ROMEDIALOGUES
JOBS AND MIGRATION

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CLOSING THE AGRICULTURAL LABOR GAP:

DECENT MIGRANT WORK OR AUTOMATION?

Policy Note

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Abstract: *In more developed economies, only a small share of the domestic workforce is employed directly in agriculture. In the European Union, agriculture represents only 4% of total employment.*[2] *Even during economic downturns, when unemployment rates are high, domestic workers in developed countries rarely take jobs on farms.*[3] *These countries produce labor-intensive crops, including fruits and vegetables, by recruiting immigrants from less developed countries to work in the fields. Consequently, farm wages rise more slowly than in other sectors, and workers lack bargaining power. This, in turn, deters investment in labor-saving technologies. It is not until migrant-sending countries begin transitioning out of agricultural work that market forces induce employers to improve wages, working conditions, and employee benefits. As farm wages and other labor costs rise, farms typically increase investment in labor-saving technologies and more efficient labor management practices. We see evidence of this in the European Union and the United States today, where the traditional migrant-source countries (e.g., Poland and Mexico) are now recruiting farm workers from other countries to support their own agricultural sectors. The experiences of the EU and the United States suggest that domestic production of labor-intensive crops requires implementation of sustainable policies for the migration of low-skilled workers from less developed countries, which may be at odds with other national policies, and long-term planning for technological advances as migrant-source countries eventually transition out of agricultural work. Additionally, the geographic dispersion of farms, lack of legal status among many farm workers, and limited worker mobility associated with most guest worker visas can make farm workers vulnerable to abuse. Policymakers must also consider how to write and enforce policies for the protection of farm workers' health, agency, and wellbeing both domestically and throughout multinational agri-food supply chains.*

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[2] Eurostat, 2021 (nama_10_a64_e).

[3] Clemens, 2023; Mitaritona, 2020; Tzortzis, 2006.

1 Introduction

Few workers in the European Union are employed directly in agriculture. Agriculture makes up only 4% of total employment in the European Union,[4] and the importance of immigrants to agricultural production is increasing. For example, in France, the share of seasonal salaried agricultural workers who were immigrants grew from 18.8% in 2010 to 24% in 2016, and 64% of immigrants in 2016 were from non-EU countries (Mitaritonna and Ragot, 2020). Closure of borders during COVID-19 led to widespread farm labor shortages in numerous EU countries and led many policymakers to question the long-term reliability of current migration practices to provide adequate supply of seasonal farm workers (European Parliament, 2021; Mitaritonna and Ragot, 2020). Despite efforts to recruit domestic workers for essential farm work, including provision of unemployment benefits while working on farms during the pandemic,[5] few domestic workers accepted employment on a farm (Mitaritonna and Ragot, 2020).

Since few domestic workers are willing to perform farm work, efforts to improve viable strategies to produce labor-intensive agricultural goods in the EU must include plans for sustainable migration, investments in the development of labor-saving agricultural technologies, and implementation of more efficient labor management practices. Furthermore, it is imperative that discussions related to farm labor, migration, and global food supply chains also include plans for the protection of farm workers' health, safety, agency, and wellbeing. Immigrants, seasonal workers, and farm workers are vulnerable for abuse since they may not know their rights or how to advocate for them, and they often work in locations that are difficult to monitor or where it may be impossible to seek protection. To the extent that the EU imports foods and ingredients from abroad, these measures will necessarily include provisions for multinational food supply chains.

2 Farm Labor and Immigration

To produce fruits and vegetables at globally competitive prices, developed countries have historically recruited immigrants to fill farm jobs that that domestic workers will not do and to perform tasks that are difficult to mechanize. The foreign farm labor force in Europe includes documented workers, undocumented immigrants, and asylum-seekers. Table 1 shows estimated seasonal agricultural labor forces by country and primary countries of origin. Large shares of the migrants employed in seasonal agriculture come from other EU member countries, including Poland, Bulgaria, and Romania. However, Poland is recruiting farm workers from Ukraine simultaneous to providing farm workers to other EU nations (European Parliament, 2021). This suggests that farm labor supply is getting tighter in countries that traditionally provided seasonal migrant labor to other wealthier countries.

