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War in Ukraine and Impacts on California Food and Agriculture

Olena Sambucci and Daniel A. Sumner

The Russian invasion of Ukraine is a tragedy for those in the region and an ongoing threat to food security in many places. California agriculture can help mitigate some food shortfalls, but direct impacts on food and agriculture in California are relatively modest.

Russia’s invasion of Ukraine, which began on February 24, 2022, disrupted normal operations for Ukraine’s farms, food processing, and shipping. Ukraine is a major exporter of key agricultural commodities such as wheat, corn, barley, and sunflower oil. Russia is also a significant exporter of some of the same commodities. The major commodities exported by either Ukraine or Russia are not major exports for California. Nonetheless, the war has several potentially significant impacts for California, including the disruption of international food markets, effects on local food prices, higher farm costs, including fertilizer and energy, and direct commodity impacts for sunflowers, wheat, and walnuts.

This article reviews the situation and outlook for Ukraine’s agricultural production and exports, provides an

overview of the impacts (and potential impacts) on international markets, and examines linkages with food commodities produced in California.

Situation and Outlook for Ukrainian Agriculture

At the start of the war in February, little agricultural activity was underway in Ukraine, but exports of previous harvests were disrupted. Ukraine exports the majority of its agricultural commodities through ports on the Sea of Azov and the Black Sea. All Ukrainian sea ports have been closed since the beginning of the war, but

some exports have continued via other transportation channels. According to the Ukrainian Ministry of Agriculture, some exports of wheat, corn, sunflower oil, and other crops were being shipped by rail and through the ports on the Danube River. Nonetheless, at the end of May 2022, stocks of commodities still waiting to be exported were much larger than is typical for late spring.

The planting season in Ukraine begins in late March and continues through the end of May (see Figure 1) for all major crops except winter cereals

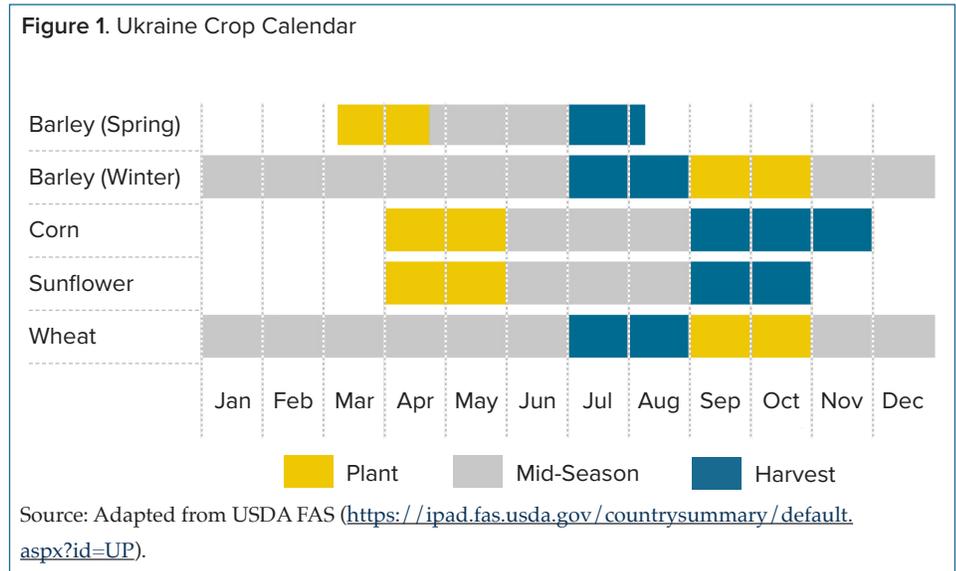
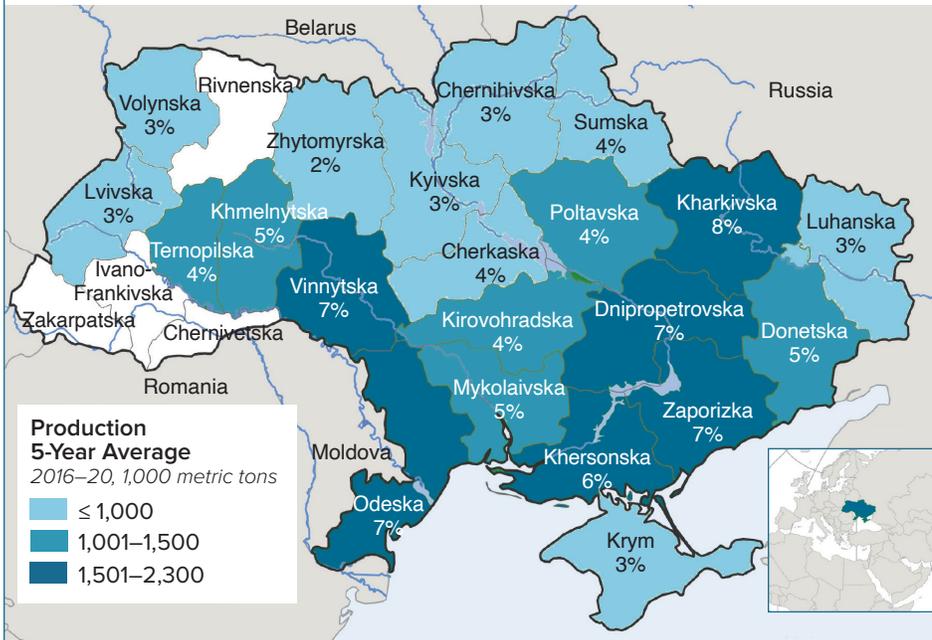


Figure 2. Wheat Production in Ukraine, by Region



Note: Percentages shown on the map indicate the percentage of national production.

