The Farm Labor Problem

J. Edward Taylor & Diane Charlton
Agricultural & Resource Economics
University of California, Davis

Why have a field of agricultural labor economics? Almost every economics department offers courses in labor economics. Why isn't that sufficient? The answer must be that agricultural labor markets are fundamentally different from other labor markets. Unique characteristics make agriculture different from other sectors and food different from other commodities, and they have profound implications for farm labor markets.

Essentials	
Why agriculture is different	Farm labor contractors
Seasonality	Migrant farm labor
Uncertainty	Immigration
Multi-stage production	

Teaching kids how to feed themselves and how to live in a community responsibly is the center of an education.

— Alice Waters

The fight is never about grapes or lettuce. It is always about people.

— Cesar Chavez

From the depth of need and despair, people can work together, can organize themselves to solve their own problems and fill their own needs with dignity and strength.

— Cesar Chavez

We asked for workers. We got people, instead.

— Max Frisch

Agriculture is different from other economic sectors (Timmer, 1988), in ways that have far-reaching implications for the analysis of labor markets. Agricultural labor demands are aggregated from the demands of many farms scattered across a large geographic space. The number of workers needed on a farm fluctuates seasonally, and there is a high level of uncertainty about the farm labor demand from the time of planting a crop to its harvest. The supply of farm workers is also dynamic. As countries develop and their per-capita incomes rise, their workforces move out of agriculture and into non-farm jobs, creating a shortage of farmworkers over time. Farmers pressure their governments to facilitate the immigration of farmworkers from poorer countries to fill the void. Even if there is an abundance of farm labor overall, local labor shortages often materialize if workers are not available in the right place at the right time.

This introductory chapter introduces the problems of farm labor demand and supply, the uncertain and seasonal equilibrium between the two, and the role of immigration in addressing the farm labor problem. It concludes with a view towards the future, discussing how agriculture must adjust to a new farm labor equilibrium as the global workforce moves off the farm.

The Problem of Farm Labor Demand

The agricultural production process is biological. It relies heavily on inputs from nature (land and weather). Consequently, agricultural production is highly seasonal. There are long time lags between applying inputs and harvesting outputs. Although the farmer can directly control how much is planted, there is great uncertainty regarding how much crop will be ready for harvest and how the harvestable crop will be valued on the market. Farming requires land, so agriculture is dispersed over a wide geographic area. Because agricultural production is geographically dispersed, involves long lags, and is highly seasonal, timely access to labor is critical to the success and competitiveness of farm operations.

Agricultural production and access to labor vary substantially around the world. In the United States, agricultural production is dominated by large agribusinesses (which McWilliams' (1939) refers to as "factories in the field"). Millions of small family farmers (or in China, hundreds of millions) dominate production in low-income countries. In most of the world, agricultural production decisions are made by households, and the family provides most or all of the labor needed on the farm. Often, hired labor is an imperfect substitute for family labor because hired workers may not work as efficiently, they may not have equal vested interest in the farm, or workers may not be available for hire near the farm.

Agriculture is marked by a high degree of risk; thus, considerations of risk are a hallmark of agricultural decision making (Moschini and Hennessy, 2001). There are two broad categories of risk in agriculture: Production risk and marketing risk. Harvests are uncertain. They are shaped by variables beyond producers' control, including pest and weather risks. This sort of uncertainty does not arise in manufacturing, where production processes are governed primarily by engineering relationships. Whether farmers have access to hired workers and a market for the harvested crop directly impacts how farmers respond to seasonality, uncertainty, and risk in agricultural production.

Once the harvestable stock of produce is mature in the fields or on the trees, agricultural production is largely a resource-extraction problem—how to harvest the crop and get it to market. Most of the risk at this stage is market-related. Seasonal variations in spot-market prices create critical timing windows for agricultural producers. Increasingly, grower-shippers have time-sensitive contractual commitments as preferred suppliers to mass merchandisers (e.g., Walmart and Costco), supermarket chains and food service industries. Failure to harvest a field on time can result in the grower-shipper failing to meet delivery commitments to buyers under Vender Managed Inventory Replacement (VMIR) and other preferred supplier agreements. Some research suggests that, with the consolidation of the retail sector, shippers have less negotiating power and are more fearful of losing accounts if they fail to comply with buyer requests (Calvin, et al.). Increasing trade integration creates price competition and narrows marketing windows, intensifying these concerns. Having access to workers at critical moments in the production process can make the difference between meeting delivery commitments or not.