[4] Based on data for employment in 2019 from The World Bank https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=EU

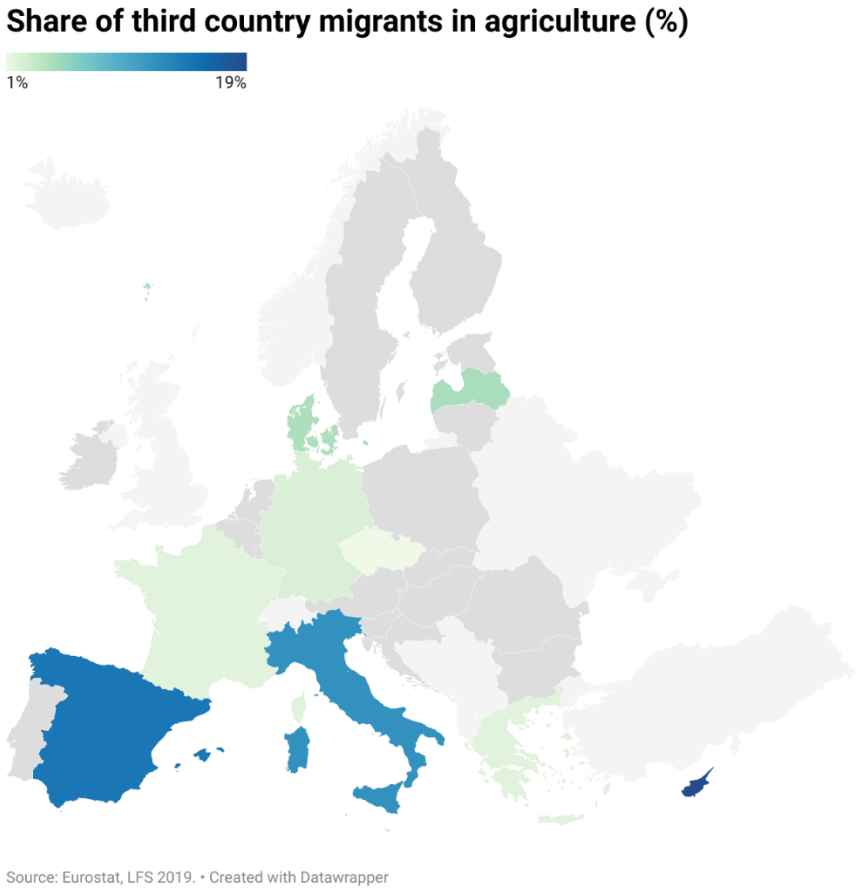
[5] All countries except Italy allowed workers to continue receiving unemployment benefits while working on a farm in 2020 (Mitaritonna and Ragot, 2020).

Table 1. Seasonal Agricultural Labor Migration by Country of Work

Country of Work	Approximate number of seasonal workers	Primary migrant-sending countries
Germany	300,000	European Member States, including Poland, Romania, and Bulgaria
United Kingdom	75,000	European Member States, including Poland, Romania, and Bulgaria
Sweden	3,000-5,000	Thailand
France		Morocco
Spain		Morocco
Poland		Ukraine
Italy	370,000	155 countries, and many are undocumented immigrants seeking asylum

Source: European Parliament (2021)

Figure 1. Concentration of migrants from outside the European Union who are employed in seasonal agriculture



Many EU countries recruit seasonal farm workers from outside of the EU member states as well (See figure 1). Countries of origin include Morocco, Thailand, Latin American countries, and sub-Saharan African countries, among others (European Parliament, 2021). Guest worker visa programs often help facilitate migration to seasonal jobs on farms. The UK's Seasonal Agricultural Workers Scheme (SAWS), first implemented after World War II and suspended from 2014-2018, helps facilitate the migration of seasonal farm workers from other parts of the EU (European Parliament, 2021). Germany began issuing seasonal agricultural work permits in the late 19th century and only discontinued the permits when using forced labor during World War II. France began a formal legal guest worker program with Italy in 1951, Spain in 1961, Tunisia and Portugal in 1963, and Yugoslavia in 1965 (Mitaritonna and Ragot, 2020). New Zealand's guest worker program to recruit seasonal farm workers from Pacific Island nations has often been viewed as a relatively successful agricultural guest worker policy and example for others (Taylor and Charlton, 2018). Nevertheless, caution is required in the creation of any guest worker policy that inhibits the movement of workers across sectors as workers can more easily get trapped in abusive working conditions.

