The Impact of the U.S. Transitioning Toward Electric Vehicles on the Corn and Soybean Complexes

Nicholas E. Piggott
Professor and Extension Specialist

John Robinson
Graduate Student

Department of Agricultural and Resource Economics
North Carolina State University, USA

Keynote Presentation to the 16th International Rapeseed Congress
September 25th, 2023
Sydney, Australia

Question

- Demand and production for corn and soybeans in the US has been bolstered by policies encouraging renewable fuels (ethanol (corn) and biodiesel (soybean oil)) to reduce the use of fossil fuels.
- Increased corn and soybean production aided by substantial federal farm subsidies.
- Recent legislation lays the foundation for adopting Electric Vehicles (EVs) and for transitioning away from biofuels and fossil fuels to reduce emissions.
- **This begs the question of what this EV policy and transition might mean for corn and soybean demand and the potential changes it may have in the U.S.; in particular, the acreage planted, and the amount of soybean oil and corn that will be available for other uses.**

The U.S. is a Leading Producer of Corn and Soybeans in the World

World Soybean Production (2021/22-2023/24 Avg)

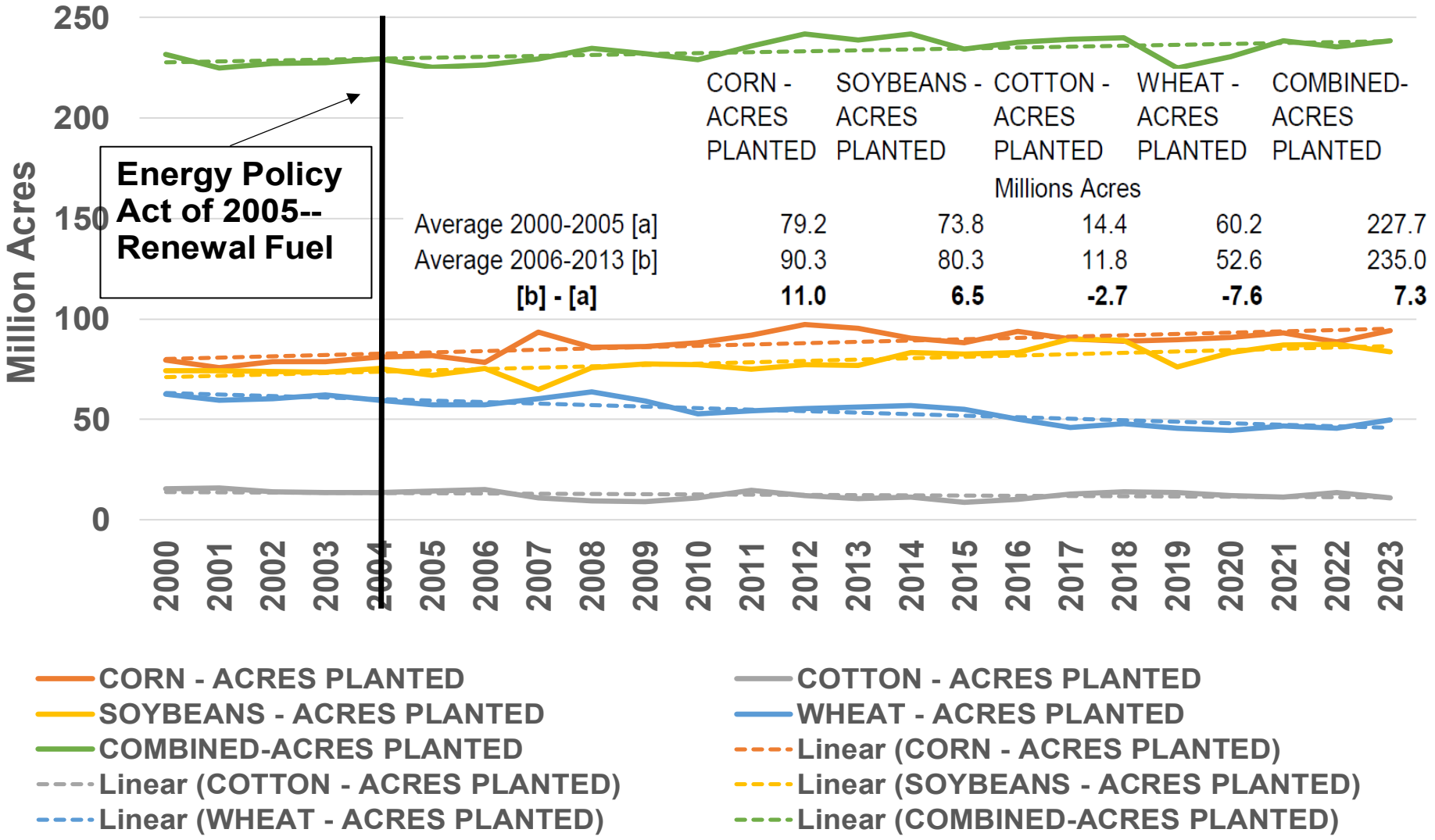
Rank	Country	Mil. Metric Tonnes	Share
1	Brazil	149.8	39.7%
2	**United States**	**117.5**	**31.1%**
3	Argentina	39.0	10.3%
4	China	19.1	5.0%
5	India	12.0	3.2%
6	Paraguay	7.7	2.1%
7	Canada	6.5	1.7%
8	Russia	5.6	1.5%
9	Ukraine	4.2	1.1%
10	Bolivia	3.3	0.9%
11	Other	13.0	3.4%
	World	377.6	100.0%

World Corn Production (2021/22-2023/24 Avg)

Rank	Country	Mil. Metric Tonnes	Share
1	**United States**	**371.8**	**31.1%**
2	China	275.6	23.1%
3	Brazil	126.7	10.6%
4	European Union	61.1	5.1%
5	Argentina	45.8	3.8%
6	India	34.7	2.9%
7	Ukraine	32.2	2.7%
8	Mexico	26.9	2.3%
9	South Africa	16.6	1.4%
10	Russia	15.2	1.3%
11	Other	188.0	15.7%
	World	1,194.7	100.0%