Labor supply risks are paramount at harvest time. An important potential component of risk is the lack of available labor at the times and places needed to harvest crops. Production risk can result from an insufficient labor supply if fruit spoils on the trees before it can be harvested or if labor shortages prevent farmers from complying with their contractual obligations higher up on the supply chain.

The sequential nature of crop production and risk mean that we cannot treat farm labor like other production inputs or like labor in other sectors using a conventional single-stage production model. The harvest depends on the stock of product available to harvest as well as the inputs applied at harvest time. The harvestable stock, in turn, is uncertain, and it depends on decisions made prior to harvest.

The Agricultural Production Function

To start, let's think about the production function. In most sectors of the economy, the production function represents a known engineering relationship between inputs and outputs, like how many textbooks can be produced from a given amount of paper, ink, capital (printing machines), labor, and so on.

Commercial farmers, like other producers, use technology to combine inputs and produce an output, with the objective of maximizing profits. (They may have other objectives as well, but for most purposes profit maximization is a reasonable assumption.) At any point in production, profit maximization implies employing additional variable inputs, including labor, up to the point where the cost of adding an additional unit of the input just equals the input's price. A farmer will not pay employees for an additional day of work unless this results in a sufficient increase in gross revenue to cover the wage bill. If by hiring workers for another day of labor she will receive an increase in harvest worth more than the wages paid, she will do it. Over time, producers may invest in new, labor-saving technologies to reduce the costs of hiring workers. They will only invest in new technologies or capital if the discounted cost savings over time are greater than the cost of the initial investment.

Farmers are like any commercial producer in that they select how many inputs to use in order to maximize profits. Agriculture, however, is different from other sectors in ways that have profound implications for labor demand.

Production Risk

The agricultural production process is biological and filled with uncertainty. Farmers rely heavily on inputs from nature, including weather.

On the plus side, nature provides inputs like sunshine and rainfall at no cost. The downside is that farmers cannot predict when rains will or will not come, whether there will be a long season with no sunshine, or whether a swarm of locusts will devastate the crop. Shocks of nature break the engineering relationship between inputs and outputs.

Agricultural economists pay a great deal of attention to incorporating risk into the production function. In agriculture, the production function is random or stochastic (from the Greek word στόχος (stóchos), meaning 'guess' or 'target'). We will learn about stochastic production analysis and what it means for labor demand in later chapters, but for now it is important to bear in mind this crucial difference between agriculture and other sectors.

Timing and Seasonality

Farm labor employment is highly seasonal. A 1938 study of California farm labor noted extreme fluctuations in seasonal labor demand[1]

[1]Barry, 2007. "Influence of Employment Agencies on Migratory Farm Labor," p. 4.

"During the peak season of September of the year 1935...there were demands for more than 198,000 workers, while in the slack season of the same year, during December and January, but about 47,000 were required, leaving over 150,000 unemployed."

More recent data from the U.S. Bureau of Labor Statistics paint a similar picture. Figure 1 shows the seasonal ups and downs of the two components of the U.S. farm labor demand between 2001 and 2009: by farmers and by farm labor contractors (FLCs). There is evidence of a slight decrease in the peak-to-trough ratio of employment in fruit, vegetable and horticultural (hereafter, FVH) production over time, but this masks another far-reaching development in the farm labor market: the expansion of labor demand by FLCs. Combining FLC and direct hiring by farmers, the aggregate peak-to-trough ratio appears remarkably stable from one year to the next—and it's big.

Agriculture really involves at least two production activities. In the pre-harvest season, the farmer's objective is to create a stock of harvestable fruit on the tree (or vine, or field). In the harvest period, his objective is to turn the harvestable stock into a marketable product, picked and packaged. There is no reason to think that the demand for labor looks at all the same in these two periods.