Source: USDA FAS. Available at: https://ipad.fas.usda.gov/rssiw/ai/up_cropprod.aspx.

such as winter wheat, barley, and rye. Winter cereal crops are planted in late August and harvested in July, so they were already in the ground at the start of the war and needed tilling and fertilizer applications come spring and summer. Winter wheat accounts for over 90% of wheat grown in Ukraine. Winter barley accounts for 42% of Ukrainian barley production, and spring barley accounts for 58%.

The production and harvest of crops for the 2022/23 production and marketing year depend on what farmers are able to plant, cultivate, and harvest. Exports then depend on subsequent marketing and export logistics. A productive season depends on success at each link in the supply chain.

Some of the most productive farmland is located in the southeastern regions of Ukraine that have been occupied by Russia during the spring of 2022. The map of wheat production by region (Figure 2) is an example of the pattern of production in Ukraine; the patterns for other grains and oilseeds differ

from wheat, but in general much of the agricultural area of Ukraine has been under threat.

According to the Ukrainian Ministry of Agriculture, about 30% of farmland has been occupied, unsafe, or has been otherwise unable to be farmed. It is unclear what is happening on farms in the occupied territories. Media reports that stocks of agricultural commodities and farm machinery have been stolen by the occupying forces and transported across the border to Russia. Farms that had been previously occupied but were later liberated had been pillaged, and fields are filled with landmines.

Farmers elsewhere in the country are proceeding with the planting season but face shortages of labor, fuel, and fertilizer, as well as depressed local prices for commodities. Local prices are low for commodities such as corn, because stocks remain from the previous growing season, that would typically have been exported already. About 14% of the labor force is normally employed in agriculture.

Although farm workers are partially exempt from being conscripted to the defense forces, the number of people available to farm is much lower than last year.

The USDA published projections for the production of major crops grown in Ukraine as of June 10, 2022. Corn production for the 2022/23 growing season is projected to be down 26% from the prior 5-year average, wheat down 21%, sunflowers down 32%, and barley down by 35%. The June report shows projections for corn, sunflowers, and barley based on relatively complete 2022 planting information, which indicates more corn than the May report, but less sunflower seeds and barley. Wheat in Ukraine is mostly winter wheat, and projected production has not changed since last month.

Agricultural Exports by Ukraine and Russia

In 2021, Ukrainian exports (by value) as a share of world exports were 57% for sunflower oil, 17% for barley, 15% for corn, 11% for wheat, and 3% for walnuts. That makes Ukraine the world's top exporter of sunflower oil, the third largest exporter of corn (behind the United States and Argentina), the fifth largest exporter of wheat (behind Russia, Canada, the United States, and France), the third largest exporter of barley (behind Australia and the EU), and the fourth largest exporter of walnuts (behind the United States, Chile, and China).

Ukrainian sunflowers are primarily crushed and exported as vegetable oil. Sunflower cake is a byproduct of oil production and is used for animal feed, primarily within Ukraine. Snack sunflower seeds are a small share of sunflower consumption and account for very little of the sunflower trade. Developing countries that tend to be most reliant on food commodity imports from Ukraine are now the most vulnerable to disruption, food

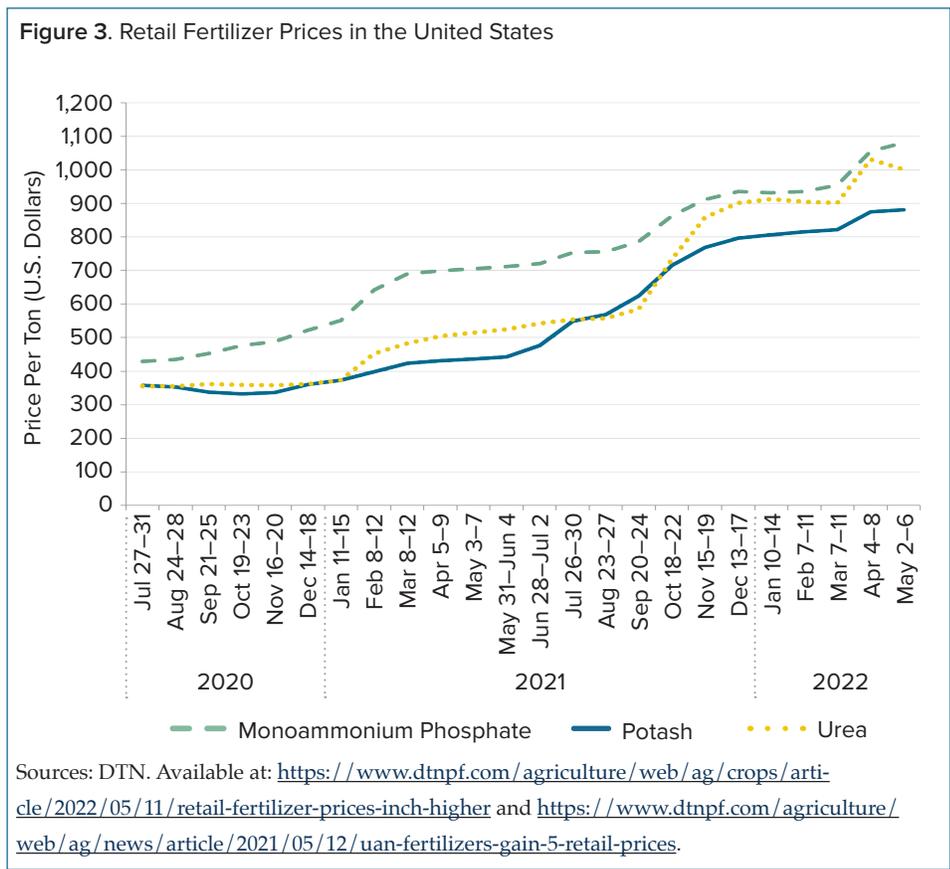
shortages, and high food prices. As usual, the poor are hurt worse. This may apply especially to destinations for Ukrainian sunflower oil and wheat.

