and sensory experience. It says the 3.0 improvements in flavor and juiciness have been validated through extensive consumer testing, where likability scores have been on par with traditional beef burgers made with 80% lean meat and 20% fat.
- **Health benefits**: Beyond is funding a 5-year initiative at the Stanford School of Medicine to research and publish on the health implications of a plant-based diet, including plant-based meat.
- **Price**: The company plans to price at least one product below the price of animal protein by 2024. It plans to do this through a combination of cost efficiencies and “product and process innovations and reformulations”.

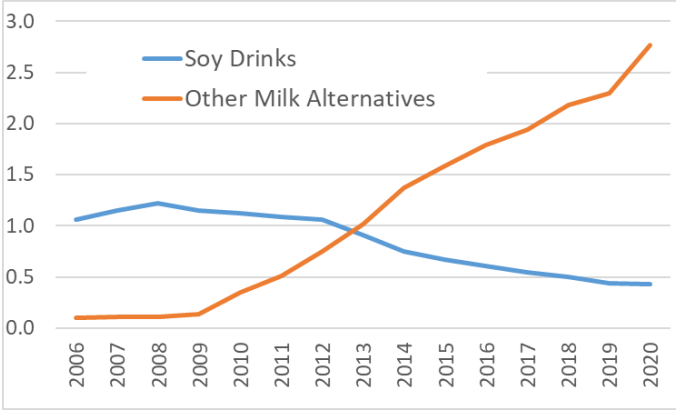
We believe that if alternative proteins could be priced at or below milk and meat, demand would probably grow very fast. So far, however, it seems the products are some way off. Figure 28 shows that in the U.S., Beyond charged an average of $5.74 per pound of product last year, whereas the wholesale price of beef was $3.66 per pound, and chicken (and pork) were much cheaper.

The No1 risk is changed perceptions around the health implications

The perceived health benefits are one of the main drivers of demand, and so we think they also represent the biggest risk to the story.

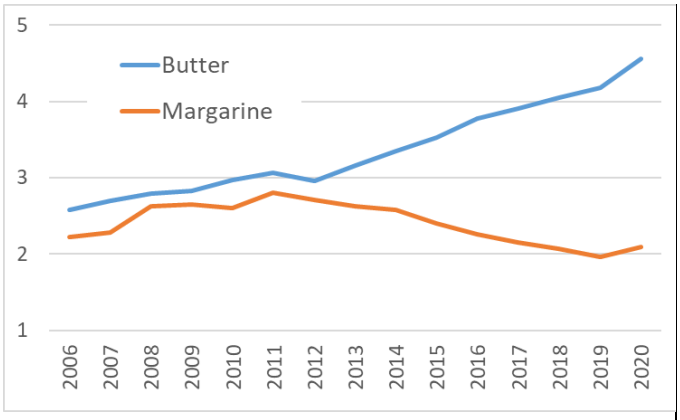
Perceptions of what constitutes a healthy diet have changed dramatically in the past. Plant-based butter – otherwise known as margarine – used to be widely considered as healthier than butter, for example, but it isn’t anymore, and as a result sales have declined since 2012 even as sales butter (which is much more expensive) have risen. There is no guarantee that alternative proteins will always grow.

Figure 29. Soy "Milk" vs Other Milk Alternatives – Retail Sales in N America ($ in Billions)



Note: The retail value of cow's milk fell from about $18B in 2012 to $16B in 2020.
Source: Euromonitor

Figure 30. Butter vs Margarine – Retail Sales in N America ($ in Billions)



Source: Euromonitor

And there is a tension with "Natural"

Furthermore there is a tension between the need to engineer these products for taste and scaling, and the consumer mega-trend for natural products (preferably organic products) with simple lists of comprehensible ingredients. This desire to get away from what is seen as overly "scientific", "artificial" or "processed" food is often strongest among the sort of people who are most likely to find the ethical arguments for alternative proteins most persuasive.