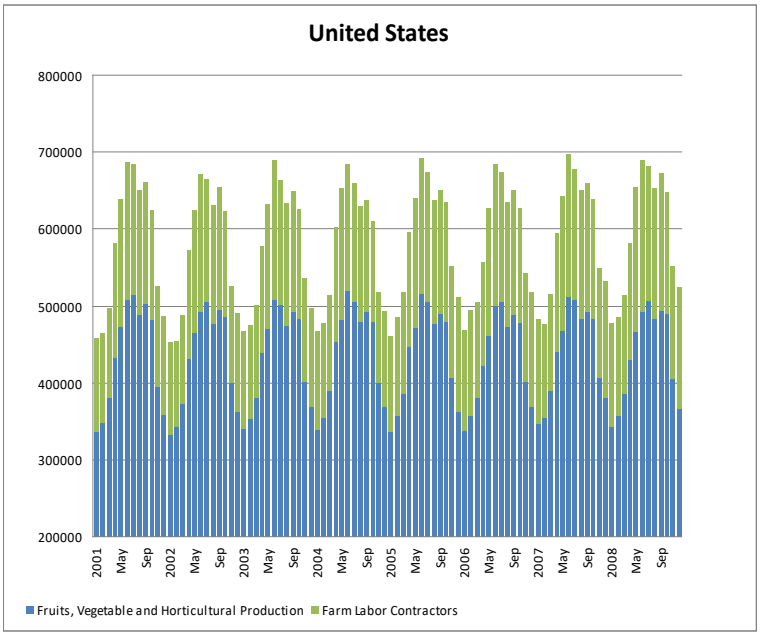

Figure 1. Employment by FVH Producers and Farm Labor Contractors in the United States is highly seasonal. Source: Created from Bureau of Labor Statistics Quarterly Census of Employment and Wages (http://www.bls.gov/cew/data.htm).

Take a typical California grape farm, for example. It employs a few workers year-round to irrigate, weed, prune, and perform other tasks required for the vine to produce fruit. The harvest season, on the other hand, is short and intense. The Fresno, California, raisin grape

harvest used to be the most labor-intensive activity in U.S. agriculture; between 40,000 and 50,000 workers were hired each fall to pick the grapes and spread them out on paper trays to dry in the sun. Today, many farms have switched to dry-on-the-vine technology, in which machines shake the dried raisins off the vine, reducing the need for farm workers during harvest.

A multi-stage production process means that agricultural labor demand tends to be highly seasonal. Combine this with risk and we can begin to understand why agriculture and farm labor markets are so different. Agricultural production *at each stage of the production process* is stochastic. Nature's surprises early in the growing season can create large swings in labor demand at harvest time.

Whenever there are time lags between input use and harvest, producers have to find ways to finance their inputs. They also have to find ways to put food on the family table even if the crop fails.

Credit is vital to most farmers in high-income countries; farmers can take out loans to purchase inputs, then repay the loans after harvest. These inputs include labor. Workers might be willing to work on your farm, but if you don't have the cash to pay them before the harvest comes in, they will not be there.

Crop insurance is a different matter. Even in rich countries, most farmers who grow labor-intensive fruit, vegetable, and horticultural (FVH) crops do not have an insurance policy that will pay out if the crop fails. (Major grain crops in the United States are an exception, but only because of the federal government's Crop Insurance Program.[2]) Farmers bear the risk on their purchases prior to harvest, knowing that the crop might fail or the price of the harvested crop may tumble.

Further imagine the challenges farmers face in poor countries, where banks won't lend money to small farmers, and formal insurance is nonexistent (Taylor and Lybbert, 2015).

Space

Farming requires land, so agriculture is spread over wide geographic areas. Contrast this with, say, information and technology industries in California's Silicon Valley, which reap *economies of agglomeration* by locating close to one another so that they can share ideas and build from one another's innovations. Even though farms are spread, timely access to diverse markets is still critical. This includes markets for the output farmers produce, but it also includes markets for inputs—including labor.

Workers have to arrive at the farms, at just the right time, or else crop losses are likely. A farmer might do everything right in the pre-harvest periods, the growing conditions might be ideal, and as a result, there might be a bumper crop in the field, but if the workers aren't available to pick the crop at the critical moment, some of that crop can rot before it is

2 You can learn about the Crop Insurance Program at the U.S. Department of Agriculture (USDA) website: http://www.rma.usda.gov/aboutrma/what/history.html.

harvested. Even if, say, the last 15 percent of the crop is left unpicked, that might represent the farmer's profit margin.

