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Schulz is the co-author with Arnold Kling of From Poverty to Prosperity: Intangible Assets, Hidden Liabilities and the Lasting Triumph Over Scarcity (Encounter Books, 2009), an acclaimed book on modern economic growth and development. He is frequently invited to discuss the research and findings in the book at various events in the United States and abroad.

During the mid-2000s, Schulz was the editorial director of TechCentralStation, a pathbreaking online think tank and magazine. Prior to that role, he was the politics editor of Fox News online in New York where he coordinated coverage of the 2000 election, post-election deadlock, and September 11 attacks. He was also the politics and opinions editor for Voter.com, a start-up political website and portal.

In addition to his work in online media, Schulz was an award-winning television producer with multiple credits on PBS and elsewhere. He also produced or co-produced several documentaries, including The Stockholder Society, The First Measured Century, and Déjà vu All Over Again: The Life of Yogi Berra.

In the 1990s, Schulz served as a policy analyst and aide to former vice presidential candidate Jack Kemp and former Secretary of Education William J. Bennett. He was also a consultant to Platinum Technology, a major relational database management firm, and a consultant at the Software Publishers Association.

Schulz has been a media fellow at the Hoover Institution at Stanford University and is on the board of advisors of the Ewing Marion Kauffman Foundation’s survey of economics bloggers. Schulz continues to publish widely in many major newspapers and magazines around the country, including The Washington Post, The Wall Street Journal, the Los Angeles Times, USA Today, and Slate. He and his wife and three children live in suburban Washington, D.C.

The views expressed herein are those of the author and do not necessarily state or reflect those of the National Chamber Foundation, U.S. Chamber of Commerce, or its affiliates.
“Population, when unchecked, increases in a geometrical ratio. Subsistence, increases only in an arithmetical ratio. … Man cannot live in the midst of plenty.”


“How can the persuasive common sense embodied in the Malthusian theory be wrong? To be sure, in the short run an additional person … inevitably means a lower standard of living for everyone; every parent knows that. More consumers mean less of the fixed available stock of goods to be divided among more people. And a larger number of workers laboring with the same fixed current stock of capital implies that there will be less output per worker. The latter effect, known as ‘the law of diminishing returns,’ is the essence of Malthus’ theory as he first set it out. But if the resources with which people work are not fixed over the period being analyzed, then the Malthusian logic of diminishing returns does not apply. And the plain fact is that, given some time to adjust to shortages, the resource base does not remain fixed. People create more resources of all kinds.”

— Julian Simon

At the time of this writing, in autumn 2012, many Americans are expressing pessimism about the nation’s future economic prospects. The unemployment rate has remained stubbornly elevated. Economic growth rates have not bounced back as quickly as Americans would like given the severity of the Great Recession.

It’s not just ordinary Americans who are pessimistic about the present economy and its prospects for the near future. Several academics and intellectuals have argued that the United States faces challenging and perhaps insurmountable headwinds.

For example, economist Tyler Cowen of George Mason University has argued that the United States is undergoing a “Great Stagnation.” The entrepreneur and investor Peter Thiel claims that we are witnessing “The End of the Future.” Economist Robert Gordon has published a widely discussed paper asking, “Is U.S. Economic Growth Over?” He suggested that the answer is yes.

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The purpose of this paper is not to rebut directly the claims made by the pessimists. Rather, it is to examine one of the great technological, humanitarian, and productivity success stories in human history—American agriculture.

In considering the past and potential future of American agriculture, we will come to understand better the roots of American economic greatness. We may also gain insights into where the next waves of technological innovation may come from and what they may mean for the country and the world.

FROM SCARCITY TO ABUNDANCE

I first became interested in the story of American agricultural success during research for the book, *From Poverty to Prosperity*, which I co-wrote with economist Arnold Kling. In the book, we examined the nature of modern dynamic economies in an effort to better understand why some nations are rich and others are poor.