USDA FSA: PSD Online (https://apps.fas.usda.gov/psdonline)

Major U.S. Row Crop Acres Including Corn, Soybeans, Wheat, and Cotton 2000-2023



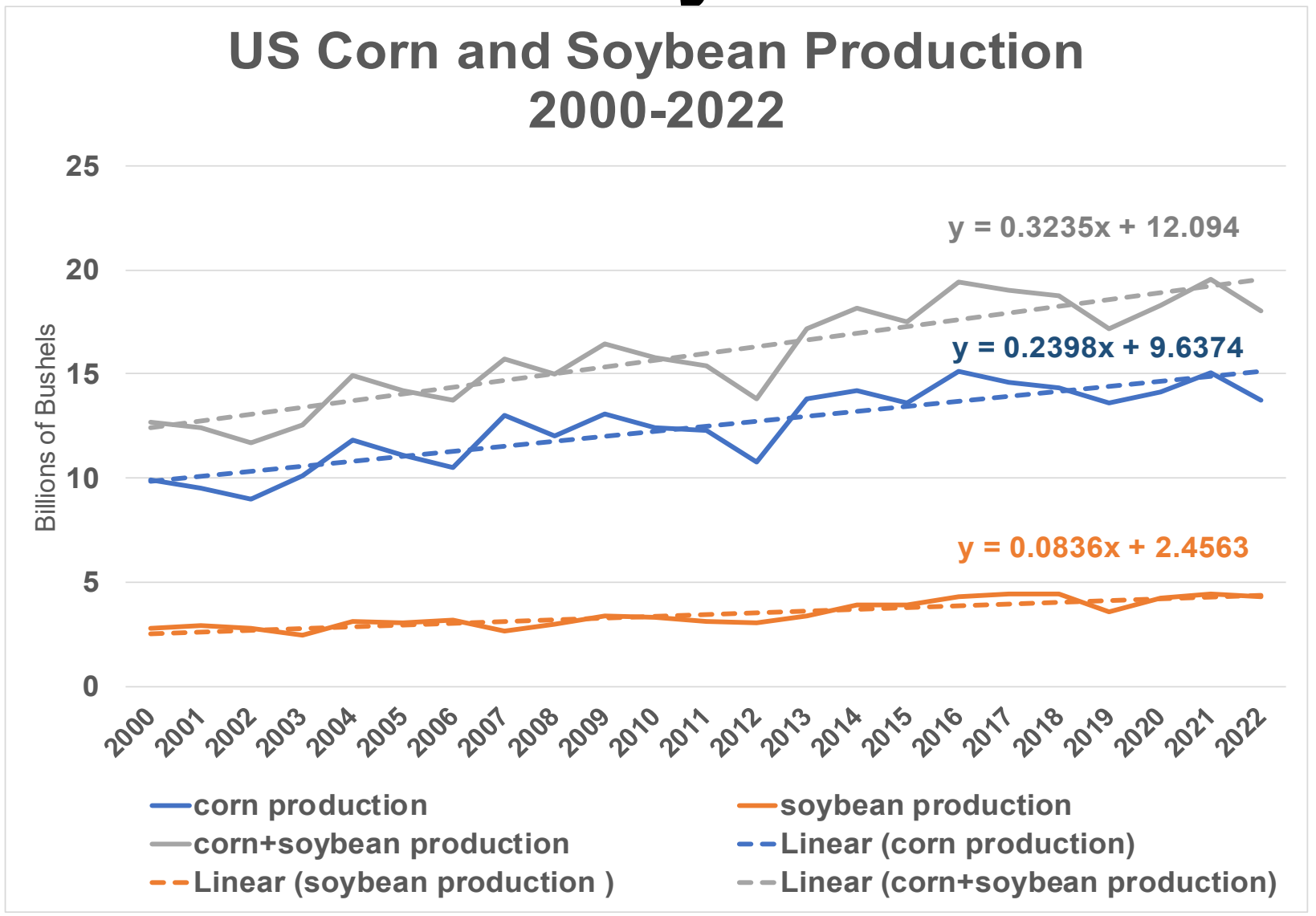
	CORN - ACRES PLANTED	SOYBEANS - ACRES PLANTED	COTTON - ACRES PLANTED	WHEAT - ACRES PLANTED	COMBINED-ACRES PLANTED
	Millions Acres				
Average 2000-2005 [a]	79.2	73.8	14.4	60.2	227.7
Average 2006-2013 [b]	90.3	80.3	11.8	52.6	235.0
[b] - [a]	**11.0**	**6.5**	**-2.7**	**-7.6**	**7.3**

Conversion

1 acre =0.40469 hectares

1 hectare = 2.471 acres

Corn and Soybean Production



- Positive trends in production accentuated by an upward trend in planted acres combined with positive trend yields in both corn and soybeans
- If these trends continue, combined production could be 26 billion bushels in 2042 (20 years)

