Wind energy utilization and consumer food prices: Evidence from U.S. energy policy shift

Jehu Mette* and Guoyu Lin †

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Abstract

The Energy Act of 2005 and the Energy Independence Act of 2007 consolidated the U.S. orientation toward renewable energy sources. At the time, wind energy utilization surged by a factor of 15 over less than 20 years and food prices increased as well. Despite the abundant treatment of the link between these food prices increases and other renewable energy sources, namely biofuels, the literature has said very little about the contribution of wind energy utilization. This paper provides evidences that wind energy consumption shocks have explained an increasing share of the variation in food prices since 2005. Consumers and policymakers' decisions can be impacted by this finding, as wind is a growing share of the domestic primary energy consumption.

JEL Classification: E32, E50.

Keywords: Wind energy consumption, Food prices, Vector autoregressions.

*David D. Reh School of Business, Clarkson University, 8 Clarkson Avenue, Potsdam, NY 13699. Email: jmette@clarkson.edu, Phone: 785-770-6956.

†David D. Reh School of Business, Clarkson University, 8 Clarkson Avenue, Potsdam, NY 13699. Email: jmette@clarkson.edu, Phone: 680-8885-223.

1 Introduction

Beginning in the 1970s, the trend in the food prices had been a steady decrease or at worst a relative stagnation (See Figure (2)). In reaction to the climate change concerns and also to secure a better energy independence, the U.S. began establishing a series of major energy policy acts since 2005. Starting with the Energy Act of 2005, President George W. Bush signed into law this omnibus bill with several tax reductions and tax credits to encourage and expand the production of renewable energy. Wind energy fell under that umbrella.

Up until then, this energy category had represented less than 0.5% of the total U.S. primary energy consumption. A rapid growth that can only be qualified as exponential ensued. Wind energy consumption increased by a factor of 15 in less than two decades (see Figure (1)). Following this Energy Act, observers noticed sharp reversals in the trends of real food prices. The literature has generally attributed those to the increased competition that biofuels brought to traditional food crops (Zhang et al. (2017), Carter et al. (2017), Rathmann et al. (2010)). Since corn can be used as a biofuel, there is a competition for land use because the corn used for nutritional purposes is different from the one used for biofuels.

Surprisingly, the literature has said very little as to whether the boom in wind energy consumption had any role to play at all in these food prices increases. Bessette and Mills (2021) studies how farmers respond to the installation of wind farms and what determines whether they are supportive or not. Because wind energy represents such a stable source of income for farmers compared to crops which are vulnerable to seasonal fluctuations or commodity prices changes, wind turbines income is remarkably predictable. This diversification of income sources, even if moderate, may be associated with less farming activities, less food supply and higher prices. In this paper, we address this question by studying the causal link between wind energy consumption shocks and real food prices by employing a structural vector autoregressive model (VAR). We find that overall food prices significantly rise in response to wind energy prices, and that several disaggregated food prices categories also experience price surges with varying level of magnitudes.

The rest of this paper proceeds as follows. Section 2 provides a brief overview of the relevant literature. Section 3 elaborates on the energy policy acts of 2005 and 2007 as well as their tax incentives. Section 4 presents our data. Section 5 expands on the methodology. Section 5 consists of our main results, and we present concluding remarks in Section 6.

2 Related literature

The growing concerns surrounding sustainable energy production has led several policymakers and industry leaders to invest in renewable energy forms. The literature is still debating the short and long term effect of this shift in orientation. In this debate, food prices occupy a central place because of their importance in consumer spending, especially for lower income households. There is still a limited amount of research investigating this question.

Blanco (2009) finds that between 2005 and 2008, wind energy generation costs had increased by more than 20% due to raw material price increases. These cost surges did not influence the strategic position of wind energy compared to other sources, given that with time, production costs fell. Kaldellis and Zafirakis (2011) emphasize the more how important the European Union (EU) has been for the evolution of wind energy. Mitchell and Tran (2010) concurs and emphasizes the role of U.S. energy policy. Around 2009, the 2020 target for Europe's wind energy generation was between 14% and 17% of total energy generation. Recently, the European commission has announced that this target had been met for 2020 with further goals for 2030 when wind energy is expected to cover up to 24% of electricity needs[1]. The EU is the current leader in floating wind energy capacity, with about 70% of the global wind production.

