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The Soybean Industry Response to the Renewable Diesel Boom, Part 1: the Long-Run Evolution of Oilseed Crushing

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Demand for soybeans is derived from the demand for soybean products. When a bushel of soybeans is crushed, there are four products: oil, meal, hulls, and waste. In the standard 'board' crush margin calculation, it is assumed that a 60-pound bushel of soybeans yields "11 pounds of soybean oil, 44 pounds of 48 percent protein soybean meal, 4 pounds of hulls and 1 pound of waste" (CME Group). The combined market value of these products along with the cost of processing, determines what the market is willing to pay for soybeans. Thus, if you care about the price of soybeans, you must understand the soybean crush.

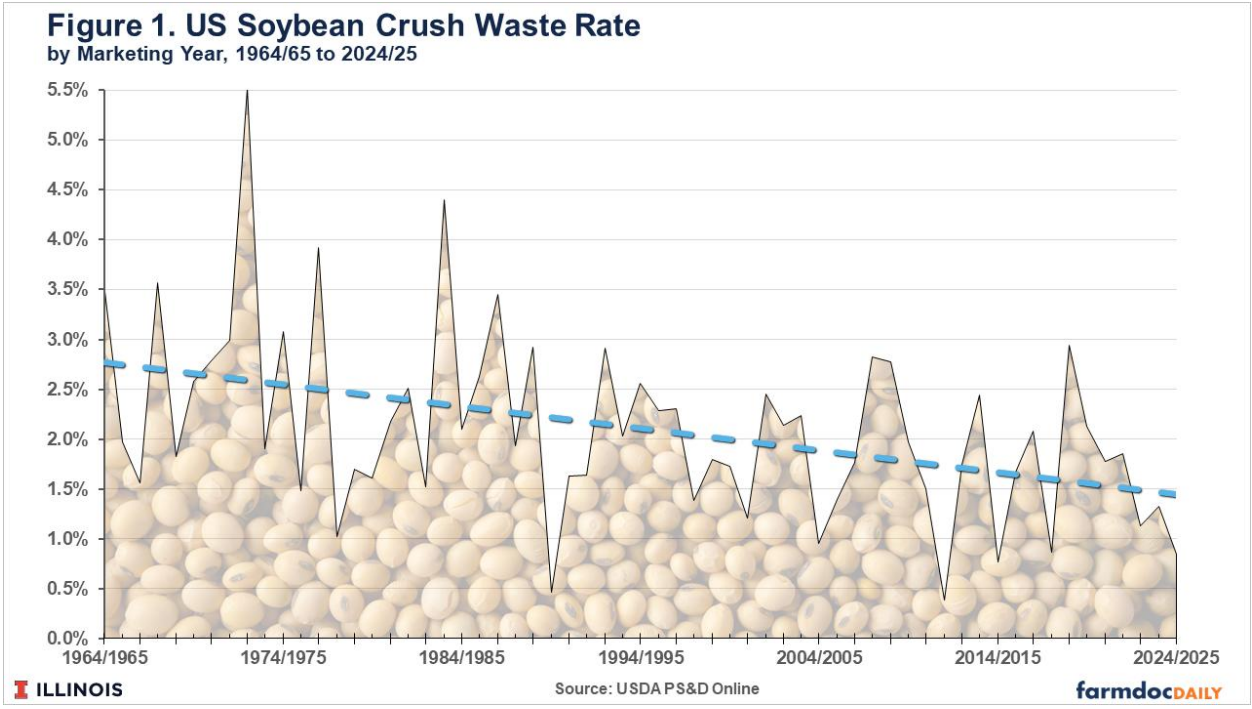
An increase demand for one product creates an incentive to grow and crush more soybeans. The recent renewable diesel boom in the US has generated new demand for soybean oil as a feedstock (see *farmdoc daily* April 12, 2024), leading to new investments in soybean crushing capacity and more domestic soybean crush use. More oil, in turn, creates additional supply of co-products, especially soybean meal, which must be incorporated into the supply and demand balance in the market for animal feed. All else equal, we expect an increase in soybean oil demand to increase the supply of meal and lower the meal price, assuming exactly fixed proportions of oil, meal, hulls, and waste in crush output.