One of the most important determinants of a nation’s success is how productive its economy is. When we consider the productivity of just one sector of the American economy—agriculture—what we find is nothing short of miraculous. Here’s how we expressed it in the book:

Maybe there is no free lunch, as the saying goes; but we do not have to work nearly as hard to put food on the table as we used to. Just two hundred years ago, over half of all Americans worked in agriculture. Today, the figure is less than two percent. Sixty years ago, a social studies teacher looking for a movie that would motivate students to sympathize with the plight of the unfortunate in America might have chosen “The Grapes of Wrath.” Today, it would be “Supersize Me.”

In the agriculture sector, farmers have found myriad ways to do much more over time with less. They’ve figured out ways to increase yields to feed a growing population, one that has demanded steadily rising amounts of calories.

We have transitioned in the United States from a nation that was concerned with food scarcity to one that must confront challenges that come with food abundance.

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A QUESTION OF OUTPUTS AND INPUTS

“Innovation accounts for most of the growth of U.S. agricultural output.”

— Dale W. Jorgensen

According to the United States Department of Agriculture’s Economic Research Service (USDA ERS), the level of farm production increased steadily over much of the 20th century and into this century. For example, farm output was more than 170% higher in the late 2000s than it was in 1948. Since the early 1980s, it has increased by nearly 50%.

This increase in productivity contributed significantly to America’s economic growth over that time.

At the same time, total farm inputs—such as the energy, land, and chemicals used to produce so much more—increased hardly at all or even declined. This is the very definition of productivity gains.

We see this productivity gain when we consider that over time while we produce increasing amounts of food, we need less land to farm, thereby reducing our ecological footprint.


For example, according to the USDA, between 1982 and 2007 the total amount of land used in agriculture declined from 54% to 51% of the total U.S. land area.10

This means that millions of acres have been freed for recreation, housing, wildlife, forests, and other uses of value to the American people.

Jesse Ausubel, director of the Program for the Human Environment and senior research associate at The Rockefeller University, documented an astonishing reversal in area of land used to feed a single person. Ausubel noted that “after gradually increasing for centuries, the worldwide area of cropland per person began dropping steeply in about 1950, when yields per hectare began to climb.” We can see this dramatic drop in the accompanying chart. “The square shows the area needed by the Iowa Master Corn Grower of 1999 to supply one person a year’s worth of calories. The dotted line shows how sustaining the lifting of average yields 2% per year extends the reversal.”11

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10 O’Donoghue.

“Oh, the Farmer and the Cowman Should Be Friends.” — Rogers and Hammerstein, Oklahoma!

We are not only getting more food out of the same or declining slices of land; we’re getting more from our animals as well. Consider the fact that we get more milk from fewer cows.

At the mid-point of the 20th century, the typical dairy cow produced 5,300 pounds of milk, according to a report from the White House Council of Economic Advisors.12

Today, the average cow produces 22,000 pounds of milk. As a result, “over that time period, the number of dairy cows in America has fallen by more than half, yet U.S. production has nearly doubled.”

American farmers are also more productive when it comes to producing chickens. The typical broiler chicken requires 1.8 pounds of feed to generate one pound of weight gain. The required feed for the same weight gain was 2.1 pounds in 1980 and 2.9 pounds in the 1950s.13

The increased meat yields from chickens are important because, as the United Nations documents in its research into food trends around the world, “rising demand for poultry meat … has consistently increased at around three times the rate of population growth over each of the past five decades.” Without an increase in supplies, global prices would have been much higher over that time.

The reasons for all this increased productivity are many, but according to the USDA they include: “Innovations in onfarm tasks, changes in the organization and structure of the farm sector, [and] research aimed at improvements in farm production.”14

Innovation. Changes in organization. Research. These are products of the entrepreneurial human will and imagination, the “ultimate resource” that the great economist Julian Simon long championed. It is in this way that people can create resources of all kinds, to meet the needs of growing populations.

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13 Ibid.
14 U.S. Department of Agriculture.
This increase in productivity has meant more income for farms and farmers. For example, between 2002 and 2007, according to a census taken by the U.S. Department of Agriculture, the total market value of products sold by American farms increased by almost half, from $200,646,355 to $297,220,491.15 This meant an increase in the value of products sold by the average farm of $94,245 to $134,807.