The second largest independent alternative meats company, Impossible Foods, argues the thing that makes meats meaty is heme[19], and that its burgers taste much better because they include plenty of heme. The trouble is that to make heme at scale in a vegetarian way, you have to use genetically modified fungus, and many consumers go out of their way to avoid GMOs.

Wendy Nicholson's research shows 63% of plant-based meat consumers are concerned about eating GMOs, vs 44% of the general population[20].

It's instructive to note that the use of soy milk has fallen since 2008 in the U.S., perhaps because of concerns about GMO-based soy. (By 2014, over 80% of global soy was GM based.)

[19] Impossible's website says: Heme is what makes meat taste like meat. It's an essential molecule found in every living plant and animal -- most abundantly in animals -- and something we've been eating and craving since the dawn of humanity. Here at Impossible Foods, our plant-based heme is made via fermentation of genetically engineered yeast, and safety-verified by America's top food-safety experts and peer-reviewed academic journals.

[20] See Citi Consumer Survey on Plant Based Meat. See also Digging into the weeds on plant-based dairy and meat

Cultured products vs. Plant-based products

This report has focused mainly on the economic outlook for plant-based alternatives, because few cultured products – in other words proteins grown in a lab – are currently more of a research project than a commercial realty. But we think idea is well worth considering.

A few companies are close to commercializing cultured protein

So far the only products on sale to the public are the chicken nuggets made by Eat Just in Singapore – and these are a hybrid of plant-based and cultured proteins. (Eat Just is a San Francisco-based company that focuses mainly on plant-based replacements for eggs.)

However Upside Foods (a start-up that used to be known as Memphis Foods) says it hopes to sell cultured chicken in the U.S. by the end of 2021, “in a handful of restaurants” subject to regulatory approval[21].

Meanwhile BioMilq has just announced that it has created cultured human milk, potentially providing parents with a superior alternative to infant formula.

In France, a startup called Gourmey says it has found a way of making cultured foie gras – a traditional delicacy that is banned in some markets because it involves force-feeding ducks and geese.

Figure 31. Cultured chicken

Source: UPSIDE Foods

[21] Foodnavigator: Upside gears up to launch cell cultured chicken by year end

But there is no clear regulatory pathway in place at the moment

Cultured products are entirely new, and therefore need regulatory approval to be sold as food in almost all jurisdictions. However there is no clear regulatory pathway for them to gain approval, anywhere in the world.

- **Singapore** has granted approval for Eat Just's products late last year, but the process is on a case-by-case process.
- **In the U.S.,** the FDA and the USDA are both involved. They started working on a regulatory framework in 2019, but it hasn't been completed yet. The FDA regulates the growth of cultured product; the USDA regulates harvesting, processing and labeling.
- **In the EU**, the Commission would need to approve any products; so far it has not approved any[22].

What about the health implications?

As we've said, one of the major reasons for eating-plant based alternatives is that they avoid animal fats. So what is the advantage of cultured-meat?

Upside argues that cultured meat can satisfy that part of the population that wants "real" meat while bringing much less risk of bacterial and other infections. Furthermore the nutritional profile can (in theory) be customized – for example it might be possible to make a steak with the fat profile of salmon.

We think cultured meat will need to be cheaper than animal meat to drive large scale adoption

Lab-grown meat and dairy has huge environmental and animal welfare benefits relative to natural meat. As we've shown however, that is unlikely by itself to drive widespread consumer adoption. Consumers who buy plant-based products mainly because they believe they taste better and are healthier. But if cultured products taste the same as traditional meat and dairy, and have a similar health profile, then why bother?

The most compelling answer is price. Cultured products can be made in a factory and have the potential to be much cheaper. If one or more companies crack this – in other words produce products that really give the same sensorial experience as traditional meat and dairy, and can do so more cheaply and in a more sustainable way -- then surely they have a very bright future.

Cultured products could increase food security for import-dependent countries

Some countries like Singapore and Japan that rely on imported meat are encouraging the development of cultured products because it could boost their national food security.