Some government policies have attempted to deter immigration, suggesting that the removal of immigrants would allow farm wages to rise, and that farm work would then appeal to domestic workers. However, the physical strain of agricultural work often deters domestic workers even when wages are relatively high. For example, German policy in 2006 that required 10% of seasonal farm workers to be German was abandoned shortly after implementation because Germans did not take the jobs.[6] Farm employers in the United States had little success in recruiting domestic workers to farm work during the Great Recession even though unemployment rates were high.[7] Although the availability of agricultural guest workers has been shown to negatively affect native employment in the United States, the magnitude of the effect is extremely small because native workers appear to have a strong aversion to farm work (Clemens, 2022). Furthermore, efforts to reduce the incidence of undocumented migration to farms have historically met with little success (Box 1).[8]

Recent literature suggests that many of the migrant workers who cross back and forth across international borders do not serve the same role or purpose as permanent workers, so native workers may not be perfect substitutes for immigrants (Basu et al, 2022). The return rates of immigrants to farm work in the EU is high (49% in France), and farmers value the speed and skill with which these workers perform their jobs (Mitaritonna and Ragot, 2020). However, the mobility of farm workers may decline as migrant-sending countries become more developed. For example, in the United States, the share of farm workers who migrate throughout the year

[6] See, for example, Tzoritzis (2006). In 2006, Germany implemented a rule requiring 10% of seasonal farm workers to be German. The unemployment rate was high and farm wages rose following this rule, but the government eventually abandoned the rule because few Germans took the farm jobs.

[7] See for example, Johnson (2011). A Colorado farmer decided not to hire H-2A guest workers in 2011 because 1 in 11 domestic workers were unemployed. However, he could not find enough domestic workers. Many domestic workers who did take a job on the farm quit within the first several hours, and 25 of them specifically said that the work was too hard.

[8] See, for example, Martin, Fix, and Taylor (2006) and Taylor and Charlton (2018).

declined sharply since 1999, largely due to structural changes in the economies of the United States and Mexico (the primary source of farm workers to the United States) and worker preferences (Fan et al., 2015). If countries that provide farm workers to the EU follow similar trends, farm workers will likely become more settled, making it more difficult for farms to attract seasonal workers for labor-intensive tasks, particularly during harvest.

Box 1: Policy Reforms Typically Fail to Prevent Undocumented Migration to Farms.
For example, the United States implemented the Immigration Reform and Control Act (IRCA) in 1986, which provided amnesty to thousands of undocumented workers who could show that they had worked in U.S. agriculture. IRCA also made it illegal for employers to knowingly hire undocumented workers and created provisions for agricultural guest worker program. However, IRCA actually increased undocumented immigration from Mexico to U.S. farms, likely, in part, because it demonstrated to potential immigrants that they might eventually receive amnesty if they worked in the United States (Boucher et al 2007). In more recent years, county and state government agencies have attempted to reduce undocumented migration by increasing the intensity of immigration enforcement within their jurisdictions. The 287(g) policies permitted local law enforcement agents to perform some of the duties of Immigration Customs and Enforcement to detain unauthorized immigrants and begin deportation procedures. However, these policies implemented at the county have resulted in large decreases in the production of labor-intensive agricultural products, including fruit, vegetables, and dairy products (Charlton and Kostandini, 2020; Ifft and Jodlowski, 2022; Kostandini et al, 2014). Undocumented immigrants are vital to U.S. agricultural production, and it is estimated that if all undocumented farm workers were removed from California, farm worker wages would rise by 42 percent. Yet, profit margins on farms are estimated at only 2 percent surplus (Richards, 2018).

3 Labor Scarcity Induces Technology Adoption

When labor becomes relatively scarce, producers seek out technologies to substitute for workers or make workers more productive (Box 2). When the United States terminated the Bracero agricultural guest worker program with Mexico in 1964, there was widespread fear of farm labor shortages. However, these did not materialize; nor did farm wages rise. Instead, farms adopted labor-saving technologies when possible, and acreage of crops that were more difficult to mechanize declined (Clemens et al., 2018). In response to increased incidence of farm labor shortages in the United Kingdom following Brexit, the UK government initiated a "food production transformation" program with 90 million pounds allocated for the innovation of improved uses of AI, robotics, and satellite data in agri-food production, and 40 million pounds allocated for encouraging farmers to invest in new technologies (Mitaritonna and Ragot, 2020).