At the same time, the expenses required to produce this cornucopia have risen at a much slower rate, up only 39% between 2002 and 2007.16 This means that a dollar’s worth of new input is producing much more than a dollar worth of new output, thanks to innovative farming techniques, the power of new technology, and more productivity enhancing measures. This enabled the net cash income off farms to increase by more than 84% over that period.

At the same time, farms are diversifying their ways of generating income beyond commodity crop production. These sources include services and goods, such as agri-tourism and other recreational activities, custom harvesting, forestry sales, and farmhouse rentals. While starting from a small base, the value of the sales from these sources increased almost 80% between 2002 and 2007, from $5,859,226 to more than $10 million.

A SCALE AND EFFICIENCY REVOLUTION

One of the ways to understand how technology, innovation, and markets have changed agriculture is to see how the number and composition of farms has changed over time.

For example, according to the Economic Research Service, in 1900 it took almost 1 million farms to produce half of all the market value of agricultural products sold in the country. This was the era of small and midsize farms.17

However, by 1987, only 76,000 farms were needed to produce half the market value of goods sold. By 2007, that number was down to 33,000 farms. Today, we live in the era of large farms.

This evolution toward larger farms has been enabled by a technological revolution that makes the stewardship of large farms possible. This includes larger and faster agricultural equipment that makes it feasible to manage larger acreage.

17 O’Donoghue.
To illustrate, compare and contrast the attached images: a vintage harvester with a modern harvester and a 3-row planter with a state-of-the-art seed planter.

Consider that “in 1970 an operator could plant 40 acres of row crops per day, planting four rows at a time at 2 miles per hour, and could harvest 4,000 bushels per day running a 4-row harvester for 12 hours per day. By 2005, a producer could plant 420 acres per day, planting 16 rows at 6 mph, and harvest 30,000 bushels per day, running a 12-row harvester.”

Today, it is estimated that producers can plant 945 acres a day and harvest 50,000 bushels a day.

Jesse Ausubel has put the benefits of productivity in helpful context when he wrote:

U.S. farmers, by raising grain yields, have spared about 150 million hectares since 1940 from what otherwise would have been needed: an area 3 times the size of Spain.

Alternately, compare a U.S. city of 500,000 people in 2000 and the same city of 500,000 people with the 2000 diet and the yields of 1920. Farming as Americans did 80 years earlier while eating as we do now would require 4 times as much land, about 450,000 hectares instead of 110,000. Looking to a U.S. 70 years hence with 100 million more people and the 2000 diet, farmers will spare 4 times the area of Iowa or more than one Spain if they lift yields only 1% per year.

18 O’Donoghue.
19 Ausubel.
A major recent contributor to this age of agricultural abundance has been the development, maturation, and utilization of genetically engineered (GE) crops.

These crops came on market for the first time in the middle of the 1990s, but the adoption of these herbicide-tolerant (HT) and insect-tolerant (called Bt for their engineered expression of a helpful protein) crops has been swift.

The aim of the engineering has been to make them resistant to herbicides and to make them resistant to insects. This has helped boost overall yields by minimizing the amount of crops lost to pests. It has also meant farmers can use fewer insecticides as they grow crops, reducing costly inputs and thus keeping prices down.

While the United States has been a pioneer in the development and adoption of gene-spliced agriculture technology, it is being used widely elsewhere in the world too. The UN’s Food and
Agriculture Organization research staff notes that “GM [genetically modified] traits that are currently under commercial cultivation, and the main crops are: soybean, maize, canola, and cotton. GM crops are now commercially planted on about 100 million hectares in some 22 developed and developing countries. Argentina, Brazil, China, and India are the largest developing-country producers of transgenic crops. The choice of GM crops varies among the developing countries, with insect resistant cotton being the most important commercially produced transgenic crop in Asian and African countries, while herbicide-resistant soybean followed by insect-resistant corn is predominant in the Latin American continent.”

Other productivity enhancements and techniques include better soil management practices, such as crop rotation systems; the use of GPS technology and other smart applications; water conservation methods; and better nutrient management systems.

