Is indoor farming poised to challenge the status quo?

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Industrial agriculture is enabling farmers to successfully feed a rapidly growing global population. In the U.S., production efficiencies and an ability to grow food inexpensively have reduced the share of disposable personal income spent on food by over 40% during the past 55 years.[1] Yet the characteristics that made industrial agriculture so successful—economies of scale (large-scale monoculture), fertilizers, pesticides, and innovation in seed genetics—have led to a backlash from today's consumers.

In lockstep with the increased societal awareness of environmental issues tied to industrial agriculture is an increasingly vocal consumer base wanting foods with clean ingredient labels, grown locally and sustainably, and from farms that care for the environment and their employees. Today, many consumers associate the development of inexpensive and highly processed foods with higher fat, sugar, and sodium levels that lead to health issues, including obesity and diabetes, and also believe them to have lower nutritional value and less taste.

This backlash has generated a growing interest in the indoor farming sector, as consumers look for fresher, healthier, tastier, and more sustainable foods. Consumers looking to reduce the carbon footprint of the food they buy are asking "*Where is my food grown*?" And, this is driving a farm-to-table movement and resurgence of local farmers' markets.

"*How is my food grown*?" This is another consumer question reflecting worries about chemicals and pesticides, following some recent large jury awards to individuals who had used these products. The goal for some consumers is that all of their food be grown in neighborhood indoor farms, enabling them to purchase fresher, tastier, and more environmentally friendly food that is pesticide free. However, the reality is that the current generation of indoor farms grow mostly

specialty products, like herbs, leafy greens, micro greens, and specialty peppers and tomatoes, leaving the staples like carrots, corn, wheat, and potatoes to be grown in outdoor fields through traditional farming methods.

What is indoor farming?

Two categories of indoor farms dominate the industry: greenhouses, which use sunlight as at least part of their energy source; and vertical farms, which use artificial light, typically LEDs, and no sunlight. Most people equate greenhouses to the large industrial structures that have been used for growing crops indoors for over 150 years. However, today's greenhouse designs are integrated with the latest technologies, including advanced seed genetics, data science and machine learning, as well as robotics and automation. It is clear to these farmers that for greenhouses to be profitable, they must both optimize these technologies and achieve economies of scale.

In contrast, vertical farms utilize new technology and have mostly proliferated as a result of the rapidly declining prices of LED lights, but have yet to be proven profitable. Nevertheless, vertical farms offer tremendous opportunities as seed companies develop genetics to optimize growing conditions, including the replacement of sunshine with more reliable and predictable LED lights. Such controlled indoor environments provide significant advantages compared to the outdoor field, which is subject to the whim of Mother Nature. We are seeing the emergence of two different types of vertical farms: one built in large warehouses to maximize economies of scale, and the other having a smaller footprint, like shipping containers, that can be placed at hotels, supermarkets, and universities, enabling produce to be harvested and eaten the same day.

Both greenhouses and vertical farms are looking to optimize production through the use of data analytics and machine learning, much easier to do in a controlled environment than in a field. Additionally, field-grown products typically are grown far from the end consumer, leading to a large amount of spoilage and food waste. With over 30% of global food production ending up as food waste[2], this problem will need to be addressed in order to feed a population projected to reach over 9.5 billion people by 2050.[3]

Investment heats up

Strong consumer interest in indoor farming has been matched by a sizeable amount of venture capital investment in this sector. Whereas indoor farming is a relatively nascent business in the U.S., the Netherlands has built a successful indoor agriculture industry, and has played a key role in feeding neighboring European countries for decades. Additionally, an increasing amount of the non-processed tomatoes and specialty peppers sold in the U.S. are grown in Canadian greenhouses, where electricity is cheaper, and in Mexican greenhouses, where labor and other production costs are lower. It isn't surprising, therefore, that indoor farming companies have raised over $1 billion in equity during the past five years.[4]

A number of companies, including AeroFarms, AppHarvest, BrightFarms, Bowery Farming, and Plenty Ag, and Shenandoah Growers each have raised over $50 million in equity, demonstrating the growing commitment to a variety of indoor farming techniques.[4] Significantly more capital is likely to be raised in the coming years as indoor farms are positioned for rapid growth, and investors bet on new entrants with unique technologies that might result in lower production costs than those realized with field-grown produce.

Trend or fad?