[22] The EU Commission also has to approve plant-based foods that weren't commonly consumed in Europe before 1997. Last year, for example, Eat Just applied for permission to introduce mung bean protein into the EU, even though mung beans have a long history of food use. This application has yet to be approved.

What about the businesses, people and landscapes on the wrong side of all this?

We should remember the potential losers from alternative proteins: dairy and meat processors, and farmers and rural communities. What's going to happen to them?

Many meat and dairy processors have taken stakes in start ups

Many meat processors and dairy companies have addressed the threat by taking stakes in some of the start-ups.

- Danone, the world leader in yogurts, has gone the furthest as it bought Whitewave, the leader in plant-based milk in the U.S., for $12.5 billion in 2017.
- Cargill is the largest U.S.-based meat processor, and it has invested about $1½ billion in a variety of companies, including two of the leading cultured meat companies – Upside Foods and Aleph Farms – and also White Dog Labs, which makes fermented animal feeds.
- Louis Dreyfus has invested in Motif Foodworks, and has a JV in Guangdong for alternative forms of aquatic feeds.
- Calidad Pascal (a Spanish dairy company) has launched an incubator for cultured protein call Mylkcubator.
- Tyson Foods launched its plant-based meat brand ("First Pride") in China this June.

It is noticeable that none of the large scale existing meat processors has sought to truly transform itself into an alternative proteins company in the way that Philip Morris International is trying to move away from cigarettes and into smoke-free products. Having said that there is a big difference. With alternative meats, perhaps only 3% of the U.S. market has moved into alternatives, and even the most aggressive forecast we've seen – the Kearney one – predicts traditional meat will still have 40% of the market in 2040. By contrast, alternatives to cigarettes have already taken about 30% of the market in Japan, and is perfecting plausible to suggest that smoking will die out in many markets by 2050[23].

Farmers, the rural way of life, and landscapes are exposed

Alternative proteins has the ability (in theory) to disrupt not only meat and dairy processing, but also the majority of the world's agriculture and hence the rural way of life, both in advanced economies and emerging ones. Farmers also face pressure from changing government priorities because an increasing number of jurisdictions have committed to zero carbon. This will be hard to meet without significant change in agriculture, especially the livestock industry.

Commercial farmers

We believe that alternative proteins are most threatening to those commercial farmers who receive little subsidy and who produce undifferentiated mass-market meat that ends up in minced/ ground products like burgers and chicken nuggets.

If alternative protein companies can start making meat of an acceptable quality at a lower price than feedlot farms, we expect there would be considerable disruption, unless these farms can be protected, perhaps through subsidy, regulation, or arguments about a "natural" product. However the poor animal welfare involved in this type of farming may start to count against it.

[23] See: When will the last smoker quit?

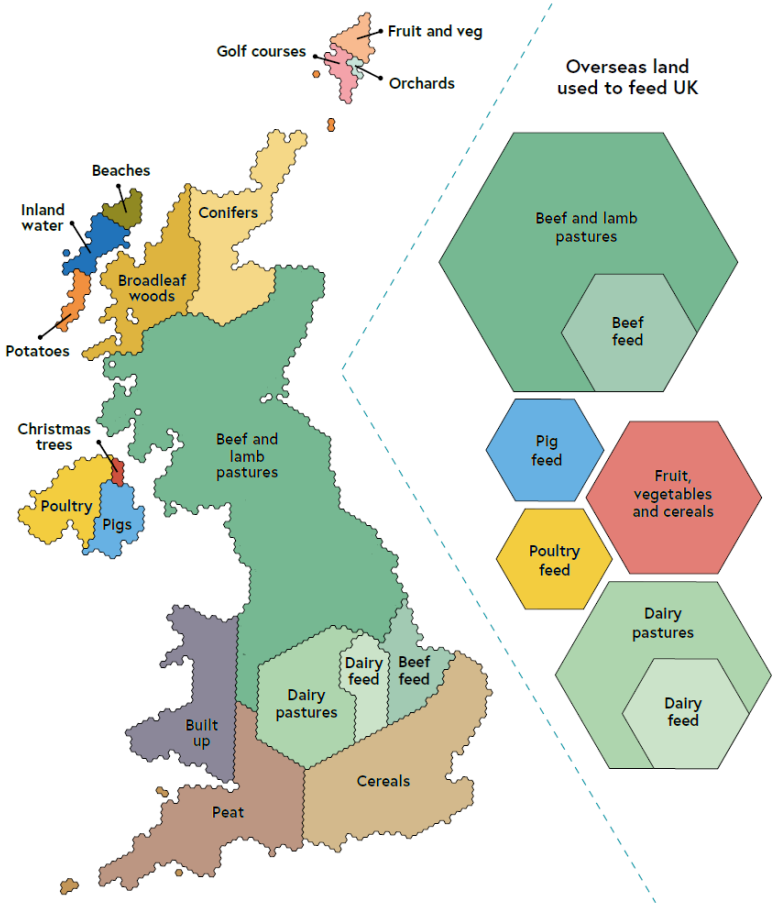
Few feedlot farms are likely to be able to switch to the arable crops used for alternative proteins.