It is worth noting that the development and use of GM technologies is not without its critics who worry about food safety and other concerns. It is beyond the scope of this paper to address those concerns completely, but it is common for all forms of technological development and material advance to generate controversies and raise novel questions. Genetic modification in agriculture is no different.

BENEFITS FOR CONSUMERS: MORE FOOD, LOWER PRICES—AND MORE INCOME FOR OTHER NEEDS

The extraordinary productivity growth in agriculture means that people have more calories and a greater variety of foods to meet their nutritional needs. Yet it means much more than that, as well. It also means that they have more income to spend on other goods and services—such as health care, education, and leisure.

Simply put, satisfying nutritional needs consumes significantly less of a family’s budget than it used to.21


In the late 1920s, purchases on food consumed about a quarter of families’ disposable income; today, it is under 10%.

The revolution in agriculture, driven by developed nations such as the United States, is performing miracles around the world. As the global population has rocketed upward since the beginning of the 20th century, the demand for food has risen as well.

This was the scenario that so alarmed English scholar Thomas Malthus and prompted his prediction that “man cannot live in the midst of plenty.” Malthus believed that a growing population would fight over agricultural outputs that couldn’t grow fast enough.

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Recent history has proved Malthus wrong. Thanks to human ingenuity, the productivity gains over the last century have been so large that global food prices, despite periods of volatility, have dropped dramatically in that time.

As economist Tim Taylor put it, “Despite the sharp rise in demand for agricultural products from population growth and higher incomes, the rise in productivity of the farming sector has been sufficient so that the price of farm products fell by 1% per year from 1900 to 2010.”

The UN’s Food and Agriculture Organization points out that “the growth of global agriculture’s productive potential has so far been more than sufficient to exceed population growth, resulting in a steady, albeit slow, increase in average per capita food availability. For the world as a whole, per capita food availability has risen from about 2,220 kcal/person/day in the early 1960s to 2,790 kcal/person/day between 2006 and 2008, while developing countries even recorded a leap from 1,850 kcal/person/day to more than 2,640 kcal/person/day.

This growth in food availability in conjunction with improved access to food helped reduce the percentage of chronically undernourished people in developing countries from 34% in the mid-1970s to just 15% three decades later.”

SOURCE: http://conversableeconomist.blogspot.com/2012/10/can-agricultural-productivity-keep.html

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23 Food Agriculture Organization, 174.
Again, it is difficult to overstate the role that innovation and technology—the human element—has played in this story. As the late University of Minnesota development economist Vernon W. Ruttan explained in the *Journal of Economic Perspectives*, “Prior to the beginning of the twentieth century, almost all increases in crop and animal production occurred as a result of increases in the area cultivated. By the end of the century, almost all increases were coming from increases in land productivity—in output per acre or per hectare. This was an exceedingly short period in which to make a transition from a natural resource-based to a science-based system of agricultural production.”

Further innovation will also be critical to meeting the food challenges of the future. According to the Organisation for Economic Co-operation and Development (OECD), “Agricultural production needs to increase by 60% over the next 40 years to meet the rising demand for food.” That sounds daunting—the question is, Can we do it?

Researchers at the Food and Agriculture Organization note, “There are signs for optimism. Over the last five decades … production has increased by a massive 170%.”

At the same time, we can’t just expect more land to be available to produce this food. The OECD says that “globally, the scope for area expansion is limited. Total arable land is projected to increase by only 69 Mha [million hectares] (less than 5%) by 2050. Additional production will need to come from increased productivity in the same way as it has for the past 50 years. Increasing productivity will be central to containing food prices in a context of rising resource constraints and will be a key factor in reducing global food insecurity.”

**FRONTIERS OF INNOVATION**

“Technology revolutionized agriculture twice in the 20th century. The tractor and other machines caused the first. Nitrogen and other chemicals were responsible for the second. The third agricultural revolution is coming from information. What do the past and future agricultural revolutions mean for land?”

— Jesse Ausubel, The Rockefeller University

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26 Food Agriculture Organization, 172.