Despite all the capital that's been raised, and the positive press surrounding indoor farming start-ups, many people have asked me whether indoor farming is a fad or a trend. Having worked closely with a number of thin-film solar companies as that sector emerged in 2004, I have noticed many parallels between that experience and what is happening in indoor farming. First, large sums of capital are being raised to fund new, but not-yet proven technology. Second, companies are making aggressive predictions about their cost structure once they reach commercial scale. Finally, a growing number of investors are rushing into a sector about which they have limited knowledge and investment experience. Consequently, as I began evaluating the indoor farming sector three years ago, I was very skeptical about its viability, since outdoor farming has occurred for thousands of years, and the growing process has already been revolutionized to substantially improve yields and reduce costs.

However, following my visit to an indoor farm in the Bay area, less than two hours' drive from Salinas, California, known as the "Salad Bowl of America", I started to understand the reason why indoor farming makes sense. The most compelling reason is taste. Produce that I have tasted that was grown in indoor farms tastes much better than the field-grown varieties available in stores

and restaurants. Most people are unaware that the seed genetics used in field-grown produce are often selected based on ability to survive transport over long distances rather than for taste optimization. Furthermore, most of the produce eaten in the U.S. is grown in California, Arizona, and Mexico, and shipped throughout the U.S. on trains and in trucks. There is no greater evidence of logistics winning over taste than iceberg lettuce. Despite being comprised of almost all water and having little nutritional value, iceberg lettuce was identified as a product able to survive being packed in ice and shipped cross country. I know very few people who are excited to eat iceberg lettuce, yet it remains a staple on many dinner tables throughout the U.S.

In addition to taste, indoor farming offers a number of other potential benefits including:

- **Year-round production** – important since even in California produce is typically harvested no more than nine months of the year, forcing reliance on additional supplies from global and potentially less regulated production areas
- **Environmental sustainability** – indoor farming has a smaller environmental footprint as a result of elimination of pesticides, reduction in water, and reduction in cross-country transportation since product can be grown regionally throughout the country in close proximity to distribution centers or retail outlets
- **Consistent production** whereby growers are able to provide the same size and quality of products to distributors and retailers in every location
- **Reduced manual labor** through the use of robotics and automation
- **Elimination of climate dependency** – produce can be grown in even the harshest weather conditions globally, which will become more important as the impact of climate change accelerates

Indoor farming companies must overcome a number of issues to achieve success, the most important of which are cost structure, type of produce grown, and branding.

Achieving a competitive cost structure

Today, very few indoor farming companies are able to produce at a cost structure competitive with field-grown produce. With so much capital being raised, most indoor farming companies are more focused on scaling production rather than profitability. While many investors are less focused on near-term profitability, it will become more important as indoor farming companies look to build new farms, and need to be able to undertake financing using debt/project finance. Even if indoor farming companies can raise enough equity capital to build new indoor farms in the short term, long-term success will be tied to optimizing capital structures through the use of low-cost debt capital.

Building market share

Although there is a substantial opportunity for indoor farms to take market share from field-grown herbs and leafy greens, these remain relatively small market opportunities. With so many indoor farming companies currently producing or preparing to produce herbs and leafy greens, these areas will likely get oversaturated at some point. Consequently, I think it is essential that indoor farms move into, or expand production in, other high-value and high-margin products such as berries, melons, peppers, and tomatoes.

Gaining brand recognition

The final area of concern is whether indoor farming companies will be able to build either category strength or a brand name that will catch on with consumers. Consumers are less familiar with the names of the companies that provide their fruit and vegetables, in contrast with major consumer-packaged goods companies, like General Mills, Kellogg's, Kraft Heinz, and Nestle, which have been highly successful at building brand-name products sold in the middle of the grocery store. Without brand visibility, most indoor farming companies likely will end up selling to larger established players, such as Taylor Farms, Del Monte, and Dole, and receive commodity pricing as opposed to the premium pricing of major brand label, which Beyond Meat and Impossible Foods have done successfully in the alternative protein sector.

Coming to a store near you

Consumers appreciate that there are major advantages for an increasing amount of high-end produce to be grown in "state-of-the-art" indoor farms. However, it remains to be seen whether indoor farming companies will have the breadth of products to truly challenge the dominance of incumbents, who have extensive field-grown production capabilities and efficient distribution networks. Indoor farms must deliver a high quality and better tasting product at a competitive

price to displace the existing growers. Nevertheless, though these are considerable challenges, I believe the indoor farming sector is poised to create significant disruption in a number of high-margin specialty crop segments. I foresee that, over time, the indoor farming sector will experience consolidation, leading to indoor farming companies with regional brands achieving a more national presence.

1. USDA Economic Research Service, Food Expenditure Series, October 24, 2018.
2. United Nations population report, June 13, 2013
3. United Nations Food and Agriculture report on Global Initiative on Food Loss and Waste Reduction, April 2, 2019
4. Pitchbook and company press releases