The soybean industry can respond to increases in soybean product demand in other ways than simply increasing the quantity of soybeans crushed. This article describes some of those changes. Broadly speaking, soybean product output can also increase through processing efficiencies that reduce waste and through shifts in the relative composition of the co-products (e.g. more oil and less meal). While these adjustments are constrained by the physical properties of the soybean itself, the composition of the crush has indeed changed in the long-run. In this article, we review the evolution of soybean processing in the US and what it tells us about the ongoing response to greater domestic demand for soybean oil as a feedstock in the production of bio-based diesel fuel.

We find soybean processing has become more efficient over time. Waste rates have decreased. At the same time, soybean oil extraction rates have increased even more so the relative composition of oil and meal in crush output has changed. Future articles in this series will consider recent changes in crush output in more detail (which are difficult to ascertain from long-run data), the impact of the renewable diesel boom on prices and margins in soybean crushing, and the long-run ramifications for soybean prices of shifting demand for soybean products.

Gains in Soybean Processing Efficiency

Changes in soybean oil extraction rates may come from changes in the relative composition of processed soybeans (e.g., more oil, less meal) or changes in waste (e.g., more oil and meal, less waste). Figure 1 presents the long-run trend in US soybean waste rates by marketing year, the residual proportion of soybeans crushed that do not show up in oil or meal production figures. There are substantial year-to-year changes - the US soybean crushing waste rate has ranged from 0.5% to 5.5% over the period from 1964/65 to 2024/25 – partly caused by the waste rate being a residual that may impound measurement error in both soybean use and oil and meal production statistics. However, the long-run trend in crushing waste rates is informative of changes in the efficiency of soybean processing.



In the long run, soybean crushing waste rates have fallen, indicating improvements in crushing efficiency over time. The linear trend shown in figure 1 indicates an average annual decrease in the waste rate of 0.02 percentage points per year. This decline in waste rates is more impressive when considered in total. The trendline waste rate declined from 2.7% in 1964/65 to about 1.5% in 2024/25, an improvement of 44%.

Trends in Soybean Oil Extraction Rates

Given the importance of soybean oil as a biofuel feedstock, we consider how much of the soybeans crushed produce soybean oil. Figure 2 shows the long-run evolution in US soybean oil extraction rates, or the proportion of total domestic US soybean crush use that produces soybean oil. While the total volume of soybeans crushed has obviously increased substantially since the 1960s, the extraction rate allows us to compare soybean oil yield across long periods of time.