Sayigh and Milborrow (2019) investigates with care the cost of wind energy and its fluctuations in recent times. The book summarizes the latest development in renewable energy in general and wind in particular. The authors argues that wind energy is one of the cheapest in the renewable category. This is true not only in the U.S. but also at the global level. Lantz et al. (2016) shows that wind energy was growing as a share of the total U.S. electricity generation, 4.7% exactly. This had grown to about 8.4% by 2020. This rapid growth is the more striking considering that this number was essentially zero two

[1] https://ec.europa.eu/info/research-and-innovation/research-area/energy-research-and-innovation/

decades earlier. Along the U.S. and the EU, China has also taken actions in a similar direction. Zhang et al. (2017) discusses the current and future renewable energy orientation of the country. This is the more apparent given China's "Renewable Energy Law" passed by congress in February 2005. At the time, renewable energy covered already 23.4% of total installed power capacity.

In general, the literature has produced much evidence of a link between renewable energy utilization and food prices, but mostly due to biofuels and their potential impact on land use. Rathmann et al. (2010) shows that there is a level of competitiveness between biofuel crops and usual food commodities. Carter et al. (2017) employs a partially identified structural vector autoregressive model to investigate food prices after the U.S. policy shift of 2005. The study reports that between 2006 and 2014, corn prices were 30% higher than they would have been compared to the predicted levels if the policy change did not occur. This is a large surge considering the position of the U.S. as a leading exporter of grain. In contrast, very little has been said on the impact of these important wind energy development on food prices. We know that in wind energy expansion depends on finding adequate areas for turbines installation. Commonly, these have been rural areas which tend to be populated by farmers, a population central to the food generation process. Bessette and Mills (2021) study communities which are more likely to support or oppose wind farm development. The study finds that production-oriented farming is associated with lower opposition. Overall, the treatment of food prices in perspective with the growth of wind energy generation and consumption has been sparse at best in the literature.

3 U.S. energy policy and tax incentives for renewables production and consumption

Midway in the first decade of the new millennium, food prices that had been decreasing since the 1970s experienced a reversal that coincided with the enactment of two major domestic energy policies. The first was the Energy Policy Act of 2005 followed by the Energy Independence and Security Act of 2007. Observers pointed out the simultaneity of the two events. In this section, we highlight some provisions of these bills, especially in terms of tax rebates and incentives that stimulated renewable energy consumption in general and wind in particular.

The 2005 Energy Policy Act was a milestone in the development of renewable sources in the U.S. economy. President George W. Bush enacted this omnibus bill in hope of addressing environmental concerns and enhance U.S. energy security. Several provisions were put into place. The Renewable Fuel Standard (RFS) required an increasing amount of ethanol in commercial gasoline. The original target was 4 billion gallons of ethanol in 2006 and 7.5 billions gallons in 2012. A substantial $14.5 billion tax reduction over 11 years also aimed to encourage domestic energy production. Tax credits were also offered to drivers of hybrid vehicles, spurring competition and interest among car manufactures to consider renewable energy power.

The second bill of 2007 aimed at extending the targets of the original one and further reduce the reliance of the U.S. economy on foreign fossil fuels. This was done by raising the ethanol production target of the RFS to 36 billion gallons by 2022 and introduce more regulations for residential and appliance equipments' efficiency. The interest for more renewable utilization coupled with the policymakers' orientation revived the interest in renewable energy and all associated research and development, as well as stock investments in renewable energy companies.

4 Data

Our data on wind energy utilization originates from the Energy Information Administration (EIA) which is part of the U.S. Department of Energy. We obtain monthly series spanning January 1983 to December 2019. We stop at this date to avoid including the effect of the global health crisis, which started in 2020. We also gather data on total renewable energy use[2] as well as total energy consumption. Wind energy consumption is recorded in British Thermal Units (BTU). We compute the ratio of wind energy consumption to total energy consumption in per capita terms for each month. We obtain the wind energy consumption as a share of total primary energy consumption per capita.

[2] This includes biomass, solar, hydroelectric, geothermal, waste and wood energy sources.