India, the largest importer of Ukrainian sunflower oil, accounted for 25% of exports in 2021, and China was a close second, with 20%. Countries in Europe, as a group, accounted for 31% of exports in 2021, and about 14% of sunflower oil from Ukraine is exported to the Middle East. In 2021, 52% of corn exported from Ukraine went to China and 32% of corn went to Europe.

Ukrainian wheat exports are important for several developing countries that rely on relatively low-priced wheat for human consumption. Main destinations for wheat from Ukraine in 2021 were Egypt (18%), Indonesia (13.5%), Turkey (8.1%), Pakistan (7.4%), and Morocco (5.8%). An additional 16% of Ukrainian wheat was exported to other countries in Africa, and 15% was exported to countries in the Middle East.

Before the Russian invasion of Ukraine, global wheat prices had risen for several reasons unrelated to the war. With the 2021/22 Ukrainian wheat harvest underway, a major concern is blockage of ports and shipping lanes that threaten exports from Ukraine. Countries that rely on wheat from Ukraine and Russia, such as Egypt and other countries in Africa, the Middle East, and South Asia, are experiencing lower wheat imports. Recent reports indicate that consumers in some of these countries have already suffered from reduced imports and the rise in prices that began before the war started.

Port and shipping concerns have become increasingly significant as the war disrupts exports from Ukraine. The most significant disruptions,



including complete blockages, apply to shipping from the ports along the southern coast of Ukraine on the Black Sea. Some of these ports have been under Russian control or significantly damaged. But even if agricultural commodities could be loaded, as at the important port of Odessa, the shipping lanes across the Black Sea have been controlled or threatened by Russian mines and war ships. Road, rail, and river transit are slow, expensive, and not feasible for the vast quantities of bulk commodities that Ukraine would typically ship.

On June 10, 2022, the USDA predicted a 61% fall in Ukrainian corn exports and a 45% fall in wheat exports for the 2022/23 marketing years. As this is being written in June 2022, it is not clear if there is a feasible negotiation with Russia that might allow bulk exports of food products to get through the Black Sea to developing country customers.

Rising Prices of Fertilizer and Energy

Fertilizer prices have been rising since the summer of 2020, long before the war in Ukraine began. Ukraine exports small quantities of nitrogen fertilizer. Russia is the world's largest exporter of fertilizer, including nitrogen, phosphate, and potash fertilizer, and is a major exporter of natural gas, which is used in the production process of nitrogen fertilizer. Prices of fertilizer in the United States have risen since the start of the war, continuing their upward trend (see Figure 3).

Fuel prices—natural gas, gasoline, and diesel—have also risen this year after falling at the end of 2021. The patterns differ somewhat this year, but a common element has been the substantial and more variable increases since the invasion became imminent. In 2022, California diesel prices rose by less than 10% in January and February, before a jump of 20% in early March and a rise of another 5% since then.

Table 1. Production of Major Crops in Ukraine

Commodity	5-Year Average	June 10 th Projection:	
		2022/23	Percentage Change
		1,000 Tons	Percent
Corn	33,646	25,000	-26
Wheat	27,927	21,500	-23
Sunflower Seeds	15,360	9,500	-38
Barley	8,739	5,700	-35

Source: USDA FAS.
Available at: <https://ipad.fas.usda.gov/countrysummary/default.aspx?id=UP>.

Table 2. Value of Exports by Commodity, 2021

Commodity	Ukraine	World	Share
	\$ Billions		Percent
Sunflower Oil	6.31	11.14	56.7
Corn	5.87	37.90	15.5
Wheat	4.76	41.61	11.4
Barley	1.17	6.87	17.1
Walnuts	0.116	3.35	3.5

Source: UN Comtrade database. Available at: <https://comtrade.un.org/data/>.

Fertilizer and energy are costly inputs for many crops in California. The share of fertilizer in operating costs is about 10% for almonds and processing tomatoes, and about 18% for corn silage. By contrast, for strawberries and lettuce, which are labor-intensive, fertilizer accounts for less than 2% of operating costs. Similarly, energy for cultivation, irrigation, and harvesting is a sizable share of costs for some crops. Transportation and processing fuels, such as for drying rice or manufacturing milk powders or tomato paste, are also a large share of post-farm costs that depress farm prices to compensate for higher costs of processing and shipping to markets.

Potential Impacts on California Food and Agriculture

Market disruption and higher fertilizer and fuel prices will have direct impacts on farm returns already under pressure from drought and several other challenges. The severity of the impacts will vary by crop. Dairy (for

which corn silage is used as feed), almonds, and grapes, are the top three agricultural commodities in California by value. Costs to produce corn silage, almonds, and grapes will be significantly affected by rising fertilizer and fuel prices. As noted above, off-farm energy costs also depress farm prices as they increase food prices for consumers.

California does not import significant amounts of agricultural commodities from Ukraine, and direct competition in international markets is limited. However, the walnut market is an exception. California is the leading exporter of walnuts, followed by Chile and China, with Ukraine a distant fourth. Still, walnut prices have fallen substantially in recent years with pressure from Chinese exports, and Ukraine competes directly with China in several low-price walnut markets.

California sunflowers are grown almost exclusively as seed for sowing, and Ukraine and Russia are major customers. In 2021, California grew

45,000 acres of sunflowers that were harvested in the fall. Exports from California ports are typically concentrated in the months from September through February for spring planting at their destinations. California exported as usual in the fall and winter months, with a major share of exports shipped to Ukraine. However, industry reports indicate that disruptions at Ukrainian ports caused some California exports to be diverted to other destinations or returned to California. The outlook is uncertain for 2022/23 exports, which will commence this coming fall.

California production of wheat overlaps with Ukraine, but the markets differ. California farms plant about 400,000 acres of wheat each year, but harvest only a quarter of that, with most of the rest used for silage. Of the harvested wheat acreage, about 20% is durum wheat used for pasta. California exports very little wheat and does not compete with Ukraine in the low-price segment.