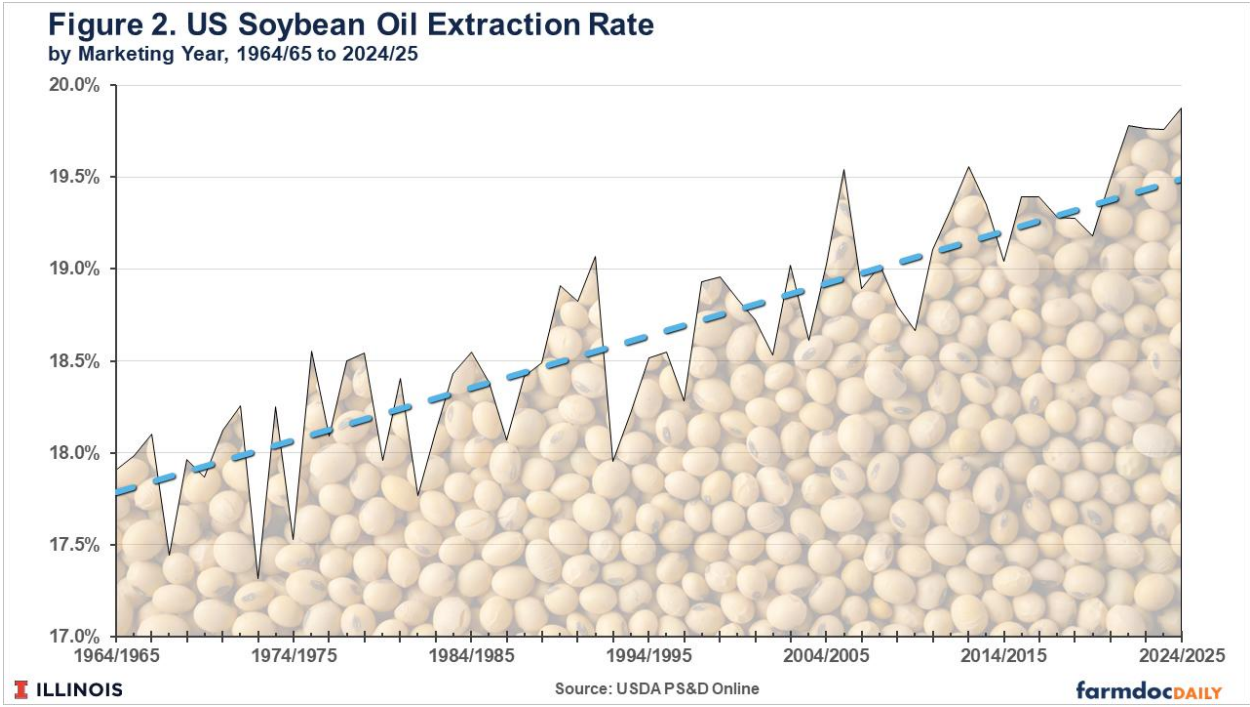
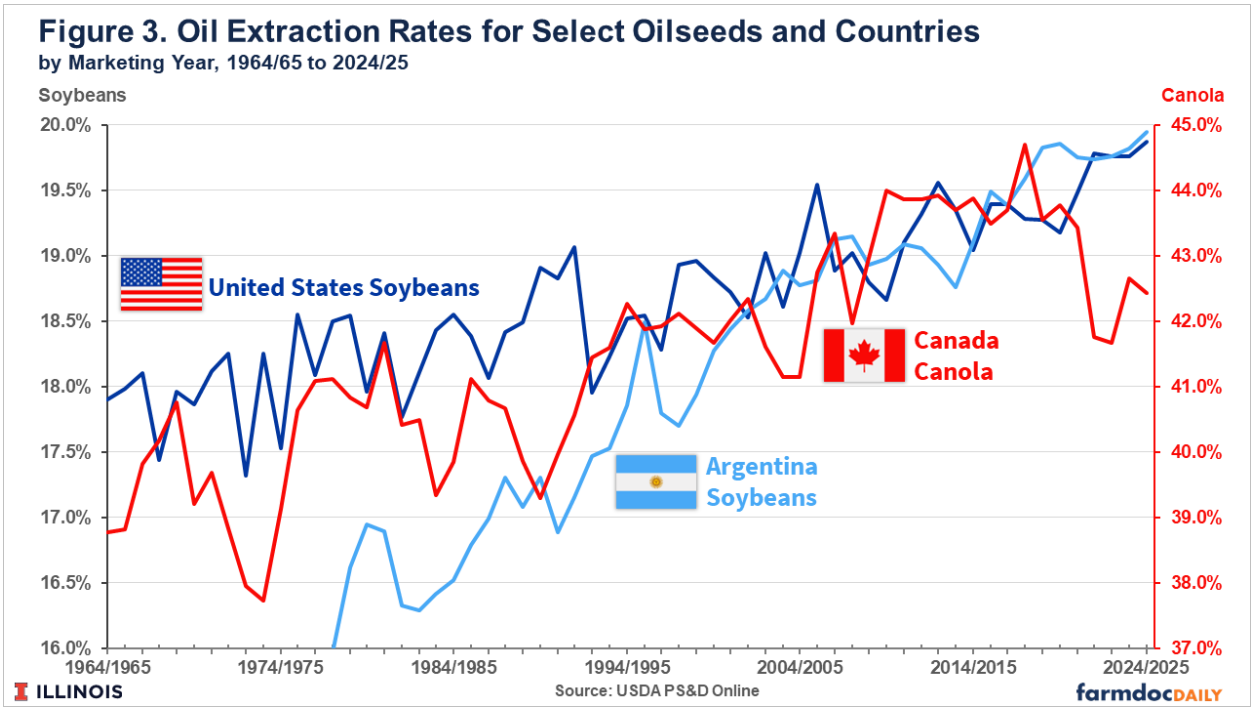