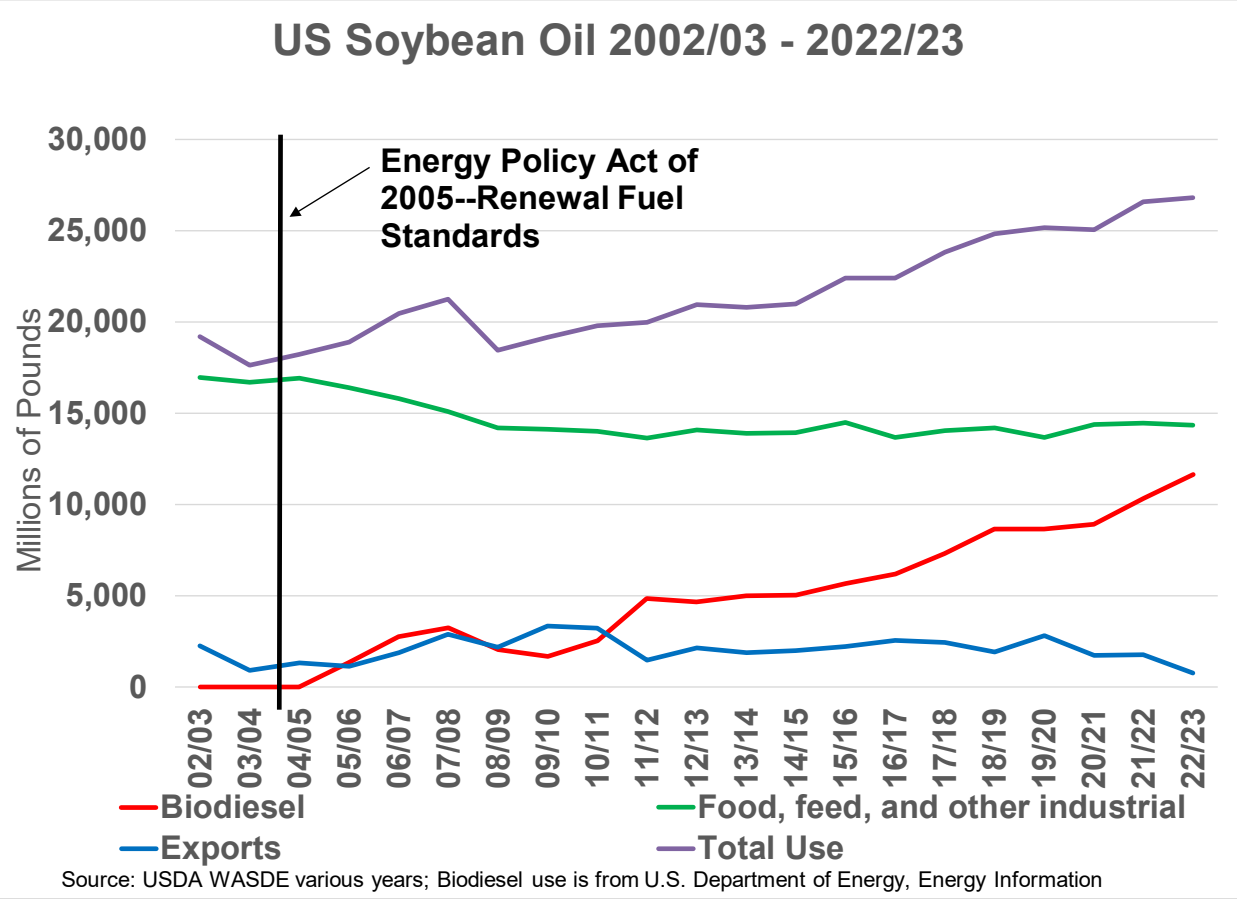
Conversion

1 bu corn =0.0254 metric tons
1 metric ton corn = 39.3683 bushels
1 bu soybean = 0.0272 metric tons
1 metric ton soybean = 36.7437 bushels

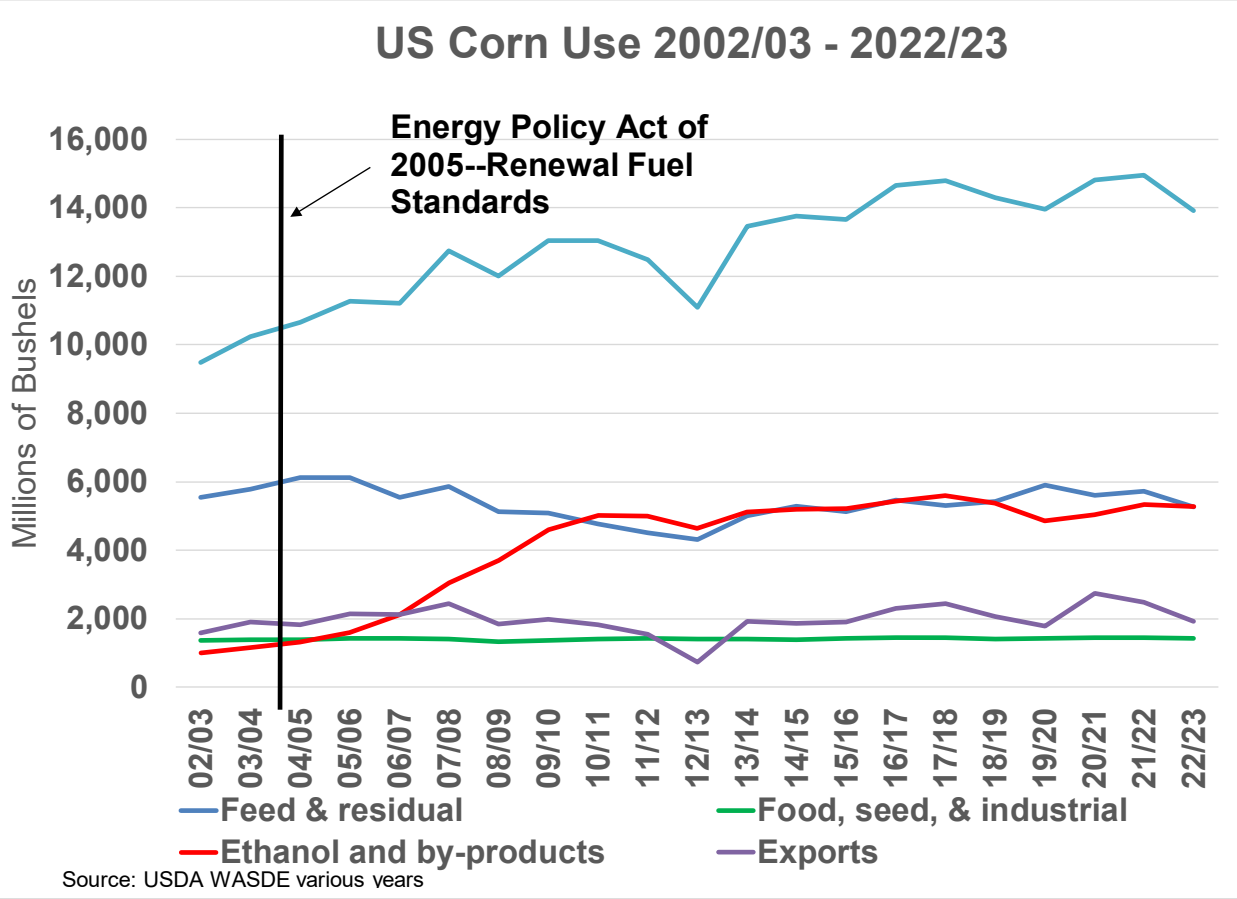
Importance of Energy Policy Act 2005, Renewal Fuel Standards, and Energy Independence Act of 2007