Box 2: Diminished Labor Supply and Technological Investments
There is myriad evidence that farms invest in more mechanization following an inward shift in the labor supply. For example, following the termination of the Bracero agricultural guest worker program between Mexico and the United States in 1964, agricultural production in U.S. counties that were formerly more dependent on Bracero workers became more capital-intensive, and some agricultural acreage was converted from crops with few mechanical options to crops that could be mechanically harvested (Clemens et al, 2018). Farms also became more capital-intensive following the

implementation of stricter immigration enforcement policies that reduced the immigrant labor supply within U.S. counties from 2005-2012 (Charlton and Kostandini, 2020; Ifft and Jodlowski, 2021). In Europe, robotic solutions are garnering more attention as the farming sector struggles to find sufficient workers (Tamirat et al, 2023).

Automatic milking systems (AMS) that robotically milk cows and collect data on milk quality and cow health were introduced in the Netherlands as early as 1992 (Rossing et al 1997). Currently 38% of milk produced in the Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden) was harvested by AMS (Dairy Global, 2022). However, adoption of AMS in the United States, where labor costs are lower, has been more gradual (Barkema et al, 2015). Harvest of fruit that was traditionally hand-picked is also gradually becoming more roboticized, and adoption of robots in meat processing plants has increased quickly in response to increased risk to workers during the COVID-19 pandemic. Currently, European and Asian meatpackers are more automated than those in the United States (Rural Migration News, 2021).

Following border closures during COVID-19 and increased labor costs and production risks associated with the pandemic, technology adoption and robotization on farms is expected to accelerate (Charlton, 2021; European Parliament, 2021; Mitaritonna and Ragot, 2020). Many crops, like grains and tree nuts, are already harvested mechanically. Fruits and vegetables, which are often more delicate and may not ripen uniformly, generally require greater dexterity, and most are still harvested by hand. Many labor-assisting technologies, such as orchard platforms that eliminate the need for ladders or robots that transport trays of fruit down rows, already exist. These technologies can enhance worker productivity on farms but do not substitute for workers. Nevertheless, engineers have made great strides in the past 10 years to create robots to harvest delicate fruits. Robotic strawberry harvesters were used on commercial farms in California last year, and engineers believe that robotic apple harvester will soon be commercially viable as well.[9] It is noteworthy that the robotic strawberry harvester does not eliminate workers. Workers are trained to operate the robots, turn them at the ends of rows and repair broken robot arms, and a crew of workers follows the robots to pick strawberries that the robot missed. New incentive schemes had to be developed since the former piece rates were not appropriate, but the work is less physically demanding, and workers can potentially get paid more to perform more comfortable and rewarding jobs.

According to a survey of farmers in Greece, Spain, France, and the Netherlands, farmers are most concerned about high up-front investment for farm robotics, safety and reliability, and adaptability to small farms (Tamirat et al, 2023). Rental markets for robotics can potentially make robotic technologies more accessible to smallholder farms (Lu, Reardon, and Zilberman, 2016). The robotic strawberry harvesters in California are currently being leased by the month, but there are plans to eventually sell robots directly to the growers,[10] which might put small farms at a disadvantage since they lack economies of scale to amortize such a large up-front investment. Further research is needed to understand how robotic and other agricultural innovations will impact small- and medium-sized farms, demand for local and foreign labor, requisite skills, and employment in downstream industries.

[9] Based on conversations with engineers at Advanced Farm in Davis, CA (2023)
[10] Based on conversations with engineers at Advanced Farm in Davis, CA (2023)

Social and labor market impacts of robotic and other mechanical innovations depend, in large part, on whether the technology was innovated in response to labor scarcity. Despite widespread fear that robots take jobs away from workers,[11] a study of Danish firms shows that those firms that were exposed to greater influxes of low-skilled immigrant workers adopted robots more slowly because there was less need for robots where labor was more abundant (Mann and Pozzoli, 2023). Social and labor market impacts of robotic and other mechanical innovations depend, in large part, on whether the technology was innovated in response to labor scarcity. When introduced and adopted in response to labor scarcity, robotization and mechanization can increase economic productivity, improve worker welfare, and possibly create jobs. However, when innovations are exogenously introduced and possibly subsidized by governments to encourage their adoption, they often displace workers and might increase unemployment or put downward pressure on wages (FAO, 2022). This shows that the context of labor-saving technology adoption is imperative for better anticipating economywide effects (Box 3).