Figure 2 shows the soybean oil extraction rate has steadily increased in the past sixty years. While the standard board crush calculation implies an extraction rate of 11/60 or 18.3%, the realized average extraction rate went up from 17.9% in 1964/1965 to 19.8% in 2023/2024. While a 1.9 percentage point increase may seem small, it implies a typical bushel of soybeans crushed today produces about 10% more oil now than it did sixty years ago. The growth in soybean oil extraction rates has been steady, following a linear trend. The average annual growth rate given by the linear trend in Figure 1 is 0.03 percentage points per year. Since the soybean oil extraction rate has been increasing more rapidly than the decline in the waste rate given above, the gains in extraction rates have not come solely from gains in processing efficiency; the composition of soybean crush output has also shifted toward oil and away from meal.

The renewable diesel boom has increased demand for soybean oil. Changing the composition of the crush toward soybean oil is a potential response to this demand shift, but Figure 2 suggests such a response is slow. However, note that soybean oil extraction rate shown in Figure 2 has been above trend in every year since 2020/21. This jump coincides with the beginning of the renewable diesel boom, providing rough evidence that the soybean industry can and has responded to events that change the composition of soybean demand.



To place the changes in the US soybean oil extraction rate in some context, we show historical oil extraction rates for soybean processing in another major soybean oil producing country, Argentina, and for an alternative oilseed, canola, processed in Canada. Extraction rates in these cases grew slightly faster than soybean oil in the US. In Argentina, average annual growth was about 0.08 percentage points per year, albeit starting from a lower baseline level in the 1970s when data are first available. Some of the increase in Argentina extraction rates may represent 'catch-up growth'. Soybean oil extraction rates in the US and Argentina are now roughly similar at between 19.5 and 20.0%.

Long-run growth in Canadian canola oil extraction rates have been similar in levels to growth in Argentina soybean and similar proportionally to growth in US soybean oil. Average annual growth was about 0.08 percentage points per year over the period 1964/65 to 2024/25, similar to Argentina. Trendline extraction rates increased from 39% in 1964/65 to nearly 44% in 2024/25. Relative to initial levels, this roughly 11% increase in the Canadian canola oil extraction rate is similar to growth in US soybean oil extraction rates over the same period. Note that Canadian oil extraction rates have been well below trend since 2020. Environmental factors, especially hot, dry weather during the growing season, are thought to be a primary cause (Canadian Grain Commission, 2023)

Implications

While the proportions of oil and meal in a bushel of soybeans are typically treated as physical constants, the long-run evolution of US soybean crush output shows this is only roughly the case. At the very least, the approximation given in the standard crush margin calculation of 18.3% oil content may need to be revised higher to reflect long-run gains in soybean oil extraction rates.

More importantly, the data suggest the soybean industry may have some ability to respond to shifts in demand for one soybean product relative to another. The composition of the soybean crush has changed, both in the US and around the world. However, there is only limited evidence of a direct response to the recent renewable diesel boom – a shift toward soybean oil and away from soybean meal – in the annual data.

There is still more to understand about the soybean industry response to changes in demand. How market prices mediate this shift and the impact on upstream prices at the farm gate and downstream prices for food and fuel require further study. In addition, the relative contributions of farmer and processor decision making and environmental conditions affecting soybean production are not identified in the aggregate data on soybean crushing.

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