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RESEARCH ARTICLE

Perceptions of Transportation Services and Food Indexes in the US: An Investigation of Dynamic Connectedness

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Abstract

This paper provides an empirical evaluation of and connectedness between transportation measures and measures related to the food industry as a pioneering study. This study uses monthly time-series data for the research exercise, including the United States from January 2000 until October 2021. The results might indicate that the connectedness between transportation and food measures is significant and worthy. In this work, it is going to be evaluated that the determination of the linkage between transportation measures and food measures, and the nature of connectedness parameters may have an important policy implication for policymakers, actors in the transportation and food sectors. The strong tendency to show a significant relationship running between variables and spillover should indicate the potentially important role of transportation in stimulating the food industry and vice versa.

Keywords: *Food industry, transportation mobility, price indices, connectedness*

Jel Codes: *L66, O18, R49*

ABD'de Ulaşım Hizmetleri ve Gıda Endeksleri: Dinamik Bağlantılılık İncelemesi

Özet

Bu makale, öncü bir çalışma olarak, ulaşım önlemleri ile gıda endüstrisi ile ilgili önlemler arasındaki bağlantılılığın ampirik bir değerlendirmesini sunmaktadır. Bu çalışma Ocak 2000'den Eylül 2021'e kadar Amerika Birleşik Devletleri'ni içeren araştırma çalışması için aylık zaman serisi verilerini kullanmaktadır. Sonuçlar, ulaşım ve gıda önlemleri arasındaki bağlantılılığın anlamlı ve değerli olduğunu gösterebilir. Bu çalışmada, ulaşım önlemleri ile gıda önlemleri arasındaki bağlantının ve bağlantılılık parametrelerinin doğasının belirlenmesinin, politika yapıcılar, ulaştırma ve gıda sektörlerindeki aktörler için önemli bir politika çıkarımına sahip olabileceği değerlendirilecektir. Değişkenler ve yayılma arasındaki anlamlı ilişkiyi gösterme yönündeki güçlü eğilim, ulaşımın gıda endüstrisini canlandırmada potansiyel olarak önemli rolünü ve bunun tersini de göstermelidir.

Anahtar kelimeler:*Gıda endüstrisi, ulaşım hareketliliği, fiyat endeksleri, bağlantılılık*

Jel Kodu: *L66, O18, R49*

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1. INTRODUCTION

The field of food, from an industrial perspective, is known as building stones of the economies in providing sufficient food to consumers by producers. It protects and supports the population, provides jobs, and gives them opportunities to earn in large and small areas of the country (Tolipova, 2020). Besides it satisfies the community requirements regarding accessibility, distribution, and quality of food products. The food industry holds a chain of diverse activities from production, which is the first process of the food, to consumption which is the last stage (Sadiku et al., 2019). This supply chain consists of many products and companies. They operate in different markets and sell a variety of food products. The planning process of food activities to reach consumers interests the food supply chain from the agricultural sector to the retail sector. Relevant markets and their product categories, which operate the firms, affect the degree of market power in the food supply chain (Bukeviciute et al., 2009).