Traditional rural communities and landscapes

It is not just farmers who are threatened, it's entire rural communities. One good example where the challenges could be momentous is the UK, because very roughly 60% of its total land area is given over to livestock farming, as the pictogram in Figure 32 shows. Over the centuries, that farming has shaped the landscape: "In this country, beef, dairy and lamb farming is largely responsible for the appearance of our 'traditional' pastured countryside. These animals are, literally, part of the landscape." [24]

And this isn't just a UK story. Globally just under 77% of all farmland is used for grazing animals, or for feed crops[25]. However the impact is likely to vary, depending on how important farming is to the national and local economy (as it is in many parts of Argentina and New Zealand) and how important livestock farming is to the national landscape (as it is in many parts of Europe.)

Figure 32. Current land use in the UK, including overseas land required to feed the UK



Source: National Food Strategy Plan (based de Ruiter, and Poore and Nemecek)

[24] This quotation comes from the National Food Plan.

[25] Source: FAO. Some of the land devoted to animals would not be suitable for arable.

There is already a regulatory backlash in Europe

In the EU, where farmers are carefully protected, a regulatory backlash is already apparent. It is already illegal to sell products there with descriptors like “oat milk” and “soya yogurt” and it looks likely that the EU will ban non-dairy products from being compared to, or even “evoke”, dairy products. This means it is likely to become illegal to describe a product as “an alternative to yogurt”, compare the product to milk (for example in terms of CO_2 emissions), or even say “does not contain milk.”

In the U.S. and Australia, however, terms like “plant-based milk” are considered acceptable. But campaign groups like the Campaign for Consumer Freedom have created ads highlighting what they say is the artificial nature of “fake meat”[26]

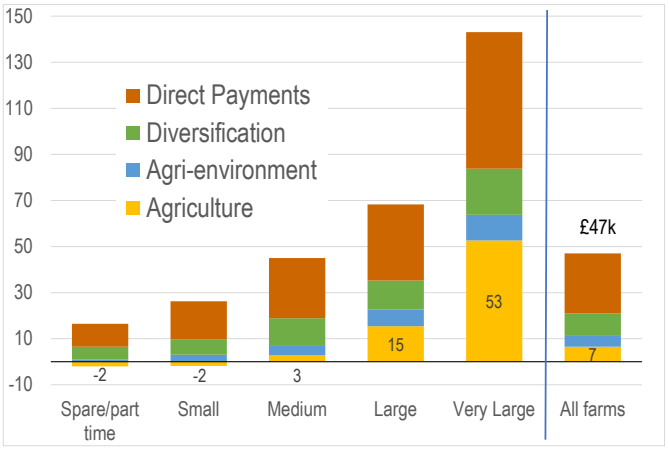
We expect the challenge will be met with a change of subsidies

In the medium-term, we expect that the challenge in more traditional farming areas will be met with a change in subsidies.