California wheat prices are generally higher than the U.S. national average and, like all wheat prices, rose from 2019 to 2020 and again from 2020 to 2021 (Figure 4). The effect of the Russian invasion of Ukraine may have influenced the resumption of the rise in wheat prices from February through April 2022, but several other factors, including prospects for lower U.S. yields, also affected wheat markets. High wheat prices may encourage more wheat to be harvested for grain in California rather than for silage, but drought may have even more influence.

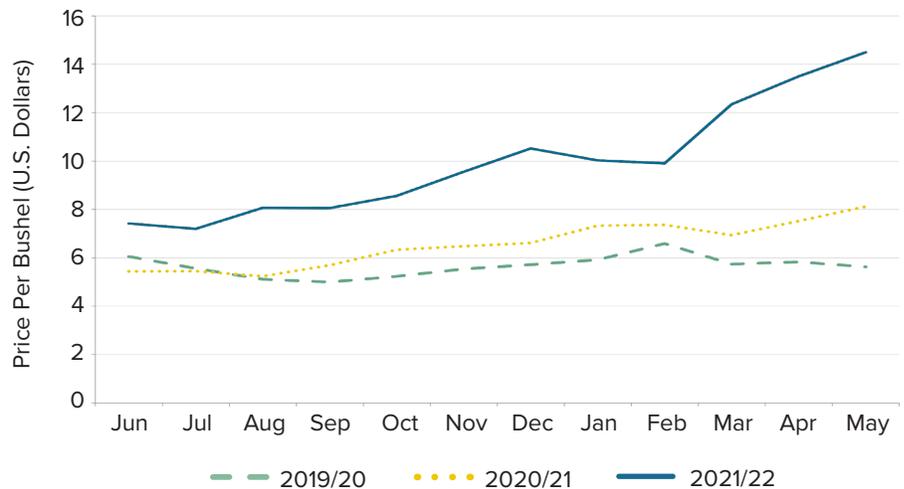
The increase in farm costs, as well as costs of processing and transportation, drive up consumer prices of food and other farm-based consumer products. Nonetheless, the increase in U.S. food prices due to the war in Ukraine will likely be, at most, moderate for two reasons.

First, for the farm commodities in which Ukraine plays a significant world export role, the U.S. commodity market is large and supplied largely by domestic substitutes. For example, in pre-war times Ukrainian corn production was a bit less than 10% of U.S. production. The projected shortfall in Ukrainian corn exports this year (about 14 million tons) is about 8% of world exports and about 4% of U.S. corn production. Year-to-year variation in U.S. corn production due to normal weather and market fluctuation is much more than 4%. That means that, although regional dislocation in the markets that Ukraine usually supplies may be severe, and the production and export blockages in Ukraine are a tragedy, the results within U.S. commodity markets will continue to be modest.

Second, for most of the food products that may face higher farm prices because of the Russian invasion of Ukraine, the farm price share in retail prices is quite small. For example, for corn, soybeans, or barley, which are primarily fed to livestock before moving toward food consumers, the impact on food prices is indirect and small.

Even for wheat, which goes directly to food products, the farm price is only about 17% of the retail price of wheat flour. More relevant, the farm cost share of wheat in a loaf of bread is only about 4%. Thus, even a 10% increase in the price of wheat in the United States would only raise the price of bread by 0.4%. Even if the price of milling and transport rose slightly because of war-induced increases in the price of energy, the increase in the price of bread in the United States is likely to be below 1%. Many factors have been causing higher food prices in the United States, but the war in Ukraine is a minor contributor.

Figure 4. Cash Prices for Red Hard Winter Wheat, Kansas City Market



Source: ERS USDA. "Wheat Data (Table 19)."

Available at: <https://www.ers.usda.gov/data-products/wheat-data/>.

Final Remarks

The crisis in Ukraine has been an evolving tragedy, evident to all. Food production in Ukraine has been hit hard, and its ability to export food commodities has been attacked directly. The impacts on Ukraine and on low-income consumers in countries that rely on imports from Ukraine have been severe. However, direct effects on California food and agriculture have been moderate at most.

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Authors' Bios

Olena Sambucci, who was born and raised in Eastern Ukraine, is a project scientist and Daniel A. Sumner is a Distinguished Professor, both in the Department of Agricultural and Resource Economics at UC Davis. They can be reached at osambucci@ucdavis.edu and dasumner@ucdavis.edu, respectively.

For additional information, the authors recommend:

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Too Little Too Late? The Two-Pronged Approach of the Federal Reserve

Bulat Gafarov and Jens Hilscher

At its most recent scheduled meetings, the Federal Reserve raised interest rates by 0.25%, 0.5%, and 0.75%. The last three readings of U.S. inflation were 8.5%, 8.3%, and 8.6%—the highest levels in 40 years. So, it is high time to act. However, the Fed has another tool in its arsenal: selling assets on its balance sheet.



How quickly will the Fed raise rates and unwind its balance sheet to fight inflation?

Photo Credit: Alex Bierwagen on Unsplash.

The Federal Reserve (the Fed) has, finally, some say, started raising rates. The rate hikes of March, May, and June at the last three scheduled meetings were perhaps long overdue. Inflation over the previous 12 months was equal to 5% in June 2021 and reached 7% in December 2021; in May it stood at 8.6%. Unemployment, meanwhile, dropped below 5% in September 2021 and below 4% in December 2021; in May it was equal to 3.6%. In the last 60 years it has never been below 3.4%.

The Fed has a dual mandate of promoting full employment and price

stability. However, even as inflation was rising from 4.2% in April 2021 to 7.9% in February, the Fed did not act. For a long time, they believed that inflation was temporary and argued that premature rate increases could damage the recovery from the pandemic. In effect, the Fed was focusing too much on the recovery and too little on price stability, even though the economy was doing well and was near full employment. Meanwhile, inflation was high, continued rising, and is now increasingly out of control. Price stability, which had been so successfully achieved since the early 1980s, is no longer something that consumers can count on. It is not too late to act. The question now is whether Fed action will be sufficient.

Why Is High Inflation Problematic?