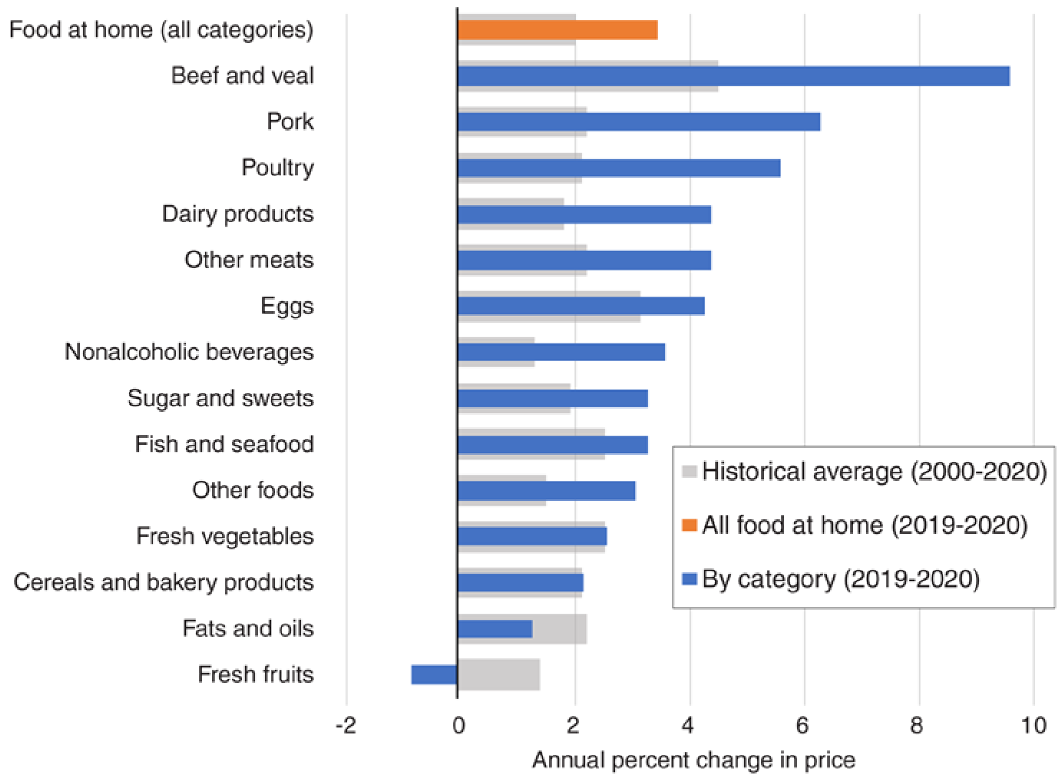
The food industry is also related to sustainable development regarding economic and social factors. Given the interconnected social, environmental, and economical dimensions of food systems, food is a common thread linking all seventeen United Nations Sustainable Development Goals (SDGs, hereafter). The SDGs are covered new action targets relating to agricultural practices by encouraging the economic development of the countries, relating with water and energy use sustainably (United Nations, 2014). Related to food, goal two in the seventeen SDGs targets to end hunger, achieve food security and increase sustainable agriculture activities by adopting sustainable food production systems, which provide productivity of the sector. These improvements with the SDGs help to maintain ecologic balance, increase agricultural capacity for producers by improving land and also product quality. This shows that the development goals are interlinked with each other, and multiple goals depend on a transformation of the food system because in food lies the fundamental connection between people and the planet so there is a path to inclusive and sustainable economic growth in terms of the way of production, transportation, storage of food, consumption in food market activities within the key elements of the supply chain of the industry (FAO, 2015).

Although it is not wrong to say that food is remarkable for all countries, the U.S. food system carries a particular value for both producers and consumers in the U.S. economy when it is looked at the sectoral analysis. One of the reasons is that it provides broad interactions with the global food system and has significant influences on the global community. From past to present, the U.S. food system has reached an observable and significant success in providing the U.S. population with a varied, relatively cheap, and extensively current supply of food. It is stated that the U.S. produces over 30 percent of the world's corn and over 50 percent of the world's soybeans. Besides, the U.S. also accounts for large shares of the world export market for several food products. Statistics showed shares that about 60 percent for corn, 40 percent for soybeans, 25 percent for wheat, and 70 percent for sorghum, this situation provides that the U.S. is an important contributor to global grain supplies (Lin et al., 2019). It has carried out the activities by a wide supply-chain maintained food to consumers that consist of producers, processors, and distributors (Nesheim et al., 2015). Indeed, food manufacturing is an integral sector of the U.S. economy with a 10 percent share of total GDP regarding the production, transportation, and export (Eğilmez et al., 2014) and approximately 17.3 million full and part-time jobs are related to agriculture which corresponds to 9.3 percent of total US employment (Glaser and Morrison, 2016).

As well as food production process, the food distribution system is also an inseparable part of the food supply chain element for reaching goods to consumers. Because of food products differ from other commodities in terms of perishable, they require attention for delivery and handling with temperature control and cooling process to prevent any spoilage. Globalized food transportation provides to overcome the deficiencies among the countries efficiently in terms of food products and to continue food supply from one region to the others with the transportation modes so that it also makes available new markets for local agriculture (Pothukuchi and Wallace, 2009). Food is transported using many modes from the first stage of the production to final consumption (James et al., 2006). Food transportation, which is one of the important rings of the food supply chain, uses water, rail, truck and air transportation which bases four fundamental transportation modes for providing to reach large quantities of food products between the countries (Wakeland et al., 2012). The modern food system enables the transport of a variety of food materials that transfers kilometers away, using different modes with combinations such as ship, rail, truck, and air transport. These processes are closely associated with industrial technology of the food system for storage that also covers energy uses from producer to consumer. Technological innovations provide advances in food transportation, increasing speed by shortening transport time and decreasing food spoilage (Hammond et al., 2015).