On a small family farm, the labor to cultivate and harvest crops is likely to be supplied by the farmer's own family. On many larger farms, such as a table grape farm in Fresno for instance, family labor is largely irrelevant. A large number of hired farm workers are needed for a short period of time to bring in the harvest.

How do farmers find so many workers on short notice? In California, the answer increasingly is farm labor contractors (FLCs). FLCs are labor-market intermediaries who, for a fee, match farm workers with jobs on individual farms. Instead of hiring workers directly, a farmer can enter into a contract with a FLC to, for example, harvest 20 acres of oranges. The FLC will calculate how many workers will be required, over how long a period, to accomplish this. His costs will include the wages he pays, payroll taxes, costs of transporting workers out to the field, book-keeping, etc. To these, he will add his profit.

FLCs have become key actors in U.S. farm labor markets. For some crops and regions, they supply most of the harvest labor that farmers demand. In theory, FLCs could be a stabilizing influence, matching crews of workers with a series of jobs on different farms. In practice, we will learn later in this book, the expansion of FLCs increased farm worker turnover for farm workers in California.

Inequality and Concentration

Some sectors, like energy, steel, or automobiles, are dominated by a few large producers. Agricultural production is different. It is by far the largest production sector in the world in terms of numbers of producers. By one estimate, there are at least 570 million farms worldwide. More than 475 million of them are less than 2 hectares in size.[3] Thus, the vast majority of the world's farms operate only a small share of the world's farmland. The world's farmers have unequal access to resources, from large agribusinesses to small-scale farms producing for farmer's markets to hundreds of millions of poor family farmers in less-developed countries.

To understand the supply and demand for farm labor, we have to understand the behavior of thousands, millions, or (in China and India) hundreds of millions of heterogeneous actors. Influencing or simply understanding agricultural outcomes requires having good economic models of diverse agricultural producers and how they are likely to respond to different kinds of market, environmental, or policy shocks. To complicate matters, as we

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3 What do we really know about the number and distribution of farms and family farms worldwide?

Background paper for *The State of Food and Agriculture 2014*, by Sarah K. Lowder, Jakob Skoet and Saumya Singh.

https://ilcasia.wordpress.com/2014/07/31/what-do-we-really-know-about-the-number-and-distribution-of-farms-and-family-farms-in-the-world/

shall see, what is beneficial for large farmers may be detrimental for small farmers.

Is It a Household or a Business?

Perhaps the most notable difference between agriculture and other sectors in poor countries is that agricultural production decisions are almost always made within economic units that are also households. Most farms in the world are family farms. Unlike firms that are focused exclusively on production decisions, agricultural households jointly and simultaneously make both production and consumption decisions. This may seem like a technical distinction, but as we'll see in Chapter 3, it drastically changes the economic analysis.

The Problem of Farm Labor Supply

In poor countries, agriculture is large relative to other sectors in the economy, and agricultural labor is abundant. Most countries begin as mostly rural and agricultural. In the early stages of economic development, then, there is reason to think that the farm labor supply is elastic (Lewis, 1954). That is, workers are available to satisfy farm labor demands even at low wages.

In high-income countries, agriculture is a relatively small sector in terms of employment and income. The human capital (skill) requirements for agriculture are minimal. One might expect, then, that the supply of labor to agriculture, like any small sector, is elastic, easily expanding to meet seasonal increases in labor demand. Contrast this with high human capital jobs, like computer programmers and doctors, for which it might take several years to train new workers when labor demands increase. Human capital investment (in particular, the investment in schooling) is a major focus of dynamic labor supply models. It is important for doctors but not for farm workers.

Real life is different. As economies develop and off-farm employment expands, the domestic agricultural labor supply shifts inward. People leave farm work. We can imagine an equilibrium model in which agricultural wages increase apace with nonagricultural wages in order to induce domestic workers to supply their labor to farms instead of factory or service jobs. There might even have to be a wage premium to induce people to take farm jobs if non-farm jobs bring nonpecuniary benefits, like being more interesting and less onerous than farm work. What would it take to get you out into the fields?