Box 3. Endogenous Technology Adoption and The Tomato Harvester Controversy

As investments in research and development for labor-saving agricultural technologies increase, caution is required to mitigate potentially negative social or environmental impacts of technology use (see for example FAO (2022)). Shortly after the tomato harvester was introduced, the University of California lost a multi-million-dollar lawsuit in 1979 for allegedly using taxpayer dollars to develop a technology that displaced field workers and put small family farms out of business (Taylor and Charlton, 2018). Although there were net gains from adoption of the tomato harvester for society, some workers and growers were made worse off and did not receive compensation (Schmitz and Seckler, 1970). This lawsuit likely deterred research and development in agricultural technologies in the following years. However, in the current era, when farm labor is scarce, development and adoption of labor-saving technologies may be the only viable alternative aside from abandoning domestic production of fruits, vegetables, and other labor-intensive crops all together. Policymakers and researchers should be proactive to learn and understand potential direct and indirect impacts associated with the adoption of new technologies and take measures to mitigate negative side effects.

4 Promoting Sustainable and Ethical Labor Practices in the Agri-Food System

Even as technologies advance, robots will not eliminate farm workers, and policymakers must take actions to address the unique needs of workers in the agri-food system and protect their agency. Given the existence of globally competitive markets and the reluctance of workers in developed countries to perform seasonal or physically strenuous agricultural work, developed countries inevitably depend on numerous foreign-born workers. Consequently, policymakers must take actions to address the unique needs of these workers and protect their agency. Guest worker policies must coordinate a delicate balance of high level of transparency and provisions

[11] See, for example, analysis by Borjas and Freeman (2019). They estimate that for every robot provided in a supply shock of industrial robots, upwards from 2-3 workers will be displaced in the job market, and this displacement effect is much larger than that of an additional immigrant.

for workers' agency while remaining logistically easy to manage and low cost to growers. The state of California created the Agricultural Labor Relations Board (ALRB) in 1975 to facilitate an orderly process for litigation and protection, implementation, and enforcement of the rights of farm workers and responsibilities of employers and labor organizations.[12] Nevertheless, labor abuses still occur in agricultural fields at disturbing rates. Agricultural firms are difficult to monitor because of their geographic dispersion. While worker mobility is vital for workers to seek out new employers and flee abusive arrangements, mobility may be inhibited by workers' legal status or visa regulations.

Investment in infrastructure that allows workers, regardless of legal status or visa type, to advocate for their rights is vital for the agricultural community. Guest worker programs help deter farm labor shortages when labor supply is tight (Zhaniser et al, 2018), but guest worker programs that tie workers to a single employer could prevent workers from advocating for their rights. One of the primary challenges in creating guest worker visa policies is to protect the rights of workers without imposing costly and unnecessary regulations on employers. Guest workers, as well as immigrants, might be particularly vulnerable to abuse because they may not know their rights or how to exercise them, and undocumented immigrants may be reticent to report abusive behavior for fear of deportation.

Given the global nature of agricultural supply chains, sustainability measures must take a holistic view of agri-food supply chains across multiple countries. Farm labor scarcity and subsequent increases in farm worker wages might increase import competition from countries where labor is more abundant, and therefore less costly. In the case of the United Kingdom, some large producers have begun growing fruits in developing countries (Mitaritonna and Ragot, 2020). Similarly, some U.S. growers also operate in Mexico (Baker, 2007). As global trade and supply chains expand, policymakers must consider environmental, health, and social impacts of increasing imports or establishing multinational value chains, particularly because methods of production are generally difficult to monitor in other countries (Box 4). If consumers value the availability of locally produced agricultural goods, geographic indicators, or other features of locally sourced products that differentiate them from import competition, they might be willing to pay a significant price premium for domestic food products. To capture this premium, domestic growers will need to do extensive market research to learn what attributes consumers value and how to deliver these attributes in the market in a transparent manner that is easy for consumers to comprehend (See for example, Messer et al (2017)).