- These policies have led to a substantial increase in the percentage of corn used in fuel production from 14.2 percent (or 1.603 billion bushels) in 2005 to 35.6 percent (or 5.326 billion bushels) in 2021.
- These policies have led to a substantial increase in soybean oil used in biofuel from 8.1 percent (1.555 billion pounds) in 2005 to 43.7 percent (or 11.600 billion pounds) in 2022.
- These renewable fuels policies have impacted the composition of how corn and soybeans are utilized across the primary demands and co-products including feed, food, fuel, meal, DDGs, oil, and exports.

Corn and Soybean Oil Utilization Since 2002/03-2022/23

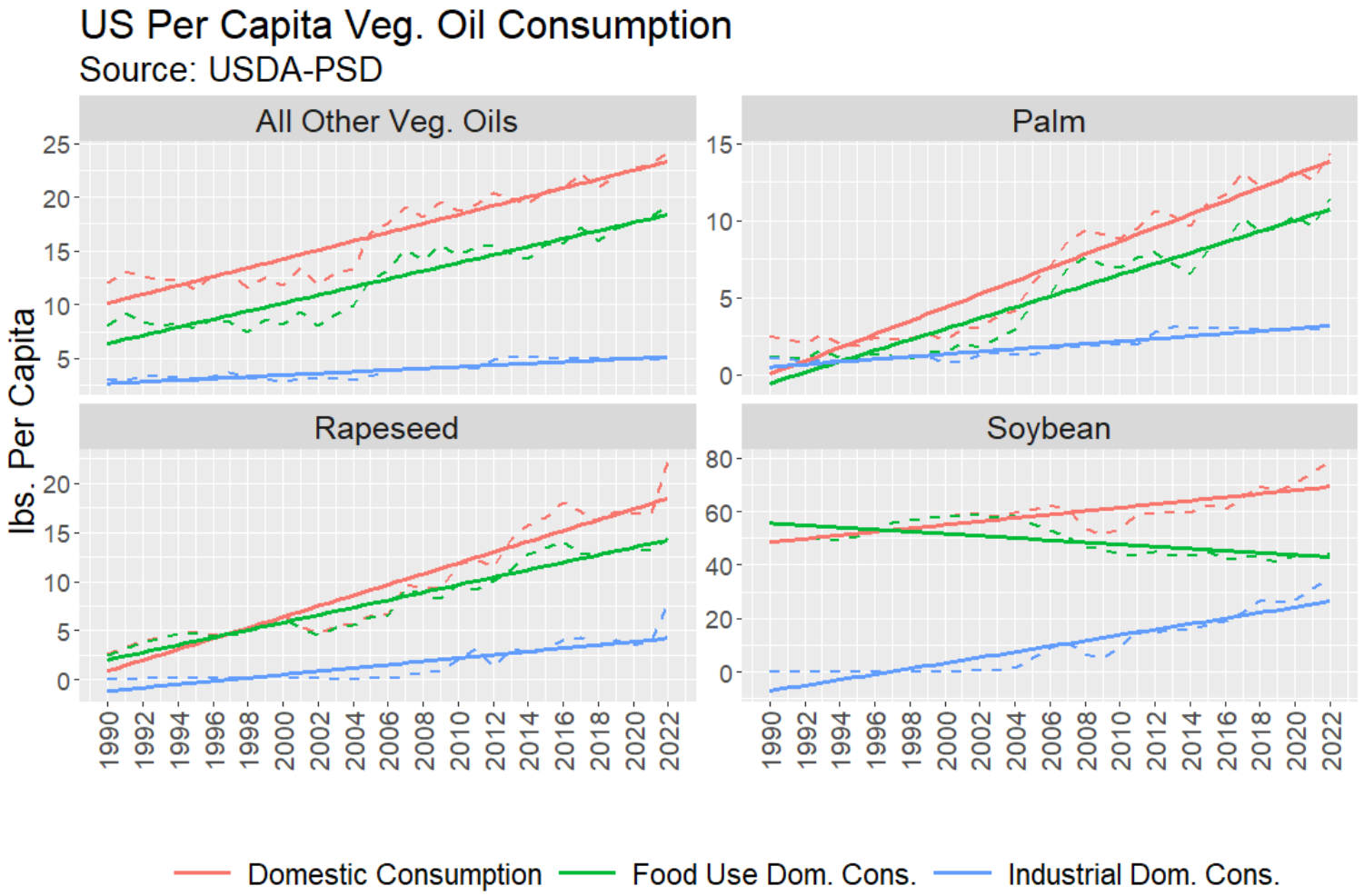


Source: USDA WASDE various years; Biodiesel use is from U.S. Department of Energy, Energy Information



