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Comment James M. MacDonald

Alston, Martin, and Pardey (AMP) provide a rich and useful framework for thinking about the links among technology, food prices, and the impacts of food price changes on welfare. Innovations in technology work through four channels and can alter:

1. price elasticities of demand and supply for farm commodities, changing the sensitivity of prices to given shifts in supply or demand;
2. the sensitivity of farm supply to external shocks, such as weather or pests, and can therefore influence the degree to which such shocks affect farm prices;
3. agricultural productivity, and the level of farm prices; and
4. economy-wide productivity and real incomes, which leads to falling shares of income spent on food and hence leaves populations less exposed to food price fluctuations.

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AMP provide examples of each of these channels, but devote most attention to the third and fourth. Given expected future growth in world population, as well as the likely impact on global meat and feed demand occasioned by rising incomes and dietary shifts in some countries, this is appropriate. Failure to meet historic rates of agricultural productivity growth could lead to sharply higher commodity prices, with attendant risks to hunger and food security, political stability, and environmental outcomes, particularly in the poorest countries.

The chapter refers to previous work involving two of the authors, which makes the case that agricultural productivity growth has already slowed, as manifested in their own analyses of productivity data and in slowing growth in global crop yields. They argue that the slowdown is in large part due to reductions in public spending on research and development, and that without major new investments in R&D, the consequences of increased demand matched to productivity failures will be on us, but most severely on the developing world, soon (Alston, Beddow, and Pardey 2009).

This is an important issue, but one that is subject to considerable controversy. In particular, the United States Department of Agriculture (USDA) productivity accounts show no such slowdown in the United States, while other work finds no global slowdown, using the Food and Agriculture Organization of the United Nations (FAO) data (Fuglie 2008). Now, the answer to that question—has a slowdown occurred in the last ten to twenty years?—is not sufficient to answer the big question for the future—whether we can and will continue to achieve high rates of productivity growth over the next several decades. But the slowdown question does provide a framing for current analyses—its use here—and policy discussions, and the present chapter suggests that there is more consensus around the issue than I think really exists.

AMP focus most of their analysis on production of staple crops, which are the primary focus of concern in the least developed countries, and for which there are extensive data on production, acreage, and yields. They devote little attention to livestock. But growing incomes in middle-income countries such as China, India, and Brazil will lead to substantial ongoing increases in meat consumption, and increased derived demand for feed grains and oilseeds. The impact of increased meat consumption on feed demand, on land use for feed production, and ultimately on crop prices will depend, among other things, on how animals convert feed to meat. Here, there are significant data problems; data on livestock feed conversion to meat and milk are scattered across many sources, poorly documented, and often unreliable. I will focus my comments on what we do know about feed conversion for livestock and how that affects our judgment about future growth possibilities.

In one well-known assessment, Vaclav Smil (2000) provides a wide-ranging analysis of what is needed to meet food consumption needs in the future.

To assess the feed and land requirements needed for increased consumption of meat and dairy products, he starts with estimates of feed conversion for three main species in the United States: chickens require 2.5 pounds of feed for one pound of live-weight gain, while hogs require 4.0 pounds, and beef cattle require 8.0 pounds of feed for each pound of live-weight gain in a feedlot (nearly half their total).

Smil (2000) further finds very little improvement in feed conversion for hogs or cattle in data extending back to 1910, and no improvement for poultry after the early 1970s. These data support a sobering picture of the impact of future demand growth on prices and resource use, since they suggest relatively high feed requirements and little historic improvement.

However, the data used, from the USDA's annual *Agricultural Statistics* (USDA 2011), are not based on surveys of farms, feed providers, or animal scientists, but on feed formulas that have not been updated in many years. The temporal variations over time do not reflect changes in breeding and feed conversion, which are held constant since 1970, but rather in the size of animals.