Box 4: Importing Labor Intensive Agricultural Goods

The fresh cut flower market increasingly sources flowers from nations like Kenya, Colombia, and Ecuador, crowding out some of the traditional, less efficient Dutch flower farms. Nevertheless, the full environmental tradeoffs of importing cut flowers are difficult to measure. The high water footprint of growing flowers in Kenya may be of concern, but less energy is required to grow flowers in Kenya compared to the greenhouses in the Netherlands. Royal FloraHolland in the Netherlands used to be a local cooperative, but has transitioned to a major global supplier group with 638 of its 6,153 suppliers

[12] See Agricultural Labor Relations Board. https://www.alrb.ca.gov/ Accessed May 18, 2023.

outside of the European Union (Ahmed et al, 2018). Royal FloraHolland has implemented numerous production standards for its suppliers to help maintain a sustainable supply chain. At the same time, non-traditional agricultural exports are shown to have important economic spillovers in the sending countries, including increased economic opportunity for women, thereby reducing migratory pressures and irregular migration.[13]

Consumer-based organizations can help enforce fair working conditions on farms when they establish sufficient transparency and gain cooperation from large buyers. The Fair Food Program (FFP) was established in the United States in 2011 following consumer boycotts on major corporations, like Taco Bell, that buy large quantities of tomatoes. Numerous such corporations, in response to consumer pressure, adopted a policy to buy only tomatoes certified with the FFP label, which denotes that the tomato farm abides by FFP protocols (Taylor and Charlton, 2018). FFP certified tomatoes are sold at a premium to cover the program costs to educate farm workers about their rights, help workers with litigation when their rights have been violated, and conduct third party audits on participating farms, among other services. The scope of FFP has grown to include farms producing a variety of crops in numerous locations, including a few farms in other countries.[14] FFP is based on a unique cooperative relationship between workers, consumers, and growers, and FFP's initial success can largely be attributed to the pressure that consumers placed on major corporate tomato buyers that had market power to demand better working conditions in the fields. Although FFP's current scope of influence is relatively small, models suggest that FFP's success can be replicated elsewhere (Kunz et al, 2023).

To protect workers' rights in international supply chains, multinational enterprises have sometimes influenced labor standards and social norms surrounding labor conditions along the value chain, even imposing standards in other countries. For example, private social standards, including standards related to the right to form trade unions, discrimination, and child and forced labor, were increasingly imposed by consumers and multinational firms based in Europe along multinational supply chains during the 1990s (Riisgaard 2009). However, despite these social pressures to improve working conditions, retailer incentives to cut costs and maintain tight ordering schedules along the global value chain often inhibited labor organization, thus undermining improvements in worker agency (Riisgaard 2009).

When farm labor is scarce, markets can help reinforce workers' rights because employers must raise wages and improve working conditions to retain workers. This is perhaps the silver lining of increasing incidence of farm labor shortages. Developed nations are currently experiencing reduced migration of seasonal farm workers (Fan et al, 2015) and increased incidence of farm labor shortages (European Parliament, 2021; Richards, 2018). Migrant-sending countries are transitioning out of farm work, much like Western Europe and the United States did in the twentieth century, which puts upward pressure on farm wages (Charlton and Taylor, 2016). Currently, Poland, which supplies farm workers to the United Kingdom, Germany,

[13] Van den Broeck, Swinnen, and Maertens (2017); https://blogs.worldbank.org/voices/investment-rural-economy-reduces-pressure-migrate-internationally.

[14] See Fair Food Program. https://fairfoodprogram.org/ Accessed May 19, 2023.

and other Western European countries, is simultaneously recruiting farm workers from Ukraine (Górny and Kaczmarczyk, 2018). A similar phenomenon is occurring in Mexico: Mexico supplies farm workers to the United States and Canada, and simultaneously recruits guest workers from Guatemala (Taylor and Charlton, 2018). As workers gain more opportunities in other sectors and locations, employers must find new ways to attract farm workers, which leads to improved working conditions.

Policymakers that have historically focused on developing and maintaining migration networks to support the agricultural sector may need to shift some resources to improving worker benefits to retain workers in agriculture. Furthermore, greater investment needs to be made in the development of labor-saving innovations for the production and harvest of crops that are not easy to mechanize. As more countries transition out of farm work, developed nations will have to compete with farms in other countries for a limited labor supply. Policies and regulations can help protect workers' rights, making agricultural jobs more appealing, and investments in research and development can make workers' jobs more productive and comfortable, and generate opportunities for workers to gain more skills in the operation and maintenance of advanced machinery and robots.