Source: USDA WASDE various years

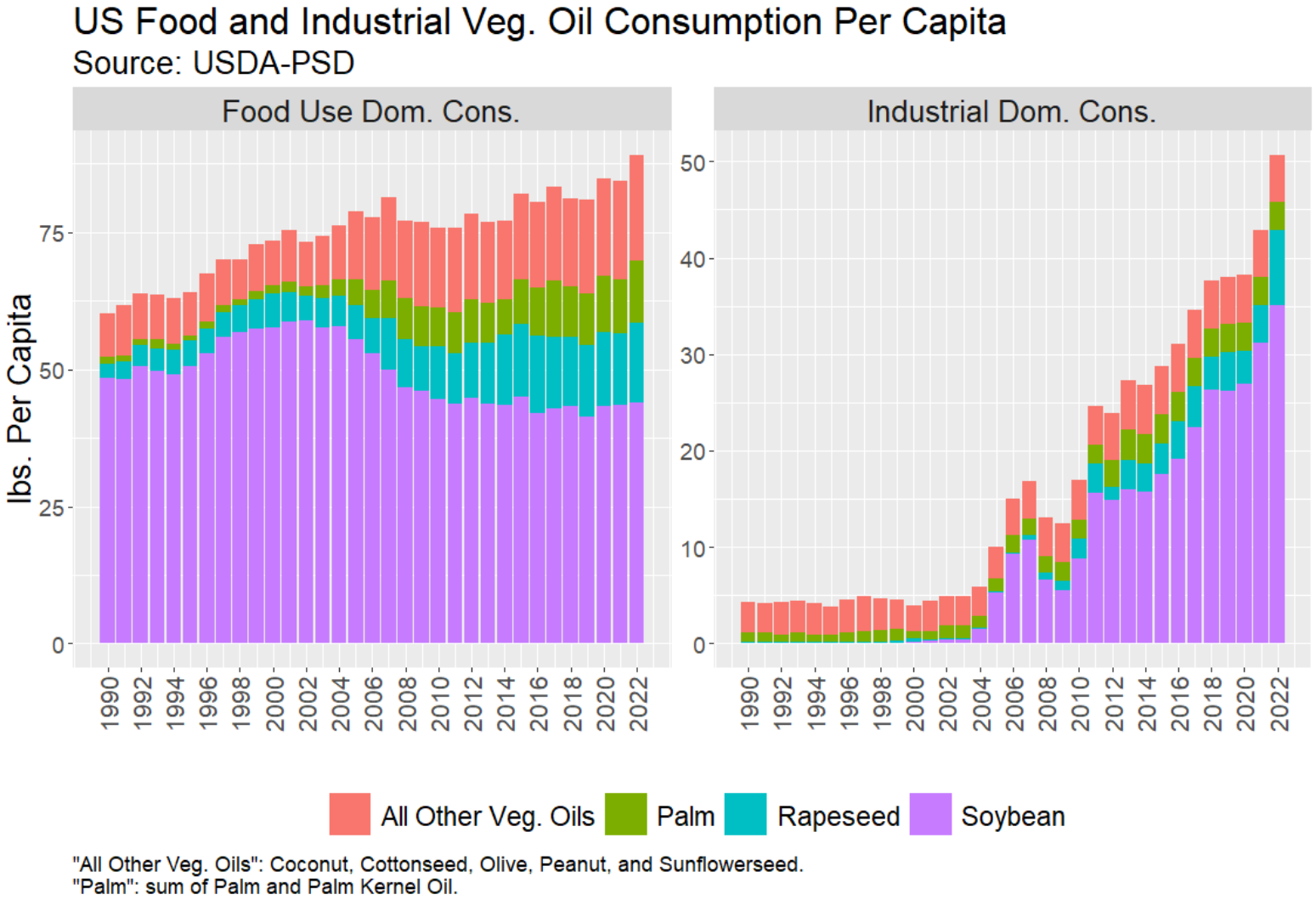
US Oilseed Consumption by Crop and End Use



"All Other Veg. Oils": Coconut, Cottonseed, Olive, Peanut, and Sunflowerseed.
"Palm": sum of Palm and Palm Kernel Oil.

- US domestic consumption of three major oilseeds (soybean, rapeseed (canola), palm) is trending upward.
- Soybean oil consumption's upward trend was driven by larger gains in industrial despite declines in food use.
- Palm and rapeseed (canola) consumption's upward trend was driven by the largest gains in food use and modest gains in industrial use.

US Oilseed Consumption by Crop and End Use



- Total food use has a modestly increasing trend, but the composition is changing—less soybean and more rapeseed (canola), palm, and others.
- Total industrial use has a steeply increasing trend dominated by soybean, then to a lesser extent rapeseed, palm, and others.

Recent U.S. Policies Aimed at Transitioning Away from Fossil Fuels

- This policy is political, complex, and has significant uncertainty
  - Electrification of transportation to reduce emissions from fossil fuels
  - EV requires infrastructure to be built for recharging
  - When built, will there be sufficient capacity on the grid, and how will the additional electricity needed be generated (fossil fuels required)?
- Recent legislation, including the Infrastructure Investment and Jobs Act of 2021 and the Inflation Reduction Act of 2022, lays the foundation for adopting EV in the U.S. and transitioning away from fossil fuel vehicles.
  - Target of 50% of EV sales shares in the U.S. by 2030
  - $7.5 Billion to build a network of 500,000 EV charging ports
  - EV purchase tax credit of up to $7,500 extended through 2023
- US Department of Energy Alternative Fuels Data Center estimates there are currently 55,949 charging stations with 145,653 ports
- US Department of Energy estimates sales of electric vehicles (HEV, EV, PHEV) doubled in 2021 to 1,431,875. The shares were 56% HEV, 32% EV, 12% PHEV
- Kelly Blue book estimates the average cost of an ICE was $48,528 compared to an EV of $55,488 in May 2023 ($6,960 more)
- Trade-offs in costs of ownership of Internal Combustion Engine (ICE) vs. EV between the cost of electricity vs. gas, maintenance and repairs, insurance, and depreciation