It is important to realize how important subsidies already are:

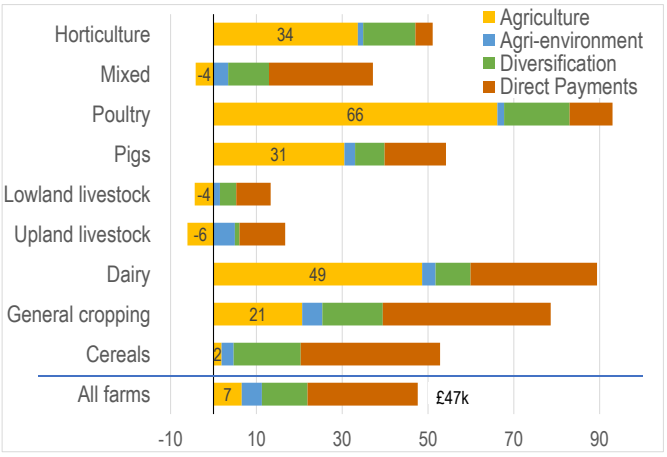
- Figure 33 plots income by farm size in the UK, and it shows only “large” and “very large” farms consistently make gross profits from agriculture — the rest are entirely dependent on subsidies and diversification.
- Figure 34 cuts the same data by farm type, and it shows that life farms are particularly dependent of subsidies.

Figure 33. Sources of farm income by farm size in the UK, (£’000s)



Size determined by Defra – the Department for the Environment, Farming and Rural Affairs. Figure 35 shows the spilt of farms in the UK by size.
Source: National Food Strategy Plan

Figure 34. Sources of farm income by farm type in the UK, (£’000s)



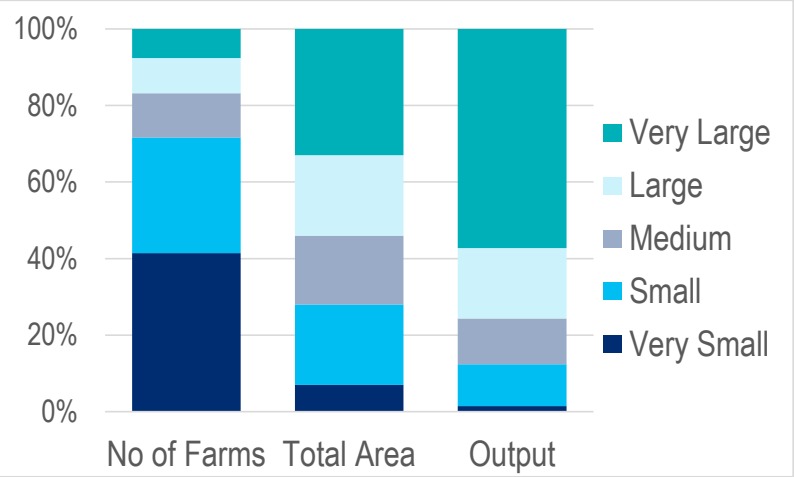
Upland livestock includes other less favorable areas
Source: National Food Strategy Plan

[26] See https://wellness.consumerfreedom.com/fake-meat-real-chemicals-campaign/ . The Campaign for Consumer Freedom does not disclose who funds its ads.

Recently the UK government commissioned an independent “National Food Strategy Plan”. It recommended changing the entire subsidy regime, with the aim of introducing a “three compartment” model across the country. This would divide farming land into three: high-yield farms (using sustainable technologies), low-yield “agro-ecological” farms, and semi-natural land.

It is not, of course, guaranteed that a plan like this will be implemented, in the UK or anywhere else. However, the growth of alternative proteins and the demands of zero carbon will force change on the agriculture globally, and it seems to us that forward thinking proposals like the three compartment model are the best way of helping rural communities adapt.

Figure 35. Split of farms in the UK, by total number, total area, and total output



Source: National Food Strategy Plan

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