The notion of food access expresses the consumers reaching healthy and low-cost food products easily from the stores such as supermarkets (Zhang and Mao, 2019). Besides, it describes the accessibility to alimentary foods including whole grains, fresh low-fat dairy products, low-fat meat, fish, fruits, and vegetables (Falls, 2012). The connection between the agricultural industry and transportation system eases food access to a large extent from both the country and abroad for U.S. consumers and when viewed from this aspect in general, societies can receive food aid with easiness of transportation from far away countries and it gains an advantage for export activities in terms of reaching food stores. These factors provide to be a leading international food enterprise for U.S. corporations (Pothukuchi and Wallace, 2009). Therefore, transportation networks have a significant element to maintain the food distribution system.

Figure 1: Index Change by Food Category, 2020



Source: USDA

As illustrated in Figure 1, various types of food price indexes rise in 2020 except fresh fruits, during the pandemic conditions. The highest change is observed for meat products with almost 10 percent and the lowest is fats and oils with almost 1.5 percent.

The food industry especially has gained more importance after the coronavirus disease Covid-19 pandemic, which has become a serious problem in terms of food supply chain for the countries. It has observed pandemic effects in farm production, processing, transport and logistics, and final demand (Deconinck et al., 2021). The reason is that many significant government restrictions have been applied on transportation of food products to countries during the pandemic all over the world because they protect the countries from pandemic conditions (Aday and Aday, 2020). Restrictions have caused stopping or slowing in some harvesting and agricultural activities, increasing losses in the harvesting activities depending on decreasing labor force and interrupting food delivery to the markets (Mardones et al., 2020). These problems have been reflected in food prices and food indexes (such as meat, dairy, cereals) relating to the mobility of goods and services via transportation costs during the pandemic.

Based on the various perspectives, this study aims to reveal the relations between transportation and food measures by using a dynamic connectedness approach. Freight transportation services and various food indexes are used to determine these spillover interactions in the U.S. from January 2000 to October 2020 with monthly data. In line with the aim and scope, the hypothesis of this study is that the food industry and transportation services have significant relations within the context of connectedness.

The remainder of the paper is structured as follows: the literature review of the study is represented in Section 2. The data and methodology used to observe dynamic connectedness between transportation services and food indexes are presented in Section 3, the empirical findings are discussed in Section 4, followed by conclusions in Section 5.

2. RELATED LITERATURE

Food transportation is an important stage of the food supply chain. It provides to link between the producers and consumers. Food travels thousands of miles thanks to more efficient means of freight transportation via air, rail, road, and sea modes. Efficient modes of transport gain an advantage for products reaching to different oceans and continents such as cereals, fruit, vegetables, meat, and milk. The transportation choice for food depends on various constraints, such as cost, the distance to be traveled, and the product. With convenient transportation systems and energy costs, food is provided to access farther away from the producers.

There are many different approaches for analyzing the linkages between the food sector and transportation. Related studies have been revealed by Baek (2016), Capone et al. (2013), Coveney and O'Dwyer (2009), Widener et al. (2017), Wilson et al. (2004) and they searched the food accessibility by transportation. Baek (2016) examined that public transportation accessibility had a negative effect on food insecurity for African American households between the years of 2006-2009 using causality analysis. Capone et al. (2013) investigated food accessibility and affordability at Mediterranean households and countries by using secondary data which includes a set of different indicators such as food consumer price index, household food expenditure, cereals imports dependency, and values of food imports over total merchandise exports. Widener et al. (2017) revealed the study related to daily food access in grocery stores of Toronto covering the changing locations in food access and the effects of public transportation activities for supplying food over 24 hours. According to the results, access to grocery stores was decreased in the late night and early morning rather than the other time period and found that trends of using public transportation were higher and changeable in the early morning hours.