27 Cluff and Jones.

28 Ausubel.
Though an innovation and productivity revolution in American agriculture has enabled us to feed a growing population and export products around the world, that’s just the beginning. Scientists, engineers, farmers, and entrepreneurs are all finding innovative ways in what Ruttan called “a science-based system of agricultural production” to add value to American agricultural production.

This added value takes many shapes and forms. For example, in addition to producing more food, our agriculture system is constantly looking for ways to improve the overall quality of the food.

Consider tomatoes. Over the last several decades, plant breeders have had great success producing tomatoes that are increasingly pleasing to the eye regarding their color and shape. A challenge today is producing tomatoes that taste even better, a task being pursued by companies such as Bayer AG and Monsanto.

Recent research published in the journal *Science* details the genetic links and trade-offs between color and taste. In adding to the store of knowledge of agricultural development, it will help commercial producers in their pursuit of better tasting tomatoes.29 30

Or how about tomatoes that not only look better and taste better but that help combat heart disease? Researchers recently presented findings31 at the American Heart Association's Scientific Findings 2012 about a genetically modified tomato that produces a peptide that can lower artery-clogging plaques in mice.32 It’s possible to imagine such modifications helping humans in the future.

### RISE OF THE FARMBOTS

Farmers are also riding the wave of artificial intelligence and robotics that are gradually transforming a variety of different economic sectors. For example, Vinod Khosla, the Silicon Valley-based venture capitalist and former chairman and CEO of Sun Microsystems, is supporting an effort to use computer vision to target and kill weeds in farm fields.33


31 Chattopadhyay, Arnab, et al. “ A Novel Approach to Oral ApoA-I Mimetic Therapy” *ScientificSessions.org* (November 5, 2012).<http://www.abstractsonline.com/Plan/ViewAbstract.aspx?sKey=201052ff-286d-4a5d-a823-1e937c1e4d22&amp;cKey=e3db6940-042b-485d-ab9d-6befferba9e71e&amp;mKey=14145D5B-F96B-4354-8237-8F0930744B4A>


According to *The Wall Street Journal*, a “prototype device has both a camera and a killing mechanism three inches behind. So when the camera recognizes a plant that’s not supposed to be in a lettuce field, a mechanical knife cuts it out or herbicide sprays down. The idea is that it’s very precise, so it’s cost-effective and minimizes the use of herbicides.”34

Additionally, dairy farmers in the Upper Midwest are adopting sophisticated robotic milkers that reduce farm costs and bolster productivity.35 According to one report:

> [A] family’s small squadron of farm droids, which includes a mechanical cow-back scratcher and an automatic feed pusher, has turned their barn into a 24-hour operation, with less hired help. The 3,000-pound, red robo-milkers work around the clock, except for twice-daily cleaning sessions. They also eliminate the chore of corralling cows for milking: After being trained to accept the robot, cows get milked whenever they please. The robot measures their production and knows if a cow needs to be milked more or less often. The robots may also reduce the farmer’s risk of getting kicked, pinned or tail-whacked. ... The robots also could reduce back, knee, shoulder, and other repetitive-motion injuries associated with wrangling a dairy herd.36

Dr. Mark J. Perry, an economist at the University of Michigan-Flint and a former National Chamber Foundation Fellow, noted the long downward march of milk prices that the country has enjoyed since the 19th century.37 Advances in robotics and other technologies may continue putting downward pressure on dairy prices to the benefit of consumers.

If milk is not your thing, then how about wine?

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34 Ibid.
36 Ibid.
An inventor in France is developing a grape-picking robot that can help vineyards by, according to one report, “pruning and de-suckering—removing unproductive young shoots—while collecting valuable data on the health and vigor of the soil, fruit, and vine stocks.”

FROM FARM TO TABLE . . . AND WAY, WAY BEYOND

American firms and entrepreneurs are also finding innovative ways to use farm and biomass products in industrial capacities. While biofuels get most of the popular attention, there’s much more going on when it comes to industrial applications of agriculture goods. The Economist magazine recently highlighted the “revival of interest in using agricultural feedstocks to make plastics, paints, textile fibers, and other industrial products.”