In the real world, rising farm wages do not induce domestic workers to do farm work. You would be extremely hard pressed to find an unemployed steel worker picking lettuce in California. The share of domestic workers in the U.S. hired farm work force has fallen to the point where, in 2006, only 23% of workers (2% in California) were U.S.-born.[4] The rest were immigrants, earning a wage easily eight times that in the villages of Mexico from which most hired farmworkers in the U.S. come. The wage rate in rural Mexico represents

[4] Estimated from the U.S. Department of Labor's NAWS Public Use Data (http://www.doleta.gov/agworker/naws.cfm).

the opportunity cost of migrating to U.S. farm jobs.[5] It is the lower bound on the reservation wage, the lowest wage a worker would accept to migrate to the U.S. instead of working in Mexico. A rural Mexican's reservation wage also includes the economic and psychic costs of migrating. Virtually all new immigrant farmworkers are illegal immigrants, so their reservation wage also reflects the risk of being apprehended, jailed, and returned to Mexico.[6]

The fact that most U.S. hired farmworkers earn low wages and come from Mexico suggests that the foreign farm labor supply has been elastic. An elastic foreign labor supply at a relatively low wage can explain why the foreign transfusion of the farm labor force occurs: The quantity of domestic labor supplied to agriculture drops as non-farm employment expands, and foreign workers come in to fill the void. Any excess demand for farm workers gets filled by foreign workers, and this keeps wages low. In the United States, a growing reliance on foreign agricultural workers and testimonials from farm workers, whose children usually eschew farm work, support Martin's (2001, p. 7) contention that "the farm workers of tomorrow are growing up outside the United States."

The supply of labor to individual farms and farm regions may be elastic in the short run, in the sense that a farm can attract more workers by offering a slightly higher wage. There is an important spatial element to this story, though. Unless the total farm labor supply can quickly adjust, farms in one region can attract new workers only at the expense of farms in other places. As one observer put it [cite guy in LAT garlic article]. The impacts of an excess demand for farm labor in one region reverberate into other regions. This produces the familiar pattern of localized seasonal farm labor shortages, even if there is an overall labor abundance and a widening farm-non-farm wage gap.

Equilibrium in Farm Labor Markets

In 2007, a *Wall Street Journal* editorial claimed that "farmers nationwide are facing their most serious labor shortage in years." The editorial asserted that "20 percent of American agricultural products were stranded at the farm gate" in 2006, including a third of North Carolina cucumbers, and it predicted that total crop losses in California would hit 30 percent in 2007. These predictions did not materialize. The example of cucumbers illustrates that farm labor shortages tend to be local, not generalized. U.S. cucumber production rose both in 2006 and 2007.[7]

This and many other farm labor-shortage anecdotes suggest that, even if the medium-to-long run supply of foreign workers is elastic, fed by new immigration, in the short run

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5 The market wage and marginal value product of labor are the same in a "separable" agricultural household model; see Singh, Squire and Strauss, 1986.

6 The migrant's reservation wage may include other elements, as well: psychic costs of working abroad, cost of living adjustments, etc.

7 "Farm Labor Shortages, Mechanization," *Rural Migration News*, Volume 13, No. 4 (October 2007). Cucumber production statistics are from USDA (http://www.nass.usda.gov/QuickStats/index2.jsp) and

farmers compete across regions for a relatively inelastic total supply of agricultural workers.

In an average year, what might be called a "first order" equilibrium supported at the margin by follow-the-crop migration ensures ample labor at a predictable wage in a given place and season. However, within a network of migration-linked farm labor markets, a stochastic shock to one local market (e.g., a late harvest in Sacramento) reverberates into neighboring labor markets (Lake County). Multi-region models would be needed to represent this spatial complexity of farm labor supply and demand.

A number of researchers point out an important caveat to the seasonal equilibrium just described. They note that the process of adjustment in farm labor markets often is sluggish and incomplete. Studies focusing on developing countries argue that wage rigidities force farm labor markets to adjust through changes in unemployment (Bardhan, 1979; Dreze and Mukherjee, 1989). Jarvis and Vera-Toscano (2004), in a fascinating study of seasonal farm labor markets in Chile, found that female workers absorbed most of the seasonal labor force adjustments, because they have the lowest reservation wage.