High inflation is often also variable inflation. Indeed, while the all-items consumer price index (CPI) has increased by 8.6% over the last 12 months, gasoline is up 48.7%, whereas education and communication are up only 0.8%. In an environment like this, planning for future expenses, for example to figure out what prices to set so that profit margins are sufficiently high to meet variable and fixed costs, becomes nearly impossible. At a minimum, it is much more difficult than when prices are stable. More importantly, wages have not kept up with inflation. Over the previous 12 months, private sector average hourly earnings increased by 5.2%, much below inflation. In effect, U.S. workers have been subjected to a large pay cut. The situation the U.S. economy finds itself in, at least with regards to inflation, is not desirable, and many hope that it will change soon.

Lower Aggregate Demand Can Lower Inflation

If inflation is too high, the Fed raises interest rates, reducing aggregate demand and decreasing inflation. Higher interest rates make it more costly for companies and individuals to borrow. At the same time, they make it more desirable to save. Desired consumption, and therefore demand, decrease. At the same time, higher interest rates can result in an appreciation of the exchange rate. In June of 2021, one Euro cost \$1.21; in June 2022, after the United States started raising interest rates, the exchange rate is equal to \$1.04. A stronger dollar reduces demand for U.S.-produced goods since they become more expensive abroad.

Individuals base their decisions not only on the current short-term interest rate. As important is expected future Fed policy. One way to get a quick sense of the expected path of interest rates over the next couple of years is to look at the yield curve. It plots the interest rates paid on Treasury debt of different maturities. If, for example, the current one-year rate is 1% and the current two-year rate is 2%, the market expects the one-year rate in one year to be approximately equal to 3%. That way, the two-year rate is the average of the one-year rate today and the one-year rate next year.

Both the one-year and the two-year rates were close to zero in June of 2021 (see Figure 1), meaning that the market did not expect the Fed to raise rates significantly in the near future. In June 2022, the situation is very different. The one-year rate stands at 3.15%, and the two-year rate is equal to 3.45%, suggesting that the one-year rate in one year will be close to 3.75%, an

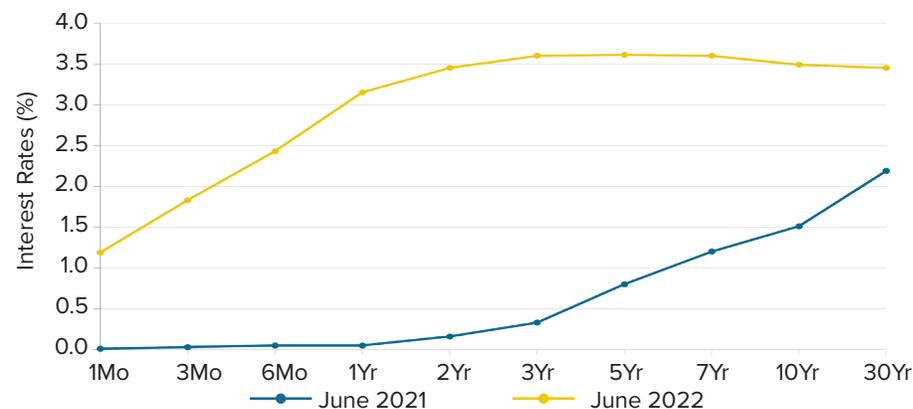
increase of 0.6%. The same logic can also be applied to rates over the next six months and rates over six months in half a year. Those numbers imply that 6-month rates will increase from 2.43% in the middle of June to 3.88% in six months. In other words, if the yield curve is very steep at the short end, then the market expects the Fed to raise rates quickly.

Short-Term Nominal Rates Are Increasing; Real Rates Have Dropped

So, now that the Fed has started to act and is expected to continue to do so, are we in the clear? Not so fast. What matters for the decisions of individuals is the tradeoff between consumption today and consumption tomorrow. Specifically, what matters to investors saving, and to companies or individuals borrowing to invest or purchase a home, is the real interest rate. This is commonly approximated as the difference between the nominal interest rate—what the Fed sets—and the inflation rate.

By some measures, it is more attractive to borrow now than it was 12 months ago. In March 2021, inflation was equal to 2.6%, and interest rates out to a three-year maturity were all close to or below 0.3%. Assuming that inflation would continue at that rate, the real interest rate was -2.5% (the one-year rate was a bit below 0.1%). Today inflation is equal to 8.6%, while the one-year interest rate is equal to 3.15%, resulting in a much more negative real rate (assuming that current inflation is a good predictor of inflation over the next year). In other words, if mortgage rates are equal to 4%, but I think that my wages track inflation, which is equal to 6%, I am in better shape than if mortgage rates are equal to 2.5%, but I expect my wages to increase only by 2% a year. In the first case, the real interest rate that I face is -2%, while it is 0.5% in the second case.

Figure 1. Treasury Yield Curve



Note: Interest rates over various maturities from 1 month to 30 years.

Source: U.S. Department of the Treasury. Available at: <https://home.treasury.gov/>.

A key question, therefore, is if inflation will start coming down soon or if it will remain at the current level. If it comes down, and if interest rates increase at the same time, real interest rates will increase, the economy will slow down, and inflation will decline. But there is an important catch. This argument assumes that inflation will start declining somehow by itself. And, importantly, real interest rates will increase only if inflation decreases, at least assuming the current expected path of interest rates. If that does not happen, real interest rates will stay low and most likely negative, aggregate demand will not slow down, and inflation will remain high.

An often-used rule of thumb is John B. Taylor’s rule which implies that positive real rates are needed to bring inflation down. Thus, if rates are not increased very quickly, and above what the market currently expects, inflation will not come down, and real rates will continue to be negative, making it less likely that inflation will decline in the future.