Light Duty Vehicle Registration Counts in the US for 2022

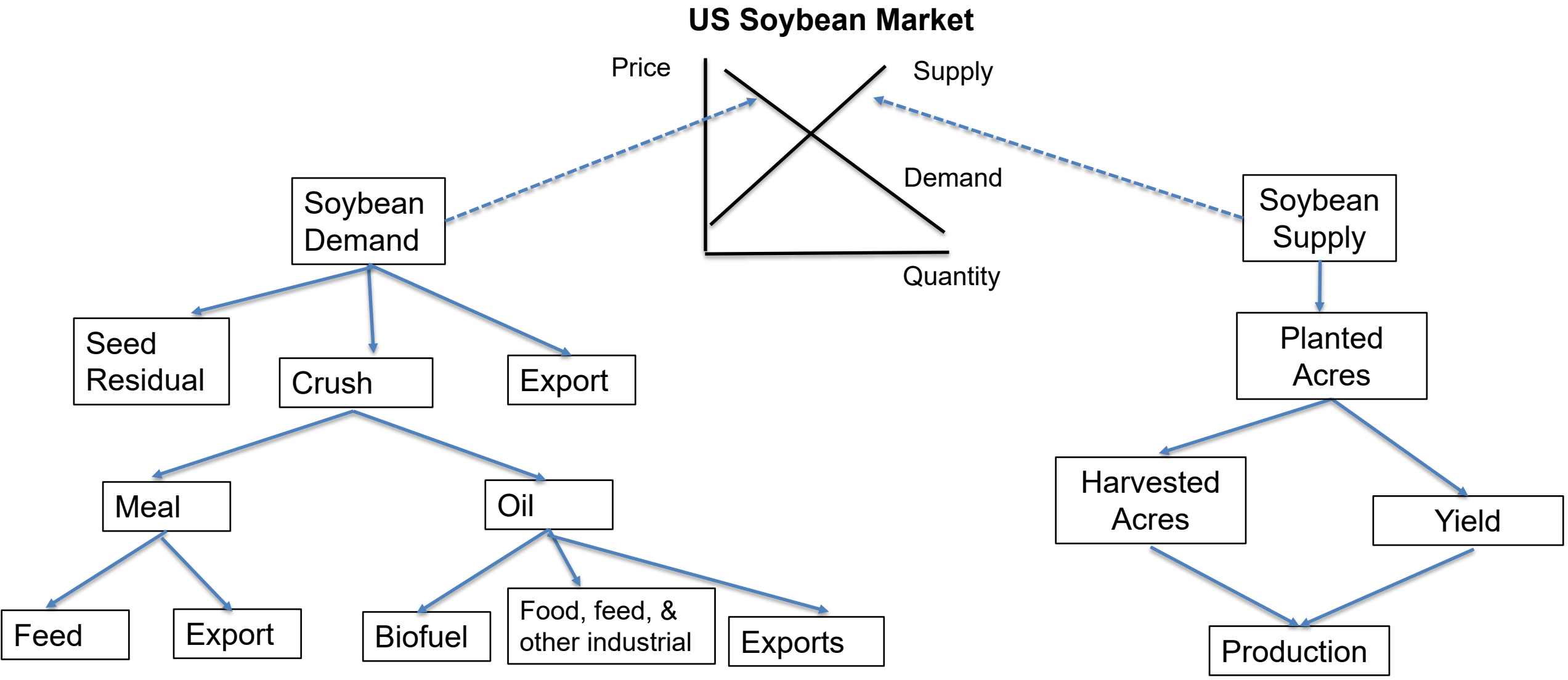
Power Source Class	Fuel Type	Fuel Type Total	Power Source Total	Share by Fuel Type	Share by Power Source
Internal Combustion	Gasoline	241,372,900		86%	
Internal Combustion	Diesel	7,156,900	248,529,800	3%	88%
Biofuels	Ethanol/Flex (E85)	20,906,700		7%	
Biofuels	Biodiesel	2,526,100	23,432,800	1%	8%
Hybrid/ Electric	Hybrid Electric (HEV)	6,291,800		2%	
Hybrid/ Electric	Electric (EV)	2,442,300		1%	
Hybrid/ Electric	Plug-In Hybrid Electric (PHEV)	1,012,400	9,746,500	0%	3%
	Total	281,709,100	281,709,100	100%	100%