In the United States, the availability of welfare and unemployment insurance create a lower bound on the reservation wage. Instead of migrating to follow the harvest, workers can stayin one place and receive unemployment insurance and other benefits. Thus, farm labor markets are likely to adjust to demand shocks via changes in the demand for welfare and unemployment insurance rather than through an endogenous wage adjustment that redistributes farm workers across regions. Minimum wage laws reinforce this. Green, et al. (2003) used longitudinal data to estimate a simultaneous model of employment and welfare use. They found that seasonal work, low earnings, and high unemployment in California's agricultural counties promoted welfare use and limited the potential of local labor markets to absorb ex-welfare recipients. In California's major agricultural counties, when unemployment peaks, welfare use increases.

A Continuum from Family Farming to an Immigrant Farm Workforce

Hired labor markets evolve over time in ways that mirror the agricultural transformation. At low levels of economic development, familial farming dominates. That is, agricultural households provide most of the agricultural inputs and consume a significant part (in most countries, most) of the output from the farm. Not surprisingly, in predominantly subsistence economies, agricultural labor markets are relatively "thin" and often characterized by informal labor exchanges. In some areas, plantations create a demand for wage labor that co-exists with subsistence production.

The importance of hired labor expands as commercial production displaces family production. Consider, for instance, the United States, where both family and hired labor have declined over the last half century as a result of mechanization, but the ratio of hired to family labor has increased, from 1:3 in 1950 to around 1:2 today (Kandel, 2008; these averages mask large differences across U.S. regions). Increasing reliance on hired workers frequently gives rise to internal migration to address labor market disequilibria across time and space. However, a collection of factors—seasonality, uncertainty of farm employment,

aversion to follow-the-crop migration, the disagreeableness of working conditions in the field, and expanding income opportunities outside of agriculture—cause the domestic supply of agricultural labor eventually to shift inward and upward, creating incentives for farmers to seek a less expensive source of labor abroad.

Migration policies also evolve, in imperfect harmony with farm labor market trends because they are the outcome of a complex and frequently internally contradictory political process. Rarely do countries implement policies explicitly to influence internal migration. Nevertheless, at the mid stage of the agricultural transformation, there tends to be growing concern for the welfare of migrant farm laborers, their families, and the communities in which they live. At this stage, as Emerson (1989) states, "a major emphasis of governmental policy toward migratory farm labor is to shift the migrant out of the migratory stream, and if at all possible, to shift him to the non-farm sector."[8]

There is an integration-immigration dilemma, however: In the absence of labor-saving technological innovations and/or a shift to crops requiring less labor, mobility out of agriculture for some workers implies the rotation of new immigrants into the farm workforce. Martin (2009a, p. xix) describes an agricultural "immigration treadmill" perpetuating rural poverty.

In high-income economies, agriculture's importance as a generator of employment diminishes, while its dependence on foreign workers invariably increases. The political process becomes a battleground in which farm interests engage the interests of other actors, some of whom oppose the use of immigration policies to guarantee an abundant supply of agricultural labor.

If border enforcement restricts immigration, the farm labor supply decreases and wages increase. Meanwhile, the juxtaposition of high farmworker wages in the high-income country and low earnings abroad keep the supply of immigrant labor elastic. This intensifies pressure at the border and makes immigration policies difficult to enforce. According to conservative estimates, more than 50% of all U.S. hired farmworkers are unauthorized immigrants.[9]

Alternatively, farmers could adopt labor-saving technologies, invest in improved labor management to raise labor efficiency, or take steps to evade immigration laws. There is evidence that penalties against knowingly hiring unauthorized immigrants, which were included in the U.S. 1986 Immigration Reform and Control Act (IRCA), accelerated a shift away from direct hiring by farmers in favor of labor intermediaries, who are more difficult for immigration law enforcement authorities to monitor (Taylor and Thilmany, 1993).

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8 Examples include the migrant and seasonal farm worker programs launched as part of the War on Poverty in the 1960s, including Migrant Headstart, Migrant Education, Migrant Health, and Job Training for Seasonal and Migrant Workers.

9 U.S. Department of Agriculture, Farm Labor. http://www.ers.usda.gov/topics/farm-economy/farm-labor/background.aspx#legalstatus.

The End of Farm Labor Abundance

A pervasive theme in this chapter is that domestic agricultural workers become increasingly scarce as countries' incomes rise. Both logic and emerging empirical evidence suggest that the same applies to the supply of foreign agricultural labor. Labor intensive agriculture in high-income countries seeks out new migrant-source areas over time. The evolution of agricultural labor markets in farm labor-exporting regions raises questions about the sustainability of a labor-intensive agricultural system dependent on immigrant labor, and indeed of labor-intensive agricultural systems generally.