Asset Purchases and Quantitative Easing

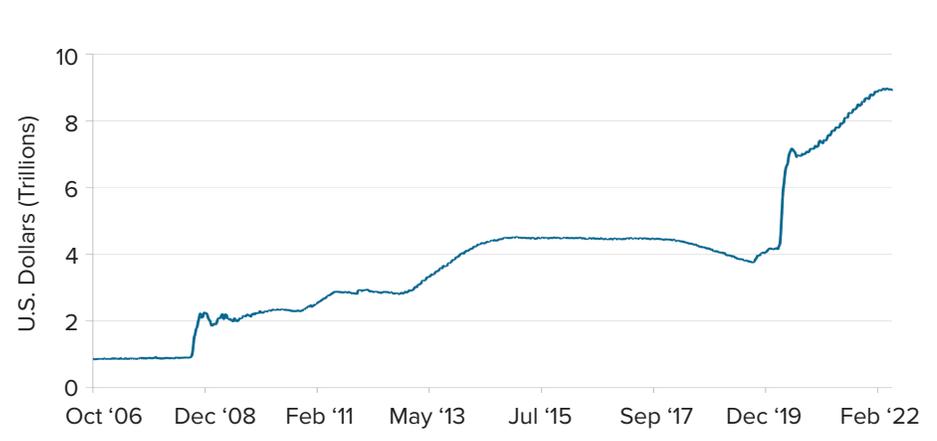
However, the Fed has another tool in its arsenal. When short-term rates hit zero after the collapse of Lehman Brothers in 2008, the Fed was unable

to decrease rates by more, an effect sometimes referred to as the ‘zero lower bound.’ Successive waves of quantitative easing, officially called ‘large-scale asset purchases,’ started. This is a policy whereby the Fed purchases longer-term fixed income securities such as long-term Treasury securities, federal agency debt, and mortgage-backed securities. These policies were designed to decrease long-term interest rates since they increase demand for, and thus the prices of, long-dated debt. As prices of bonds increase, the yield (the effective interest rate if held to maturity) of those bonds declines, thus leading to reductions in long-term market interest rates.

Figure 2 (on page 8) plots the total assets held by the Federal Reserve. The initial sharp increase happened only weeks after the collapse of Lehman Brothers in September 2008. In the following years, purchases continued. The Fed started to raise rates in December 2015; then, in 2018 and 2019, there was a steady decline in the assets held by the Fed. In early 2020, in response to COVID, there was another sharp increase.

In June 2022, the balance sheet of the Fed stood at \$9 trillion. For comparison, the 2020 U.S. GDP was close to \$21 trillion, while the total debt

Figure 2. Federal Reserve Total Assets, 2006–2022



Source: Federal Reserve. Available at: <https://fred.stlouisfed.org/>.

of non-financial corporations in the United States was \$7.4 trillion in 2021. Suffice it to say that this is a lot of debt.

Now that there is no longer any reason to support the economy, the Fed will unwind it—meaning that assets held will decline either by bonds reaching maturity or by the Fed actively selling them. Once that happens, the supply of debt will increase, the price will fall, and long-term interest rates will increase. At the same time, mortgage interest rates and companies' borrowing costs will increase in response. This second tool—selling off securities from a large balance sheet—has only been available since these assets were amassed starting in 2008. But the presence of these assets on the balance sheet does give the Fed a unique opportunity to raise rates both at the short and the long end of the yield curve simultaneously. Indeed, the 10-year interest rate has increased from 1.51% in June 2021 to 3.49% in June 2022 (see Figure 1), which, for such a long-dated bond, is a substantial change. Perhaps more importantly, the TIPS (Treasury Inflation Protected Securities) real interest rate, a proxy for the real interest rate over the next ten years, has increased sharply from -1% in March 2022 to 0.9% in June 2022. The last time this rate was positive was over two years ago.

But what will happen if the Fed sells much of its bond holdings and the interest rate on long-dated securities increases substantially? It will result in the Fed selling bonds at a loss, at least if the Fed decides not to hold the securities until maturity. The Fed will then have engaged in a buy high, sell low strategy which, even though it may be saving the economy, is potentially tricky to explain politically.

Indeed, raising short-term rates generally results in higher long-term rates, too. And herein lies a possible catch to the clear-cut path in front of the Fed. The potential for large losses on its balance sheet may be preventing the Fed from being more aggressive in raising short-term rates and not wanting to unwind its asset portfolio quickly. The Fed knows that raising rates quickly, selling off its assets, and bringing inflation under control will most likely result in substantial balance sheet losses that could then result in realized losses for the Fed. Not an enviable spot to be in, and one the Fed recognizes. A memorandum from 2009 states, "Holding a large portfolio of long-term securities exposes the Federal Reserve (and thus taxpayers) to appreciable capital losses if interest rates rise quickly as the economy recovers." Importantly, however, this difficulty does not alter the need for quick, decisive, and, at this point, overdue action.

Going forward we will all be watching short- and long-term interest rates as well as inflation very closely. Will short and long-term real rates increase quickly enough to make real rates positive and slow down the economy? Will aggregate demand decline sufficiently to bring inflation under control? Or are we in for a repeat of the 1970s when the Fed did not act decisively, inflation got out of control, and the economy had to endure a severe recession in the early 1980s with high real interest rates to reestablish price stability?

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Authors' Bios

Bulat Gafarov is an assistant professor and Jens Hilscher is an associate professor, both in the Department of Agricultural & Resource Economics at UC Davis. They can be reached at bgafarov@ucdavis.edu and jhilscher@ucdavis.edu, respectively.

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When Governments Increase Their Funding of Public Goods, How Do Individuals Respond?

Matthew J. Kotchen and Katherine R.H. Wagner

We discuss how standard public goods theory can explain a wider range of individual responses to changes in government funding of public goods than the literature suggests. For example, increases in volunteerism in national parks in response to increases in public parks funding are consistent with volunteers obtaining private benefits, such as park enjoyment, and contributing to environmental conservation within the model of “impure altruism.”



Volunteering in the National Park Service provides mutual benefits to both the parks and the volunteers.

Photo Credit: Katherine R.H. Wagner.