Source: https://afdc.energy.gov/vehicle-registration

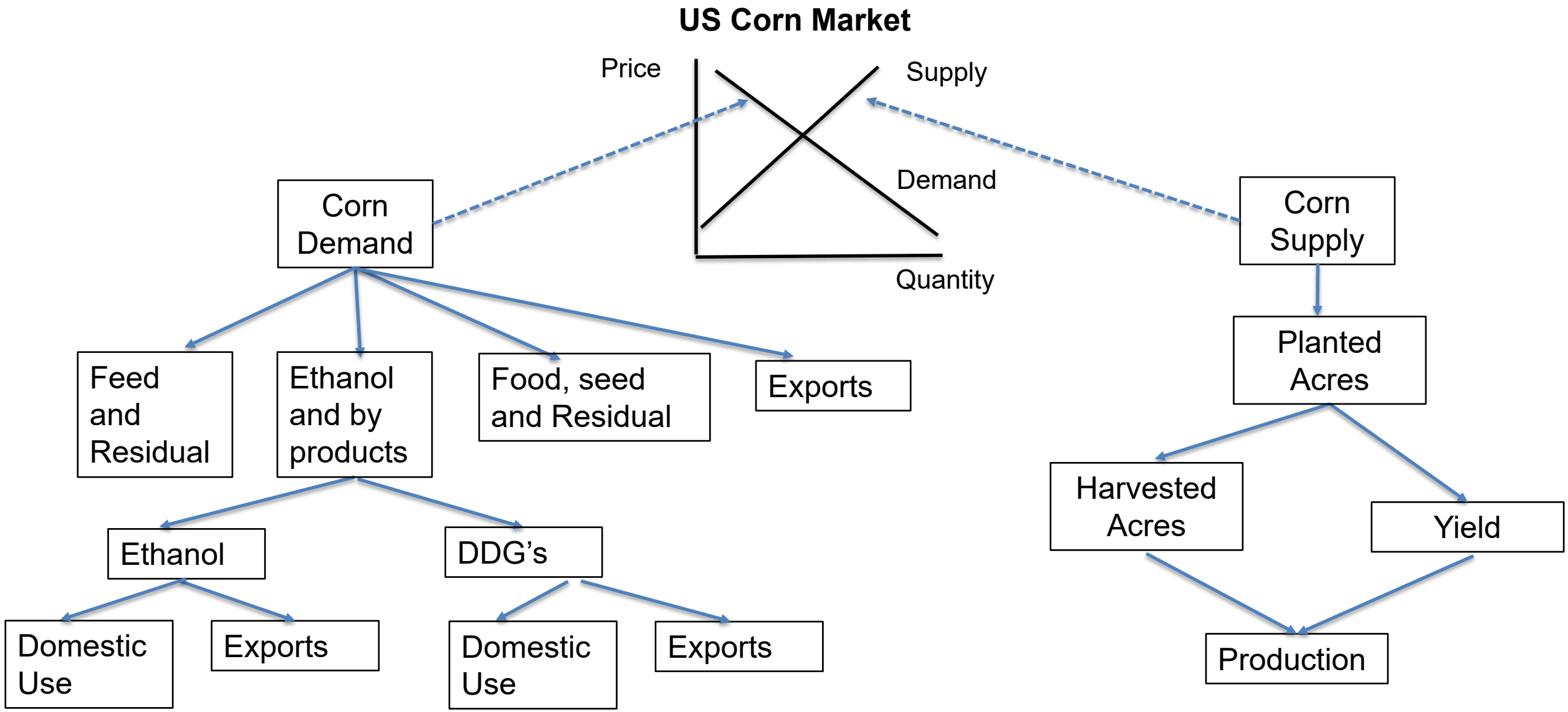
Economics of Joint Products

- Example: An increase in demand for soybean oil for biodiesel will drive soybean oil prices higher and lead to more crush to satisfy oil demand. However, without an increase in demand for meal, the additional crush will lead to lower meal prices
- When raw commodities are processed into co-products, the value of the raw product is determined by the value of the joint co-products
  - Fixed proportions in co-product supply
  - Demand for co-products is typically unrelated
  - Stable markets for consumption of both co-products to maintain raw commodity value
- Increasing demand for one co-product and a resulting higher price increases the value of the raw product. Increased value of raw production increases production and, in turn, co-product processing and supply. The increased production satisfies the increased demand for the one co-product, but without an increase in the demand for the other co-product, the increased production will lead to lower prices of the other co-product, offsetting some of the increased value of the raw commodity

US Soybean Complex



US Corn Complex



Model Soybean and Corn Complexes Jointly

- Relationships on the supply and demand sides require joint modeling soybean and corn complexes
- Supply-side
  - In the primary growing regions, a 50:50 rotation for soybeans and corn for agronomic reasons such as improving soil health, managing weed pressure, managing disease and pests
  - Planted acreage variation can be impacted (marginally) by the relative profitability of corn versus soybean as they compete for acres (ratio of new crop soybean/corn futures ≈ 2.4 during January - March each year)
- Demand-side
  - Corn and soybean meal are critical components in livestock feed
  - A co-product of corn being converted into ethanol produces DDGS, which can also be used in livestock feed and is a substitute for corn and soybean meal
  - The amount of substituted DDGS varies by market share and substitute rates by livestock/type. USDA estimates 1MT of DDGS substitutes for 1.22 MT of corn and soybean meal combined (Hoffman and Baker, 2011).

Economic Model of U.S. Corn and Soybean Complexes

- We utilize an Equilibrium Displacement Model approach (Piggott, Piggott, and Wright 1995, AJAE)
  - Baseline level of endogenous variables: acres, quantities (demanded and supplied), and prices
  - The system (matrix) of equations includes
    - 32 endogenous variables and so there are 32 equations to be solved jointly
    - 25 exogenous variables, including yields of co-products for soybeans (meal and oil) and corn (ethanol and DDGS)
    - 21 exogenous factors (technical changes or policy changes) that can be used to estimate the impact on *ALL* endogenous variables (e.g., a change to the domestic demand for biodiesel)
    - Elasticities: domestic demand (10); export demand (6); supply (4); acreage response (4)
    - Elasticities values are estimated econometrically, taken from the literature, or assumed

- This model has evolved. It was first derived in the early 2000s solely for the soybean complex. After the Energy Independence and Security Act of 2007, the corn complex was added. The model is utilized by CENTREC Consulting Group, LLC, which developed a user-friendly dashboard version of this model for the United Soybean Board.

Simulation Results Soybean Complex

	Baseline	Simulations		
	2021	10% Decline in Domestic Biofuel Demand [a]	10% Decline in Domestic Ethanol Demand [b]	10% Decline in Domestic Biofuel Demand and Ethanol Demand [a] +[b]
U.S. Soybean Production				
Soybeans				
Acres (M)	**87.20**	**-0.2%**	**0.3%**	**0.0%**
Production (M bu)	**4,465**	**-0.3%**	**0.8%**	**0.5%**
Domestic (M bu)	**2,306**	**-1.7%**	**0.4%**	**-1.3%**
Exports (M bu)	**2,158**	**1.2%**	**1.2%**	**2.4%**
Price ($/bu)	**$13.30**	**-0.9%**	**-0.8%**	**-1.7%**
Soybean Oil				
Production (M lbs)	**26,143**	**-1.7%**	**0.4%**	**-1.3%**
Domestic Biofuels (M lbs)	**10,348**	**-9.6%**	**0.1%**	**-9.5%**
Domestic Food, Feed (M lbs)	**14,465**	**2.8%**	**0.5%**	**3.4%**
Exports (M lbs)	**1,773**	**7.9%**	**1.5%**	**9.4%**
Price ($/lb)	**$0.73**	**-6.1%**	**-1.2%**	**-7.3%**
Soy Biofuels				
Production (M gal)	1,362	**-9.6%**	**0.1%**	**-9.5%**
Price ($/gal)	$5.13	**15.9%**	**-0.1%**	**15.8%**
Soybean Meal				
Production (K ST)	**51,811**	**-1.7%**	**0.4%**	**-1.3%**
Domestic (K ST)	**38,966**	**-0.3%**	**0.5%**	**0.2%**
Exports (K ST)	**13,524**	**-5.9%**	**0.2%**	**-5.7%**
Price ($/T)	**$439.8**	**4.0%**	**-0.1%**	**3.8%**
Crush Margin				
Crush Margin ($/bu)	**$3.947**	**-0.1%**	**-0.1%**	**-0.3%**