On the other side, there are also some studies related to the relationship between transportation infrastructure and agricultural production. Felloni et al. (2001), Inoni and Omotor (2009), Lokesha and Mahesha (2016), Ogunleye et al. (2018) tried to analyze the effect of road infrastructure on agricultural production. Felloni et al. (2001) investigated whether there was any impact of transportation infrastructure and electricity on agricultural production and productivity by using cross-sectional data in China which covered 83 countries and 30 provinces and results showed that agricultural production was related to the determination of the density of roads and the availability of electricity. Ogunleye et al. (2018) found that there was a positive and statistically significant relation between road transport infrastructures (LRT). Besides, results were proved causality from agricultural sector development to transport infrastructure as unidirectional for Nigeria, using Granger Causality and Ordinary Least Square estimation techniques for secondary annual time series data from 1985 to 2014.

Even if there is extensive literature on food and transportation, a limited number of studies directly focusing on food transportation depend on the distance to consumers. Grebitus et al. (2013) examined the importance of distance on transportation and its' influences on consumer preferences. They analyzed that distance in transportation changed with the consumers' willingness to pay (WTP, hereafter) for food and found that the average WTP is falling in distance traveled.

Several studies try to explore the energy usage in food and transportation services, including Alghalith (2010), Baffes (2007), Baumeister and Kilian (2014), Baffes and Dennis (2013), Chen et al. (2010), Harri et al. (2009), Ibrahim (2015), Pimentel et al., (2006), Taghizadeh-Hesary et al. (2019), Tiwari et al. (2020), and Weber and Matthews (2008). Based on the energy (prices) perspective, most of these studies found a significant relationship between food and transportation costs via energy prices. One of these studies, Alghalith (2010) analyzed the uncertainties on both oil and food prices in common and tried to find a correlation on food prices with these indicators by using a non-linear least squares regression for the annual time series data (1974–2007). According to the results, they emphasized that food prices increased with the higher oil prices in the same direction. On the other hand, Baumeister and Kilian (2014) found that there was no strong connection between oil price shocks and U.S. retail food prices in terms of a rise in the price by using the structural dynamic econometric model. Besides, they stated that there is no statistical evidence about changes in retail food prices on the cost of food supply chain activities such as processing, packaging, transportation, and distribution depending on increases in the oil prices. Ibrahim (2015) investigated the relations between food and oil price for Malaysia using a nonlinear autoregressive distributed lags (NARDL) model and his empirical results of the study referred that when the relationship between oil price increases and food prices, there was a significant contribution to each other in the long run. Tiwari et al. (2020) found that the price indices of energy fuels and food products including industrial inputs, agriculture raw materials, metals, and beverages, had significant relations based on time-frequency analysis, using the causality and connectedness approach by showing Diebold and Yılmaz (2012). Their findings are especially significant in terms of fuel and food prices, fuel and industrial prices, and fuel and metal prices.

As well as many studies emphasizing positive relations between oil and food prices, some findings of studies give also a different point of view to the subject. Such studies, i.e., Lambert and Miljkovic (2010), Nazlioglu and Soytas (2011), Zhang and Reed (2008), and Zhang et al. (2010) investigated whether any impact of changes in the oil prices on food prices and he could reach the results that there was a unidirectional relation even if some evidence pointed out neutrality between them. On the other hand, Zhang et al. (2010) also emphasized that it was not any relations in the short or long run among indicators regarding prices of food products such as corn, rice, soybeans, sugar, and wheat prices. That means this situation was not caused by drastic increases in oil prices.

Recent studies in the literature have also revealed that the Covid-19 outbreak causes some important changes in the food supply chain in terms of transportation of goods and services depending on restrictions. Chitrakar et al. (2021), Coluccia et al. (2021), Goeb et al. (2021), Hobbs (2020), Singh et al. (2021), and Walters et al. (2020) investigated the pandemic effects on the food supply chain, emphasizing the restrictions of the transportation services. Coluccia et al. (2021) presented that as well as Covid-19 impact was observed in the agri-food demand and whole changes of supply chain activity's reaction depending on the pandemic restrictions of countries, its effects reflected logistics and transportation services so its effects reflected logistics and transportation services. Goeb et al. (2021) explained the changes in rice prices, relating to the disruptions of transportation for reaching the consumer.