Smil is an informed observer who used what was available, but that is not what is needed. The Economic Research Service (ERS) has added new evidence on US practices with data from the Agricultural Resource Management Survey (ARMS), an annual farm survey that is the USDA's primary source of data on the financial and productive performance of US farms. I will focus initially on what we have learned about poultry and hog production.[1]

United States hog production underwent a dramatic transformation in the last two decades: fewer but larger farms now specialize in single stages of production, with a tight system of coordination among stages, and with close attention paid to breeding, feeding, and production practices. One major outcome of that transformation was a sharp improvement in feed conversion: Key and McBride (2007) estimate that feed conversion in finishing operations improved to 2.14 (pounds of feed to produce one pound of weight gain) in 2004, from 3.83 in 1992.

Poultry production has displayed ongoing incremental improvements in breeding, feed formulations, and housing. In 1980, it took the industry fifty-two days to produce a four-pound broiler (the standard for the time), at an average feed conversion of 2.08 pounds of feed per pound of weight gain (MacDonald and McBride 2009). In 2011, four-pound birds were produced in thirty-six days, on average, at an average feed conversion of 1.75.[2]

1. We do not do specialized cattle feedlot surveys as part of ARMS, and therefore do not have estimates of feed conversion for beef. But Belasco, Ghosh, and Goodwin (2009), with access to feedlot records from large Kansas feedlot firms, estimate mean feed conversion for fed cattle at those sites to be 6.2 pounds, well below the Smil estimate.

2. I use a four-pound bird for comparison to the 1980 standard. The industry standard in 2011 was closer to a six-pound bird, with an average cycle time of forty-nine days and average feed conversion of 1.95 pounds of feed per pound of gain. The 2011 data are drawn from the 2011 ARMS version 4 (broilers), a representative national survey of commercial broiler operations.

These estimates are well below those provided in Smil (2000), and they show substantial improvements over time. They suggest that increased global meat consumption can have much less impact on feed and land use, and crop prices, than Smil's estimates suggest, and they also give reason to expect continuing efficiency improvements. Moreover, recent developments in genomics allow for much more rapid, inexpensive, and targeted selection in breeding, and also suggest that there may be more variation in animal populations than was previously realized. These developments are having important impacts in dairy production, and may lead to further applications in hogs, in poultry, and particularly in beef cattle. There is, therefore, reason to expect that further innovations can improve feed efficiency and can also be targeted to water use, disease susceptibility, heat stress, and meat attributes.

The ARMS data are not ideal for these purposes. I believe that they are an improvement on what was available, and they provide a useful perspective on the spread of a variety of production practices among US producers. The samples are designed to be representative of commercial production, but the survey is designed to focus on annual financial and production outcomes and not the collection of performance data; all the more reason to gather better data on applications of the science and on developments in actual practices.[3]

These measures largely reflect innovations in genetics, feeds, and housing. But management also matters for thinking about feed conversion in emerging economies. Large firms, such as Tyson Foods from the United States and CP Group from Thailand, are developing production complexes in several countries with growing meat consumption. These firms have access to the latest genetic and mechanical technology—that is, the knowledge is globally transferable within the companies. But management organization may still be a challenge.

Production complexes include feed mills and processing plants, as well as farms for egg laying, egg hatching, replacement birds, and grow-out to slaughter weights (with the equivalent stages for pork production). In the United States, farmers contract with poultry companies to raise their birds for grow-out; the farmers provide labor, capital, and energy, while the companies provide them with chicks, feed, transportation, and veterinary service. Independent growers appear to realize higher productivity and lower costs than company-owned farms, but it remains to be seen whether the US model will work in other settings, or whether the companies will come to rely more on full integration and company-owned farms.

3. For example, the hog estimates are based on the ratio of total feed provided to the respondent (farmer) in a year, divided by output, which is total live-weight gain in hog production. Output is measured with little error, but annual feed deliveries may not match production closely. Moreover, some contract farms do not know how much feed is delivered. As a result, the treatment of extreme values, and the treatment of missing values, matters for the estimates. In more recent surveys, we have asked directly for feed conversion data, and that provides tighter estimates, with missing values still a problem.

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