Understanding how changes in government provision of public goods affect private contributions is a central question in public economics. Individuals are unable to capture all of the benefits from contributing to public goods such as clean air, seawalls, public radio, or environmental conservation, and so they are typically reluctant to pay for them privately. As a result, such goods are typically publicly provided. The extent to which public funding of public goods decreases or increases (i.e., crowds out

or crowds in) private contributions determines the optimal supply of these goods by governments. In addition, testing for crowding out is the standard approach in the economics literature for distinguishing between competing theories for why individuals contribute to public goods.

This article highlights how government provision of public goods affects private provision. We first discuss how a broader range of individual responses is possible in the standard model of “impure altruism” describing underlying motives for engaging in charitable activity, which implies that the commonly used test between competing theories is based on an implicit special case of the model. Second, we propose a new test to distinguish between these models describing individual motivations that is valid under more general conditions.

Finally, we conduct an empirical analysis that focuses on the significance of these results for interpreting the response of volunteerism to increases in funding of the U.S. National Park Service (NPS). The NPS’s mission is to preserve natural and cultural landmarks for current and future generations’ recreation and education. The NPS annually hosts over 330 million visitors per year across its more than 400 parks. Yet, despite the popularity of its parks, the NPS has accumulated a deferred maintenance backlog that exceeds \$12 billion. Its chronic underfunding is a topic of active policy debate. The agency is almost entirely funded by federal appropriations; during the government shutdown at the end of 2018 and beginning of 2019, the parks experienced widespread damage from unauthorized access of sensitive areas and operational disruptions due to a lack of public funding.

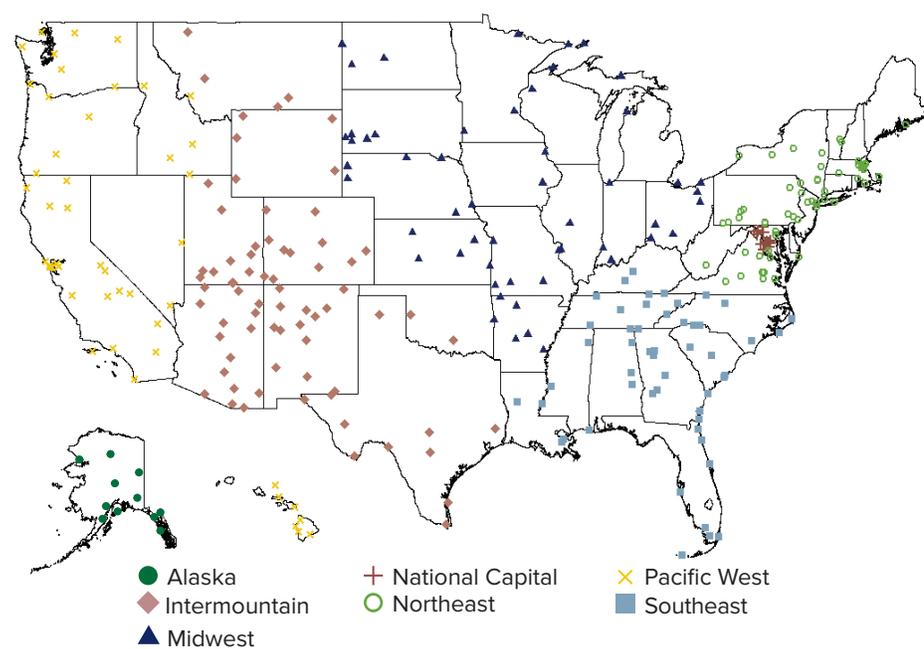
Theory of Private Provision of Public Goods

We revisit classic public goods theory and come to different conclusions, which has implications for the provision of public goods such as environmental conservation or public defenses against natural disasters. The economics literature begins by defining the model of “pure altruism,” which proposes that individuals contribute to public goods only because they care about the total amount of the public good provided. For example, funding a seawall that reduces the risk of inundation for all members of a community makes protected individuals happier, but the pure altruism model proposes that they don’t care whether any improvements are due to public funding or their private donations; they only care about the total protection provided. Since public and private contributions are perfectly substitutable in this model, any increase in public provision is completely offset by a decrease in private provision.

Such complete crowding out is seldom observed in the real world, however, and the standard model of “impure altruism” seeks to reconcile the disconnect between the theoretical predictions and empirical observations. In this more general impure public good model, individuals obtain a jointly produced private benefit as part of their giving. Individuals feel good about themselves when contributing to a public good such as community flood protection or conservation, and they don’t obtain this same “warm glow” if the government provides funding instead.

The existence of a private benefit from giving means that government and individual contributions are no longer

Figure 1. Geographic Distribution of Parks Managed by the National Park Service



Note: Map shows distribution by administrative region, excluding five parks in American Samoa, the Mariana Islands, and Puerto Rico.

Source: National Park Service. Available at: <https://bit.ly/3Ny9AGo>.

perfect substitutes, and so, according to the standard theory, a one dollar increase in public funding results in less than one-for-one crowding out. A substantial body of empirical literature tests between the models of pure and impure altruism by assessing whether crowding out is incomplete.

Our first main theoretical result is that the impure altruism model admits a much broader range of possible outcomes—including crowding in and more than one-for-one crowding out—under the model’s standard setup. Individuals’ responses depend on the degree of complementarity or substitutability between the public and private benefits from contributing to the public good. For example, if private enjoyment of volunteering in parks is higher when the park is of higher quality, then this complementarity creates the possibility for crowding in, rather than crowding out. The same effect could arise if the scale or scope of a public program influences how good you feel about funding it (i.e., the private “warm glow”).

Such crowding in is actually observed in about one-third of the studies in the literature. Figure 2 shows the distribution of crowding effects from a survey of hundreds of estimates. We can see that researchers do, in fact, commonly find both crowding in (i.e., a positive estimate) and more than one-for-one crowding out (i.e., an estimate below minus one).