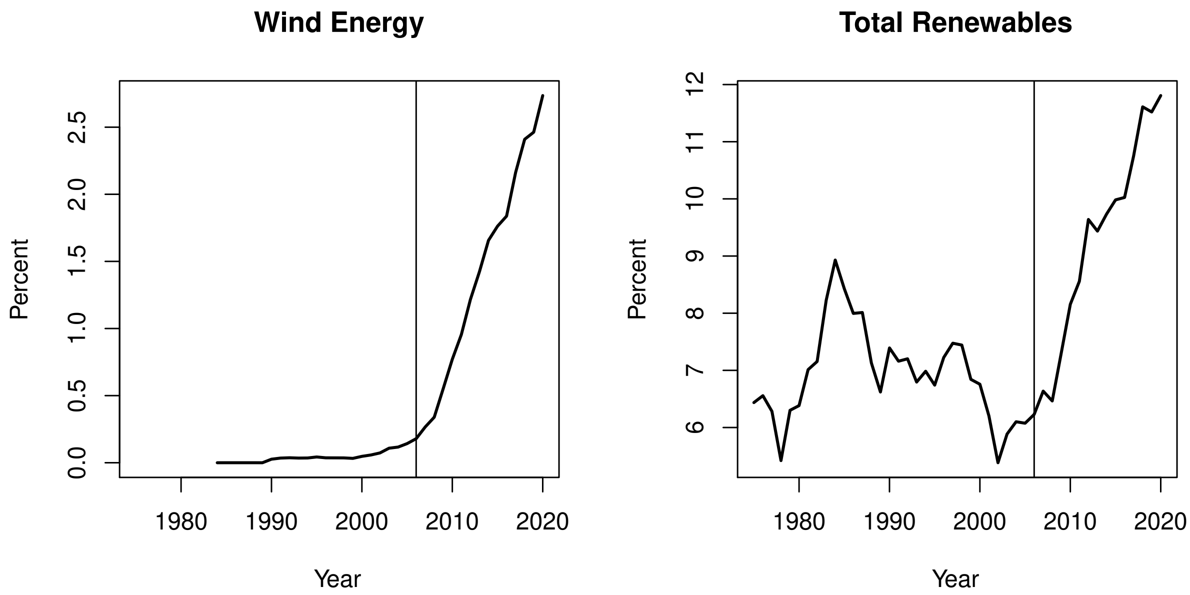

Figure 1: Percent of total primary energy consumption under wind and total renewables: 1974-2019

Figure(1) shows that although wind energy had been produced in the U.S. since the 1980s, it is not until 2005 that its consumption took off significantly. After 2005, a sharp growth occurred. Wind energy went from representing about 0.17% of the total primary consumption to more than 2.7% in 2020. This represents a growth by a factor of 15 within less than two decades. We also see that renewable energy as a whole has significantly increased since that date. Close to 12% of the total primary energy consumption come from renewable sources, compared to only 6.5% in 2005.

Data on food prices are also publicly available and obtained from the Federal Reserve Economic Database (FRED). We gather consumer price indexes for food prices as well as US core CPI (excluding food and energy). The monthly data also span January 1974 to December 2019. Aggregate food prices are based on the U.S. urban average for food and beverages. All food price indexes are deflated by the core CPI to obtain real series. This helps to account for potential influence of monetary policy shocks. Alongside aggregate food prices, we gather cereals and baked good prices, meat and poultry, fruits, non-alcoholic beverages, alcoholic beverages, food at home and food away from home.