3. DATA

This study uses a monthly time-series data set for the U.S. including the period from January 2000 to October 2021.The data set consisted of food and transportation measures, which were obtained from two different sources. Freight Transportation Services Index, (Chain-type Index 2000=100 (FRE, hereafter), Consumer Price Index for All Urban Consumers: Food in the U.S. City Average, Index 1982-1984=100 (CPI, hereafter), Industrial Production: Manufacturing: Non-Durable Goods: Food, Index 2017=100 (INP, hereafter), Industrial Capacity: Manufacturing: Non-Durable Goods: Food, Index 2017=100 (INC, hereafter), Capacity Utilization: Manufacturing: Non-Durable Goods: Food, Percent of Capacity (CAU, hereafter) and Manufacturers' Total Inventories: Food Products, Millions of Dollars (MTI, hereafter) were taken from the Federal Reserve Bank St. Louis Economic Research database. Food Price Index, Meat Price Index, Dairy Price Index, Cereals Price Index, Oils Price Index, Sugar Price Index were obtained from Food and Agricultural Organizations of United Nations (FAO). These indexes show the real food prices (Index 2014-2016=100).

Table 1: Descriptive Statistics

Variables	# of Observations	Mean	Median	Minimum	Maximum
FRE	262	115.41	112.00	95.00	142.00
CPI	262	220.74	221.08	165.60	284.23
INP	262	94.93	94.40	87.35	102.47
INC	262	118.35	118.13	109.43	128.48
CAU	262	80.21	80.56	72.57	83.04
MTI	262	44.75	43.74	30.19	62.78
FOOD	262	94.49	96.07	65.76	132.13
MEAT	262	89.41	91.36	66.70	113.52
DAI	262	98.80	99.57	52.98	161.44
CER	262	97.24	96.29	61.13	158.90
OILS	262	98.44	93.93	45.74	183.87
SUG	262	89.43	83.47	40.00	173.84

Note: Expansions of variable abbreviations can be found above in the introductory paragraph of the Data section.

All variables are gathered in seasonally adjusted form. These twelve variables, see descriptive statistics in Table 1, are used to examine dynamic connectedness analysis for explaining the relationship between food and transportation.

4. METHOD

The aim of using the connectedness approach is to provide versatile output covering spillover parameters in the context of the relationship between food and transportation indices. The study tries to investigate which indices are affected by others. Therefore, this method supplies multidimensional spillover results within all variables.

The time-varying vector autoregressive (TVP-VAR) dynamic connectedness approach used in this study follows the methodology conceptualized by Antonakakis et al. (2020), which is the improved version of Diebold and Yılmaz (2012 and 2014).

$$Y_t = \beta_t Y_{t-1} + \varepsilon_t \varepsilon_t \sim N(0, S_t) \quad (1)$$

$$\beta_t = \beta_{t-1} + v_t v_t \sim N(0, R_t) \quad (2)$$

$$Y_t = A_t \varepsilon_{t-1} + \varepsilon_t \quad (3)$$

Where Y_t, ε_t and v_t are $N \times 1$ vectors and A_t, S_t, β_t, and R_t are $N \times N$ matrices.

$$\tilde{\varphi}^g_{ij,t}(h) = \frac{\sum_{t=1}^{h-1} \psi^{2,g}_{ij,t}}{\sum_{i=1}^{N} \sum_{t=1}^{h-1} \psi^{2,g}_{ij,t}} \quad (4)$$

$\tilde{\varphi}^g_{ij,t}(h)$ denotes the h-step ahead generalized forecast error variance decompositions (GFEVD), $\psi^g_{ij,t}(h) = S^{-\frac{1}{2}}_{ij,t} A_{h,t} \sum_t \varepsilon_{ij,t}$, Σ_t the covariance matrix for the error $\varepsilon_{ij,t}$ and $\sum_{j=1}^{N} \tilde{\varphi}^g_{ij,t}(h) = 1$, $\sum_{i,j=1}^{N} \tilde{\varphi}^N_{ij,t}(h) = N$.

The total connectedness index (TCI), which is based on GFEVD can be formulated by the equation below.

$$C^g_t(h) = \frac{\sum_{i,j=1, i\neq j}^{N} \tilde{\varphi}^g_{ij,t}(h)}{\sum_{j=1}^{N} \tilde{\varphi}^g_{ij,t}(h)} \times 100 \quad (5)$$

The total directional connectedness (the spillover of variable i) TO all other variables (j) can be formulated by the equation below.

$$C^g_{i\to j,t}(h) = \frac{\sum_{j=1, i\neq j}^{N} \tilde{\varphi}^g_{ji,t}(h)}{\sum_{j=1}^{N} \tilde{\varphi}^g_{ji,t}(h)} \times 100 \quad (6)$$

The total directional connectedness (the spillover of variable i) FROM all other variables (j) can be formulated by the equation below.