Nowhere are agricultural labor markets more integrated across borders than in Mexico and the United States. New research by Charlton and Taylor (2016) finds that the supply of farm labor from rural Mexico is diminishing over time. U.S. and Mexican farmers compete for an ever-smaller number of farm workers from rural Mexico. Migration is network driven (Massey, et al., 2005); new migrants tend to follow past migrants into the same destinations and jobs (Mora and Taylor, 2005; Richter and Taylor, 2008). As immigrant workers move out of agriculture and into factory and service jobs, future migrants do, too. The supply of labor to agriculture diminishes.

In Mexico, the regional shift in labor supply to U.S. farms is happening quickly. Mexico has entered into a new agreement with Guatemala to import Guatemalan farmworkers. Thus, Mexico is in a transitional phase of being both an importer and exporter of farm workers. It would not be surprising to see an increase in Central American migrant workers in U.S. agriculture in coming years. However, with a combined population one-third the size of Mexico's and accelerating urbanization, Central America's potential to replace Mexico as a significant source of U.S. farm labor is limited.

In Western Europe, regional integration under the European Union (EU) has created new sources of farm labor from the former Soviet bloc countries. Large numbers of farmworkers from Poland work fields in Germany and the United Kingdom. In time, one would expect that the migration networks currently channeling eastern European workers into agricultural jobs in the west will become more urbanized, like networks from Mexico. Worried about its heavy reliance on foreign agricultural workers, Germany offered farmers generous subsidies to hire German-born farm workers. That experiment failed, though, and the program was abandoned. Israel offered a different alternative to its farmers. In December 2009 it announced a new public initiative to invest in mechanization of Israeli farming "in an effort to reduce the need for foreign workers."[10]

[10] Arutz Sheva, Israel National News Briefs, "NIS 625M to be Invested in Mechanization of Agriculture," http://www.israelnationalnews.com/News/Flash.aspx/177179.

Robots in the Fields

Countries dependent on imported agricultural labor have two options. The first is to seek out new sources of farmworkers and (through immigration policy) grant farmers access to them. The second is to invest in reducing farm labor demands through a combination of technological change, improved labor management practices, and trade.

Stepping into a Wellsian time machine and glimpsing the agricultural future in today's farm labor-importing countries like the U.S., we are sure to find a combination of higher capital intensity and labor productivity, big labor-saving innovations involving machine learning and robotics, a shift to more imports of crops that are hard to mechanize, and higher farm wages.[11] The farm workforce will change; tekked-up workers will be needed to work in a tekked-up agriculture.

The transition to this new agricultural world is likely to proceed unevenly across countries and commodities. The profitability of labor-saving technological changes and crop mixes at a particular place and time will depend on the availability of low-cost labor. Policies facilitating access to low-wage immigrant labor and developments abroad that stimulate emigration will continue to discourage the adoption of labor-saving technologies. Mechanical harvesters and new IT-assisted labor-saving solutions exist for most crops, their usage limited mostly by low wages for harvest workers and quality and productivity concerns that can be addressed by future research and development (Sarig, et al., 2000).

New developments in information and technology, machine learning, and artificial intelligence point to a future of robot-assisted agricultural production. Engineering departments at universities and high-tech startup firms in Silicon Valley are beginning to develop labor-saving solutions for a diversity of crops that combine mechanical engineering with artificial intelligence and machine learning.[12] The perishable nature of FVH crops, imperfect substitutability between capital and labor, and consumer demands for high-quality locally grown produce will insure that some production of labor intensive crops persists even in high-wage countries. In time, though, the farm labor-immigration policy connection is bound to weaken, as changes in the availability of low-cost labor, technologies, crop mixes, and trade reduce countries' reliance on imported agricultural workers.

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11 *The Time Machine* is a science fiction novel by H.G. Wells.

12 Harvesting the Future: "Helper robots" are poised to help increase agricultural efficiency. UC Davis Department of Engineering, http://engineering.ucdavis.edu/blog/harvesting-future-helper-robots-poised-help-increase-agricultural-efficiency/