For the joint scenario:

- Soybean oil production declines 1.3%, domestic demand declines 9.5%, and price declined 7.3%
- Soybean oil used in biofuels declines by 9.5%, with production diverted to other uses, increasing food (3.4%) and exports (9.4%)
- Soybean meal production declined 1.3%, resulting in a 3.8% price increase and a reduction in exports of 5.7%
- Soybean acreage response is small in [a] (-) and [b] (+) and offsets each other for no change, and there is a 1.7% decline in soybean price
- Decline in the crush margin of -0.3%

Simulation Results Corn Complex

	Baseline	Simulations		
U.S. Corn Production	2021	10% Decline in Domestic Biofuel Demand [a]	10% Decline in Domestic Ethanol Demand [b]	10% Decline in Domestic Biofuel Demand and Ethanol Demand [a] +[b]
Corn				
Acres (M)	93.25	0.1%	-0.3%	-0.2%
Production (M bu)	15,074	0.3%	-0.7%	-0.4%
Domestic, Feed (M bu)	5,718	-0.0%	0.5%	0.5%
Domestic, Food/Seed (M bu)	1,440	-0.0%	0.2%	0.2%
Domestic, Fuel (M bu)	5,326	1.0%	-3.1%	-2.1%
Exports (M bu)	2,471	-0.0%	0.9%	0.9%
Price ($/bu)	$6.00	0.1%	-1.8%	-1.7%
Ethanol				
Production (M gal)	14,979	1.0%	-3.1%	-2.1%
Domestic (M gal)	13,946	2.9%	-10.6%	-7.7%
Exports (M gal)	1,242	1.1%	6.6%	7.7%
Price ($/gal)	$2.40	-0.7%	-4.4%	-5.2%
DDGS				
Production (M ST)	40.1	1.0%	-3.1%	-2.1%
Domestic (M ST)	27.6	3.3%	-3.3%	-0.0%
Exports (M ST)	12.6	-3.9%	-2.6%	-6.5%
Price ($/ST)	$232.7	3.6%	2.4%	5.9%
Crush Margin				
Crush Margin ($/bu)	$2.886	0.4%	-5.3%	-4.9%

For the joint scenario:

- Ethanol production declines 2.1%, domestic demand declines 7.7%, and price declined 5.2%
- Corn used in ethanol declines by 2.1% with production diverted to other uses increasing feed (0.5%), food (0.2%), and exports (0.9%)
- DDGS production declined 2.1%, resulting in a 5.9% price increase and a reduction in exports of 6.5%
- Corn acreage response declines by 0.2%, with a reduction in corn production of 0.4% and a reduction in corn price of 1.7%
- Decline in the crush margin of 4.9%

What Do These Impacts Mean for Canola?

- In the domestic US markets, soybean oil, canola, and palm oil are major edible oils that compete in consumption
- Simulation of 10% reductions in biofuels and ethanol revealed soybean oil from the biofuels use is diverted to food use (+3.4%) and soybean oil has become cheaper (-7.3%)
- Estimated a Seemingly Unrelated Regression system of double-log demand equations for soybean oil, canola oil, and palm oil

Elasticities of Demand for US Edible Oil Market

		Price	
		Soybean	Canola
Qauntity	Soybean	**-0.43***	**0.51***
	Canola	**0.69***	**-1.00***

Notes:

SUR double-log demand system using annual data 1991/92-2020/21

* denotes statistically significantly different from zero at the 5% level

For the simulated joint 10% decline in biofuels from soybean oil and ethanol % Δ in US Canola Oil Demand:

= *Elasticity of Demand*$_{q\_canola,\ p\_soy\ oil}$ × % Δ in soybean oil price

= 0.69 × -7.3% = -5.0%

What do these impacts mean for competing crops such as Canola?...

- The respective export changes will impact world markets. Simulations for the 10% joint reductions in biofuels and ethanol revealed the following impacts on US exports
  - Soybeans (+2.4%), soybean oil (+9.4%), and soybean meal (-5.7%)
  - Corn (-0.9%), ethanol (+7.7%), and DDGS (-6.5%)
- Requires an economic model of the world soybean and corn complex that accounts for trade between countries to assess the potential impact of trade and prices on competing oilseeds such as canola
  - Potential substitution of canola oil for US soybean oil in other countries

Conclusion

- The US EV policy has potential implications for the demand for US corn and soybean production and their respective co-products, bolstered by policies that have encouraged the production of renewal fuels for almost 20 years.
- A simulated 10% reduction in the demand for soybean oil used in biofuels and ethanol reveals
  - Slight declines in corn and soybean prices (1.7%) and little change in acreages (-0.2%)
  - Corn used in ethanol declined by 2.1%, and other uses increased feed (0.5%), food (0.2%), and exports (0.9%)
  - Soybean oil used in biofuels declined by 9.5%, with production diverted to other uses of food (3.4%) and exports (9.4%), with a 7.3% decline in soybean oil price
- Estimated a 5% decline in canola oil demand in the U.S. because of increased supplies of cheaper soybean oil (-7.3%) on the edible oil market.
- Canola markets in other countries might also be impacted with an estimated increase of U.S. soybean oil exports of 9.4%.