$$C^g_{i\leftarrow j,t}(h) = \frac{\sum_{j=1, i\neq j}^{N} \tilde{\varphi}^g_{ij,t}(h)}{\sum_{i=1}^{N} \tilde{\varphi}^g_{ij,t}(h)} \times 100 \quad (7)$$

The net total directional connectedness, which is the difference between the total directional connectedness to and from, can be formulated by the equation below.

$$C^g_{i,t}(h) = C^g_{i\to j,t}(h) - C^g_{i\leftarrow j,t}(h) \quad (8)$$

The sign of the net total directional connectedness illustrates if variable i is driving the network ($C^g_{i,t}(h) > 0$) or driven by the network ($C^g_{i,t}(h) < 0$).

$$NPDC_{ij}(h) = \frac{\tilde{\varphi}^g_{ji,t}(h) - \tilde{\varphi}^g_{ij,t}(h)}{N} \times 100 \quad (9)$$

Finally, the net total directional connectedness is used to examine the bidirectional relationships by computing the net pairwise directional connectedness (NPDC) can be formulated by the equation above.

5. EMPIRICAL RESULTS

Before the dynamic connectedness application, an important step is to check the stationarity properties of the variables. To check the stationarity properties the Augmented Dickey-Fuller (ADF) unit root test procedure was applied. The ADF test results are presented in Table 2.

Table 2: ADF Unit-root Test Results

Variables	Level (t-stat)	1st Difference (t-stat)
FRE	-2.286	-5.056***
CPI	-1.443	-5.667***
INP	-2.638	-10.878***
INC	-1.566	-8.027***
CAU	-3.023	-10.536***
MTI	-2.864	-6.983***
FOOD	-2.697	-7.779***
MEAT	-1.989	-5.517***
DAI	-2.714	-5.922***
CER	-2.197	-5.869***
OILS	-2.251	-10.679***
SUG	-3.013	-11.688***

Note: Test is applied to the logarithmic series. The null hypothesis of the test is that the series contains a unit root. *** denotes the rejection of the null hypothesis of the series at a 1 percent level of significance. Critical values are gathered from MacKinnon (1996).

Tables 3 and 5 present the connectedness results including directional, net, and total spillover parameters among transportation and food measures. It is indicated that the directional connectedness from each measure to all other measures can be found via row ("TO") and directional connectedness from all measures to each measure can be found via column ("FROM"). These connectedness results also show the net directional spillover can be found via row ("NET"), where a positive (negative) value highlights the net transmitter (receiver) of spillover effects in the analysis or vice versa.

Looking at the results in more detail in Table 3, FRE (with 7.09 percent) and four food measures are found as a net transmitter, except CAU. It is observed that CPI is the net transmitter of spillover with 18.53 percent is followed by MTI with 16.03 percent, INP with 8.68 percent, and INC with 0.86 percent, respectively. Besides, while CPI and MTI are the largest contributions to other indicators, INP and FRE are the largest contributions of spillover effects from other indicators, respectively. On the other hand, CAU is the net receiver of spillover effects by 51 percent.

Table 3: Connectedness between FRE and CPI, INP, INC, CAU, MTI

	FRE	CPI	INP	INC	CAU	MTI	FROM

FRE	23.04	20.13	17.71	16.65	2.45	20.02	76.9
CPI	16.64	24.48	16.04	17.90	1.00	23.94	75.52
INP	18.40	19.50	21.00	19.87	3.03	18.20	79.00
INC	17.22	20.17	17.87	25.82	0.15	18.76	74.18
CAU	14.51	10.18	20.18	4.28	40.68	10.18	59.32
MTI	17.25	24.07	15.88	16.35	1.50	24.92	75.08
TO	84.05	94.05	87.68	75.04	8.13	91.11	**TCI**
NET	7.09	18.53	8.68	0.86	-51.19	16.03	73.34

Note: TCI is Total Connectedness Index, TO is the contribution of a variable to others, OWN is the contribution of variable including own, FROM is the contribution of a variable from others, and NET is the net spillover (TO-FROM).

According to Table 3, the total connectedness index (TCI) indicates a 73.34 percent of the connectedness volatility within all these measures. TCI is found in a higher amount with 74.52 percent in Table 5 considering FRE and FAO indexes concerning parameters monitored in Table 3.