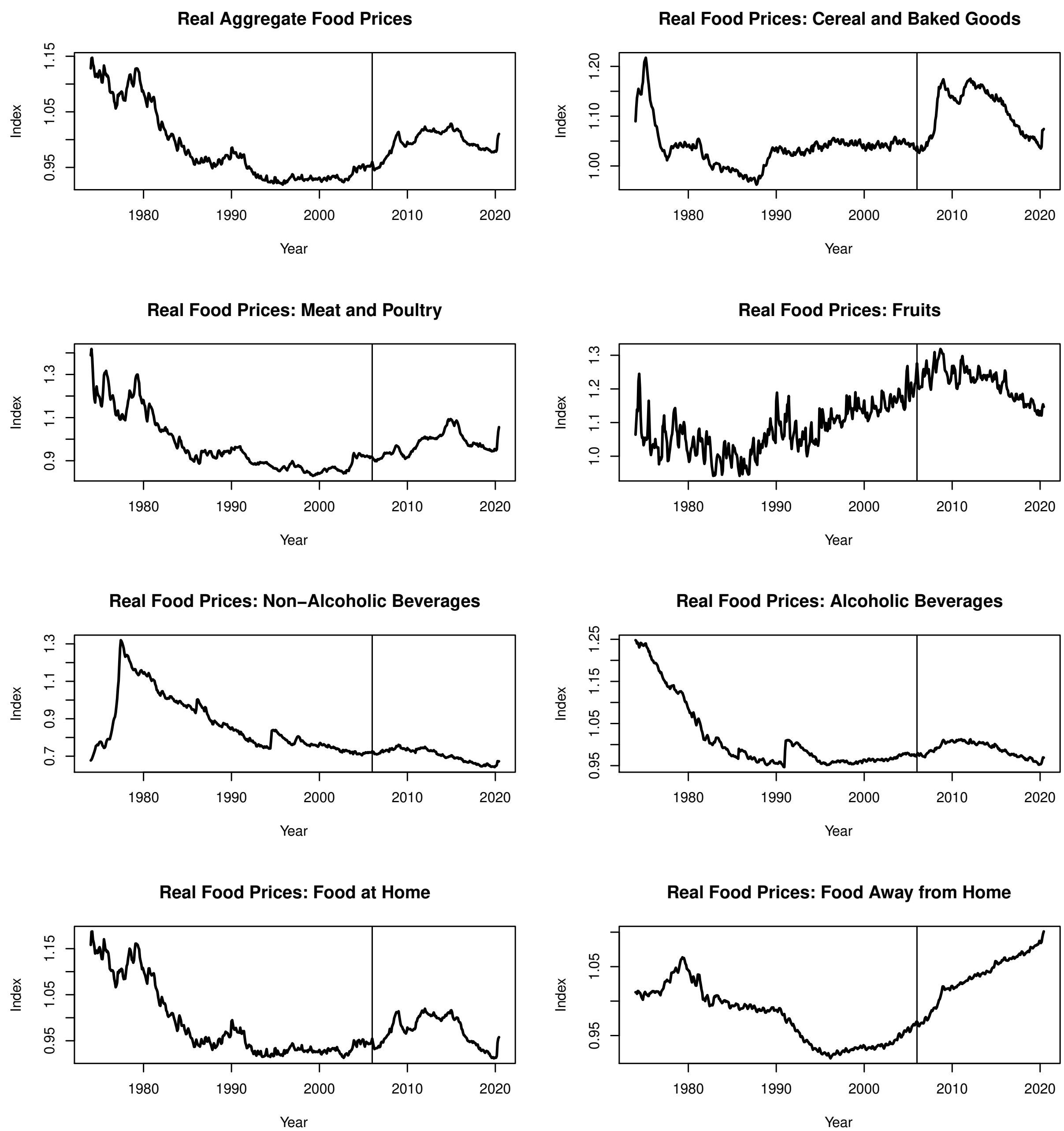

Figure 2: U.S. real food prices computed as consumer price indexes (CPI) deflated by US core CPI. The vertical line identifies the January 2006.

Figure (2) shows the falling prices trend in most series. Since the 1970s with the exception of cereals and fruit prices which have respectively stagnated and mildly increased. After 2005, real aggregate food prices display a clear increase, which is visible in other disaggregated food price series. This observation is the object of our analysis.

5 Methodology

We employ a standard vector autoregressive model (VAR) to investigate the question:

$$\begin{bmatrix} W_t \\ F_t \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} W_t \\ F_t \end{bmatrix} + \begin{bmatrix} \epsilon_{W,t} \\ \epsilon_{F,t} \end{bmatrix}. \tag{1}$$

W_t represents the percentage change in wind energy consumption form one month to the next and F_t is the percentage change in food prices[3]. L is the lag operator, $A(\cdot)$ is a polynomial in L, while $\epsilon_{W,t}$ and $\epsilon_{F,t}$ are the reduced form residuals for each equation. Our identification assumption is that shocks to wind energy utilization influence food prices in the same month, whereas it takes at least a month for the reverse to happen. This restriction is reflected by this transformation of the reduced forms residuals to structural shocks:

$$\begin{bmatrix} \epsilon_{W,t} \\ \epsilon_{F,t} \end{bmatrix} = \begin{bmatrix} B_{11} & 0 \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} u_{W,t} \\ u_{F,t} \end{bmatrix}, \tag{2}$$

Pre-multiplying the left hand size of Equation (1), we obtain the identified structural VAR model to compute impulse response functions and calculate forecast error variance decompositions for each food price categories in response to wind enrgy utilization shocks. Premultiplying Equation (1) by our non-singular matrix results in the SVAR model:

$$\begin{bmatrix} B_{11} & 0 \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} W_t \\ F_t \end{bmatrix} = \begin{bmatrix} B_{11} & 0 \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} W_t \\ F_t \end{bmatrix} + \begin{bmatrix} u_{W,t} \\ u_{F,t} \end{bmatrix}. \tag{3}$$

[3]We express the variables in percentage change based on Augmented Dickey Fuller (ADF) and Philip-Perron unit root tests of stationary. Those tests results are available upon request and include the drift and drift and trend versions.