5 Concluding Remarks on The Unique Challenge of Farm Labor Markets

Agricultural labor markets pose a unique challenge to policymakers to create and enforce fair working conditions. Whether food is produced domestically or imported, labor conditions on farms and in the agri-food system are typically difficult to monitor. Developed nations inevitably depend on a foreign-born workforce to perform seasonal and physically demanding tasks on farms because workers do not readily return to agricultural work once they have left (Richards and Patterson, 1998). Immigrants may be particularly vulnerable to labor abuse, but under the right conditions, agricultural employment can create valuable opportunity for low-skilled workers, especially immigrants who have relatively few employment options, to advance economically. Technological developments may be part of the solution if they are introduced in such a way as they generate opportunities for workers to develop new skills and to increase their marginal productivity, thus translating to better wages and potentially better working conditions. However, policymakers must support market forces that lead to improved working conditions on farms and increased agricultural productivity while simultaneously regulating and enforcing fair labor standards. Continued research and dialog must accompany these policy efforts, so that we continue to learn the social, environmental, and health impacts of various policy measures and economic outcomes.

Works Cited

Ahmed, J.U., Linda, I.J., and Majid, M.A. 2018. “Royal FloraHolland: Strategic Supply Chain of Cut Flowers Business.” *Sage Business Cases*. Sage Publications: SAGE Busienss Cases Orginals: London.

Baker, D. 2007. “U.S. Farmers Move to Mexico: What Happened to the Land?” *The American Prospect: Ideas, Politics & Power.* September 5, 2007.

Barkema, H.W., von Keyserlingk, M.A.G., Kastelic, J.P., Lam, T.J.G.M, Luby, C. Roy, J.P., LeBlanc, S.J., Keefe, G.P., and Kelton, D.F. 2015. “Invited Review: Changes in the Dairy Industry Affecting Dairy Cattle Health and Welfare.” *Journal of Dairy Science.* 98(11): 7426-45.

Basu, A.K., Chau, N.H., and Park, B. 2022. “Rethinking Border Enforcement, Permanent and Circular Migration.” *Economic Modeling.* 108: 105733.

Borjas, G.J. and Freeman, R.B. 2019. “From Immigrants to Robots: The Changing Locus of Subsitutes for Workers” *The Russell Sage Foundation Journal of the Social Sciences.* 5(5): 22-42.

Charlton, D. 2021. “Seasonal Farm Labor and COVID-19 Spread.” *Applied Economic Perspectives & Policy.* 44(3): 1591-1609.

Charlton, D., and Taylor J.E.. 2016. "A Declining Farm Workforce: Analysis of Panel Data from Rural Mexico." *American Journal of Agricultural Economics* no. 98 (4):1158-1180.

Charlton, D., Taylor, J.E., Vougioukas, S., and Rutledge, Z. 2019. “Can Wages Rise Quickly Enough to Keep Workers in the Fields?” *Choices* 34(2): 1-7.

Charlton, D. and Taylor J.E. (2020). Rural school access and the agricultural transformation. *Agricultural Economics*, 51(5):641-654.

Clemens, M.A. 2022. “The Effect of Seasonal Work Visas on Native Employment: Evidence from US Farm Work in the Great Recession.” *Review of International Economics* 30(5): 1311-1514.

Clemens, M.A., Lewis, E.G., and Postel, H.M. 2018. “Immigration Restrictions as Active Labor Market Policy: Evidence from the Mexican Bracero Exclusion.” *American Economic Review.* 108(6): 1468-1487.

Dairy Global. 2022. “Nordic Region: What’s the AMS Situation on Dairy Farms?” (November 1, 2022). https://www.dairyglobal.net/dairy/milking/nordic-region-whats-the-ams-situation-on-dairy-farms/ . Accessed May 10, 2023.

European Parliament. 2021. “Migrant Seasonal Workers in the European Agricultural Sector.” Briefing.

Fan, M., Gabbard, S., Alves Pena, A., and Perloff, J.M. 2015. “Why Do Fewer Agricultural Workers Migrate Now?” *American Journal of Agricultural Economics* 97(3): 665-679.

FAO. 2022. *The State of Food and Agriculture 2022. Leveraging Automation in Agriculture for Transforming Agrifood Systems.* Rome, FAO. https://www.fao.org/documents/card/en/c/cb9479en

Górny, A. and Kaczmarczyk, P. 2018. “A Known but Uncertain Path: The Role of Foreign Labour in Polish Agriculture.” *Journal of Rural Studies.* 64: 177-188.