Our second main theoretical result is that crowding in is consistent only with impure altruism. Hence, if we take as a starting point a setting where public and private benefits from contributing to a public good are complementary, such as volunteerism in the NPS, we may in fact observe crowding in and conclusively reject pure altruism as a motivation for private provision.

Public and Private Provision of Conservation

Indeed, we find evidence of crowding in of volunteerism in the NPS in response to higher levels of public funding. We estimate the effect of changes in parks’ federal appropri-

ations on within-park volunteerism using data on all NPS units (e.g., parks or historic sites) over 16 years. The changes in park funding that we exploit are based on differences in congressional support for other pro-environmental legislation in a given year. The resulting fluctuations in park funding are plausibly uncorrelated with other changes in each park that affect volunteerism, such as expansion of park programs. This approach allows us to identify the effect of the funding changes on volunteerism, rather than these other factors.

Overall, we estimate that a \$1,000 increase in a park’s annual funding increases volunteerism by 12 hours, on average. Using the NPS’s standard wage rate, this volunteerism is valued at approximately \$270. This means that an additional dollar of federal funding crowds in roughly 27 cents’ worth of volunteerism, over and above the direct benefit of the increase in public funding to the park.

In this setting, we conjecture that the impure altruism model applies because volunteerism in the NPS is characterized by the joint production of both public conservation benefits and volunteers’ private park enjoyment. The NPS explicitly highlights this joint production in their promotional materials, emphasizing that “the primary purpose of the Volunteers-In-Parks program is to provide a vehicle through which the NPS can accept and utilize voluntary help and services from the public in such a way that is mutually beneficial to the NPS and the volunteer.”

We also find different effects of funding across park and program types that are consistent with the theory. Volunteers’ experiences differ depending on the type of park and program with which they are involved: volunteers in parks focused on outdoor recreation, for example, can take advantage of park improvements in the same

way as visitors. We find crowding in of volunteerism in environmentally oriented parks and outdoor volunteer programs, where complementarity between park quality and volunteer enjoyment seem most likely to arise. By contrast, we find no meaningful effects in cultural parks or indoor activities.

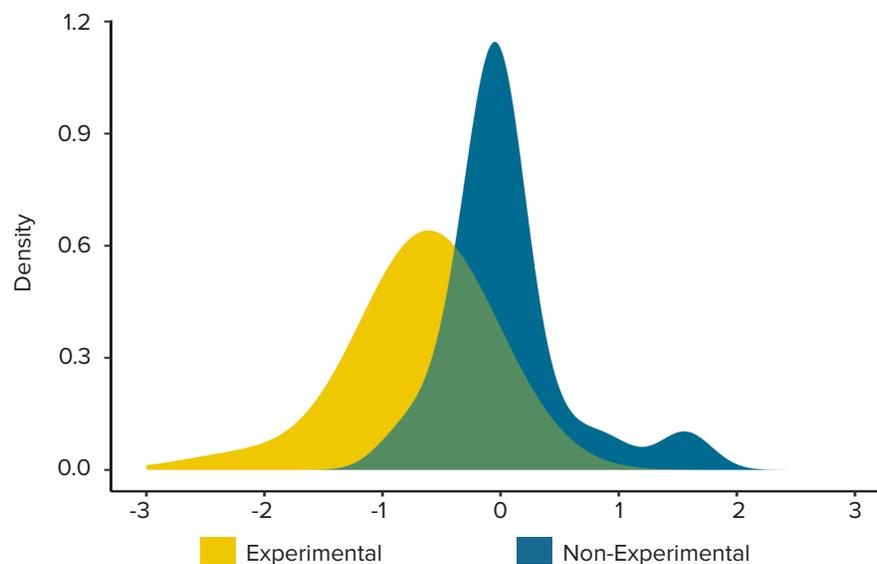
Policy Implications

The implications of these results for interpreting individual responses to government policy are consequential. First, the theoretical analysis shows that a broader range of outcomes are possible under the standard assumptions of the impure altruism model. A finding of crowding in need not be explained away by appealing to alternative explanations such as changes in fundraising, but rather is consistent with individuals obtaining private benefits from the act of giving.

Second, crowding out cannot be used to test between the models of pure and impure altruism—as is typical in the literature—without additional assumptions. By contrast, the presence of crowding in is consistent only with impure altruism.

Finally, the possibility of crowding in and our empirical evidence of it suggests that increasing public funding of public goods could leverage greater private contributions, and accounting for this behavioral response could meaningfully increase the marginal benefit of providing public goods. Given that individuals may plausibly give more when public funding increases, our results emphasize the importance of accounting for individuals' responses in government budgeting. This is an important consideration for publicly funded social and environmental programs such as the NPS, which suffers from perennial budgetary shortfalls and a growing deferred maintenance backlog. Newly authorized funding to the NPS through the landmark Great American

Figure 2. Distribution of Estimated Responses of Private Provision to Changes in Public Provision



Note: Negative is crowding out, positive is crowding in.

Source: de Wit and Bekkers. 2017. Based on 325 estimates from 54 studies from the public economics literature, shown separately for experimental and nonexperimental studies.

Outdoors Act, for example, may in fact generate larger returns than previously anticipated, hopefully allowing us to enjoy these parks for many years in the future.

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Authors' Bios

Matthew J. Kotchen is a professor at Yale University and NBER. Katherine R.H. Wagner is an assistant professor in the ARE department at UC Berkeley. They can be reached at matthew.kotchen@yale.edu and katherine.wagner@berkeley.edu, respectively.

For additional information, the authors recommend:

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Giannini Foundation of Agricultural Economics, University of California

Department of Agricultural and Resource Economics
UC Davis
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Co-Editors

Ellen Bruno
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Ria DeBiase
Giannini Foundation of Agricultural Economics
Department of Agricultural and Resource Economics
University of California
One Shields Avenue
Davis, CA 95616
E-mail: rwdebiase@ucdavis.edu
Phone: 530-752-3508

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