6 Empirical results

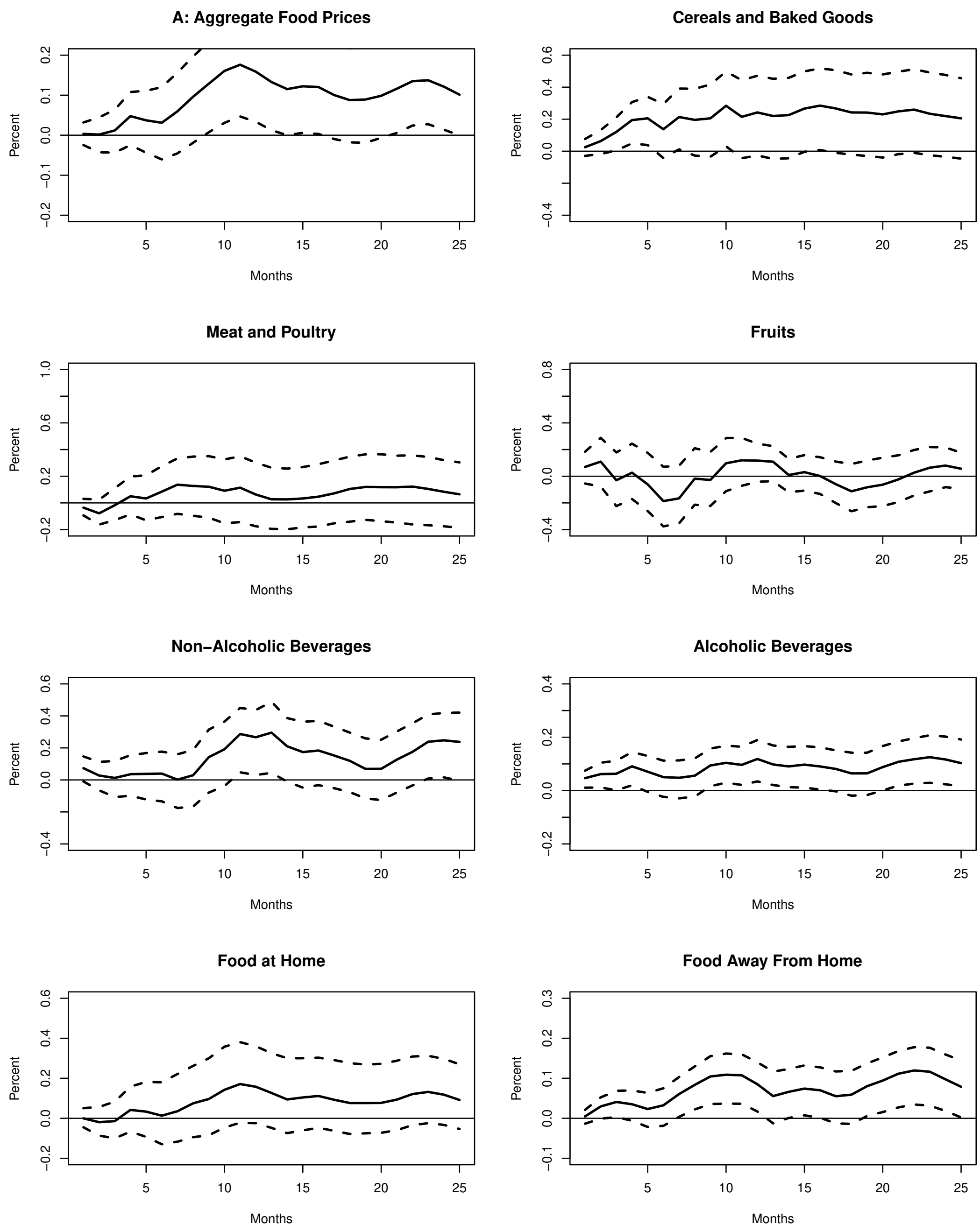

Figure 3: The impact of wind energy consumption shocks on foods prices. Solid lines are the cumulative impulse response functions and dashed lines are the 90% confidence bands based on the Wild bootstrap with 1000 replications. The sample period is 2006-2019.