Ifft, J. and Jodlowski, M. (2016). “Is ICE Freezing US Agriculture? Farm-Level Adjustment to Increased Local Immigration Enforcement” *Labour Economics.* 78: 102203

Johnson, Kirk. 2011. “Hiring Locally for Farm Work is No Cure-All.” *The New York Times*. October 5, 2011.

Kostandini, G., Mykerezi E., and Escalante C. 2014. “The Impact of Immigration Enforcement on the U.S. Farming Sector.” *American Journal of Agricutlural Economics.* 96(1): 172-192.

Kunz, N., Chesney, T., Trautrims, A., and Gold, S. 2023. “Adoption and Transferability of Joint Interventions to Fight Modern Slavery in Food Supply Chains.” *International Journal of Production Economics.* 108809.

Lewis, W.A. 1954. “Economic Development with Unlimited Supplies of Labour.” *The Manchester School* 22(2): 139-191.

Lu, L, Reardon, T. and Zilberman, D. 2016. “Supply Chain Design and Adoption of Indivisible technology.” *American Journal of Agricultural Economics* 98(5): 1419-1431.

Mann, K. and Pozzoli, D. 2022. “Automation and Low-Skill Labor” *IZA Institute of Labor Economics* DP No. 15791.

Martin, P., Fix, M., and Taylor, J.E. 2006 . “The Quest for Ag Jobs” in *The New Rural Poverty.* (Chapter 7) Urban Institutes: Washington, D.C. pp. 73-86.

Messer, K.D., Costanigro, M., and Kaiser, H.M. 2017. “Labeling Food Processes: The Good, the Bad and the Ugly.” *Applied Economic Perspectives and Policy.* 39)3): 407-427.

Mitaritonna, C. and Ragot, L. 2020. “After Covid-19, Will Seasonal Migrant Agricultural Workers in Europe be Replaced by Robots?” *Centre d’Etudes Prospectives et d’Informations Internationales*. Policy Brief No. 33 (June 2020).

Richards, T. “Immigration Reform and Farm Labor Markets” *American Journal of Agricultural Economics* 100(4): 1050-1071.

Richards, T.J. and Patterson, P.M. 1998. “Hysteresis and the Shortage of Agricultural Labor” *American Journal of Agricultural Economics.* 80(4): 683-695.

Riisgaard, L. 2009. “Global Value Chains, Labor Organization and Private Social Standards: Lessons from East African Cut Flower Industries.” *World Development.* 37(2): 326-340.

Rossing, W., Hogewerf, P.H., Ipema, A.H., Ketelaar-De Lauwere CC., De Koning C.J.A.M. 1997. “Robotic Milking in Dairy Farming” *Netherlands Journal of Agricultural Science*. 45(1): 15-31.

Rural Migration News. 2021. “Meat and Covid” 27(1). https://migration.ucdavis.edu/rmn/more.php?id=2550 . Accessed May 10, 2023.

Schmitz, A. and Seckler, D. 1970. “Mechanized Agriculture and Social Welfare: The Case of the Tomato Harvester.” *American Journal of Agricultural Economics*. 52(4): 569-577.

Tamirat, T.W., Pedersen, S.M., Orum, J.E., Holm, S.H. 2023. “Multi-Stakeholder Perspectives on Field Crop Robots: Lessons from Four Case Areas in Europe.” *Smart Agricultural Technology.* 4: 100143.

Taylor, J.E. and Charlton, D. 2018. “Farm Labor and Immigration Policy” in *The Farm Labor Problem: A Global Perspective*. Elsevier Academic Press.

Timmer, C.P. 1988. The Agricultural Transformation in vol. 1 *Handbook of Development Economics*. (pp. 275-331).

Tzortzis, A. 2006. “When Germans Join Migrant Field Hands, the Harvest Suffers.” *Christian Science Monitor.* May 24, 2006. https://www.csmonitor.com/2006/0524/p01s04-woeu.html . Accessed May 10, 2023.

Van den Broeck, G., J., Swinnen, and M., Maertens. 2017. “Global value chains, large-scale farming, and poverty: Long-term effects in Senegal. *Food Policy* 66: 97-107.