Researchers at the Food and Agriculture Organization of the United Nations (FAO) highlight many of the properties that make bio-based products attractive to industrial producers. “Natural fibres have intrinsic properties—mechanical strength, low weight, and low cost—that have made them particularly attractive to the automobile industry. Car manufacturers are now using abaca, flax, and hemp in press-moulded thermoplastic panels for interior components. The low density of plant fibers also reduces vehicle weight, which cuts fuels consumption.”

For example, Ford Motor Company has developed soy-based foam for use in its car seats and headrests. If you happen to drive a new Taurus, Mustang, F-150 truck, or any other Ford vehicle, you have been sitting on plants whether or not you know it. According to the company, all of its North American-made cars and trucks use bio-based foam products.

While you’re finding plant products in cars, you may one day find agricultural products in the road too. One company in Valley View, Ohio, is transforming hog manure into a useful and marketable product. NuVention Solutions transforms the waste into an asphalt-binding additive

40 Food and Agriculture Organization.
with the potential to replace 15% of the asphalt used on road projects. The company is exploring other applications as well, such as roofing materials.

Major American drink and bottling companies are also exploring promising possibilities of using plant-based materials for their containers. For example, Coca-Cola has announced plans to work with a Wisconsin-based company that can convert corncobs into bottles for the refreshments company. Pepsi has plans to use other agricultural waste, such as pine bark and orange peels, in making its plastic bottles.

Meanwhile, the U.S. military is investigating using wood biomass for industrial applications, such as body armor and ballistic glass. The automotive, electronic, aerospace, and medical supply sectors also see promise in wood biomass.

The FAO points out that “worldwide, the construction industry is moving to natural fibers for a range of products, including light structural walls, insulation materials, floor and wall coverings, and roofing. Among recent innovations are cement blocks reinforced with sisal fiber now being manufactured in Tanzania and Brazil.”

All of these technologies and innovations and many more promise to enhance the human condition. They do so by lowering the cost of satisfying basic necessities; creating valuable new goods and new markets; improving our subjective and aesthetic experiences; and by satisfying the demands of a growing global population, one with a rising, aspirational middle class.

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THE AMERICAN WAY

Perhaps the most important thing to keep in mind as we consider the future material needs of humanity is how we may continue the agricultural modernization of the kind practiced in the United States and to extend that model far and wide.

As Jesse Ausubel puts it:

If the world farmer reaches the average yield of today’s U.S. corn grower during the next 70 years, ten billion people eating as people now on average do will need only half of today’s cropland. The land spared exceeds Amazonia. This will happen if farmers sustain the yearly 2% worldwide yield growth of grains achieved since 1960, in other words if social learning continues as usual. If the rate falls by one half, an area the size of India, globally, can still revert from agriculture to woodland or other uses. If the ten billion in 2070 prefer a meaty diet of 6,000 primary calories/day for food and fuel (twice today’s average primary calories), they roughly halve the land spared. A cautious global scenario of sustained yield growth and more calories still offers more than 10% of present world farmland, more than 10 Iowas or 3 Spains.48

The importance of agricultural productivity of the kind the United States has pioneered is difficult to overstate. Agriculture productivity is the sine qua non of human development. As the historian Peter Timmer explains, “No country has been able to sustain a rapid transition out of poverty without raising productivity in its agricultural sector. … The process involves a successful structural transformation where agriculture, through higher productivity, provides food, labor, and even savings to the process of urbanization and industrialization. A dynamic agricultural sector raises labor productivity in the rural economy, pulls up wages, and gradually eliminates the worst dimensions of absolute poverty.”49

The American experience with agriculture productivity is nothing short of a modern miracle. It has fundamentally transformed economic reality so that Americans need not wrestle with scarcity but instead face issues related to abundance. America’s post-scarcity food world is giving birth to novel biomass-based products and industries. The challenge today is to extend the productivity miracle at home and through technology transfer, investment, and trade extend the miracle to every corner of the globe.

48 Ausubel.
For more information on this subject, go to
ncf.uschamber.com/agriculture