Figure (3) shows the response in each food price category to a 1% shock in wind energy utilization. We report the results for the time period since the 2005 Energy Act. Wind energy shocks are associate with significant price increases in many categories over time. Some series show non-significant effect, but we do not find evidence of any food price decreases in response to wind energy consummption shocks.

In response to a 1% surge in wind energy consumption, aggregate food prices rise by 0.1% about 10 and 20 months after the shock. For a comparable change, cereals and baked goods prices increase by 0.2% 4 months after the shock. In addition, non-alcoholic beverages, alcoholic beverages and food away from home all display comparable real price increases in the medium and long run. Table (1) provides further evidence of the contribution of these shocks to long run real price variations. As expected, wind energy consumption explains a growing share of the overall food price variation as time goes on. Particularly for cereals and baked goods and food away from home, a substantial share of fluctuations come to be explained by these shocks.

Table 1: Percent contribution of wind energy consumption shocks to overall variation of food prices

Horizon (months)	Aggregate food prices	Cereals and baked goods poultry	Meat and poultry	Fruits	Non-Alcoholic beverages	Alcoholic beverages	Food at home	Food away from home
1	0.03%	0.43%	0.39%	0.48%	1.83%	4.25%	0.00%	0.15%
6	3.03%	7.70%	3.44%	4.63%	2.35%	7.21%	2.84%	5.83%
12	10.55%	13.95%	4.97%	6.91%	9.10%	10.27%	6.13%	16.31%
24	13.79%	15.33%	5.86%	8.24%	13.04%	13.10%	8.24%	23.59%
36	15.60%	16.09%	6.20%	8.61%	14.43%	14.55%	9.37%	26.66%

Notes: Forecast error variance decompositions based on structural VAR model. The sample period is 2006-2019.

7 Conclusion and policy implications

In light of the current environmental debates surrounding global warming and the impact of non-renewable wastes, several leading economies have taken strong measures to progressively increase the amount of renewable energy they utilize. The Energy Act of 2005 as well as the Energy Independence Act of 2007 exemplifies this U.S. energy policy orientation. These two bills came with several tax provisions and incentives designed to encourage the expansion of renewable energy production.

Up to that point, wind energy consumption had represented a very small share of the U.S. primary energy consumption. After the Energy Act of 2005, the consumption of this category of renewable energy multiplied by a factor of more than 15. At the same time, U.S. food prices also increased. The literature has profusely depicted a link between these food price surges and biomass consumption due to the potential land competition that it creates. As to the role of wind energy production, the record is much more parsimonious at best.

This is surprising as inland wind turbines are usually installed in rural areas where farmers are the predominant population. The perception that wind turbines can be installed on farmland with minimal costs is simplistic. In reality, installing a windmill is not only costly monetarily, but could also impose a cost on crops' production. For example, the Illinois Agricultural Aviation Association (IAAA) warns that farmers with wind turbines may lose the ability to apply farms products and fertilizers using airplanes due to the risk of flying near windmill [4]. In addition, windmills generate additional income for the farmers who do decide to install them. The town of Sheldon in New York is an extreme example of this case[5]. Local taxes have been thoroughly removed and replaced by revenue coming from increased wind energy generation. This could decrease incentives to generate revenue from crops and affect the food supply and food prices.

As more investigation of the working channel of this relationship is needed, the contribution of this paper resides in showing that wind energy consumption surges did affect food prices in the medium and long run. We find that prices of aggregate food, cereals and baked goods, beverages, food at home, and food away from home increased in response to wind energy utilization shocks.

These results represent important information for policymakers and consumers as the expansion of wind energy continuous. Considering lower income families for which food expenditures represents a comparatively large share of expenses, such increases could be more significant. For future research, this is an opportunity to further investigate the mechanism at play and the impact that these changes may bring about to other markets of interest to consumers and policymakers.

[4] https://agaviation.com/wind-farms/.

[5] https://cleanpower.org/blog/wind-power-creates-town-no-taxes/

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