Table 4: Net Pairwise Connectedness between FRE and CPI, INP, INC, CAU, MTI

Variables	%	Role of FRE	Role of Food
FRE and CPI	-3.49	FRE is Receiver	CPI is Transmitter
FRE and INP	0.69	FRE is Transmitter	INP is Receiver
FRE and INC	0.57	FRE is Transmitter	INC is Receiver
FRE and CAU	12.06	FRE is Transmitter	CAU is Receiver
FRE and MTI	-2.77	FRE is Receiver	MTI is Transmitter

Pairwise connectedness parameters, as visible in Table 3, should be read from column to row direction. On the one hand, the column titled FRE includes from FRE to others and on the other hand, the row titled FRE includes from others to FRE parameters. For example, from FRE to CPI is 16.64 percent and from CPI to FRE is 20.13 percent. Net pairwise connectedness between FRE and CPI is 3.49 in favor of CPI. Therefore, FRE is the receiver while CPI is the transmitter. Net pairwise connectedness parameters between FRE and CPI, INP, INC, CAU, MTI can be found in Table 4.

According to Table 4, which presents the roles and net pairwise connectedness parameters, FRE is receiver towards CPI and MTI, with 3.49 and 2.77 percent, respectively. Moreover, FRE is a transmitter against CAU with 12.06 percent, INP with 0.69 percent, and INC with 0.57 percent.

As can be seen in Table 5, freight transportation and food price indexes, which consist of a general (FOOD) and five commodity groups (meat, dairy, cereals, oils, and sugar), are analyzed by using a dynamic connectedness approach. The results present from the “directional from others” column that the gross directional volatility spillovers from others to the MEAT are relatively large, at 79.2 percent, followed by the FOOD, with the spillovers from others explaining 79.14 percent of the forecast error variance. As for the net directional volatility spillovers, while FOOD is the net transmitter of spillover, SUG is the net receiver spillover effects, followed by MEAT and FRE respectively, which have negative values. Total connectedness of the system reaches 74.52 percent indicates that these food and transportation measures are linked with each other.

Table 5: Connectedness between FRE and FOOD, MEAT, DAI, CER, OILS, SUG

	FRE	FOOD	MEAT	DAI	CER	OILS	SUG	FROM

FRE	34.82	13.18	17.52	10.59	9.55	9.18	5.17	65.18
FOOD	6.91	20.86	10.19	15.26	18.25	17.56	10.97	79.14
MEAT	12.82	18.52	20.80	13.77	13.27	12.21	8.60	79.20
DAI	7.68	18.05	9.65	27.38	15.48	12.80	8.96	72.62
CER	5.47	21.88	8.45	12.45	22.65	19.14	9.96	77.35
OILS	7.29	20.30	7.56	14.16	18.15	22.07	10.47	77.93
SUG	13.38	15.31	10.22	8.37	10.61	12.35	29.76	70.24
TO	53.56	107.23	63.58	74.60	85.31	83.25	54.13	**TCI**
NET	-11.62	28.09	-15.62	1.99	7.96	5.32	-16.11	74.52

Note: TCI is Total Connectedness Index, TO is the contribution of a variable to others, OWN is the contribution of variable including own, FROM is the contribution of a variable from others, and NET is the net spillover (TO-FROM).

Table 6 lists the roles and net pairwise connectedness parameters of FRE and FAO indexes. FRE is receiver towards almost all indexes FOOD with 6.27 percent, MEAT with 4.70 percent, CER with 4.08 percent, DAI with 2.91 percent, and OILS with 1.89 percent. FRE is playing as a transmitter only against SUG with 8.21 percent.

Table 6: Net Pairwise Connectedness between FRE and FOOD, MEAT, DAI, CER, OILS, SUG

Variables	**%**	**Role of FRE**	**Role of Food**
FRE and FOOD	-6,27	FRE is Receiver	FOOD is Transmitter
FRE and MEAT	-4,70	FRE is Receiver	MEAT is Transmitter
FRE and DAI	-2,91	FRE is Receiver	DAI is Transmitter
FRE and CER	-4,08	FRE is Receiver	CER is Transmitter
FRE and OILS	-1,89	FRE is Receiver	OILS is Transmitter
FRE and SUG	8,21	FRE is Transmitter	SUG is Receiver

The net pairwise connectedness results for FRE and food measures also showed variability (compare Tables 4 and 6) thus indicating the roles of FRE regarding food measures' roles in situations that do not control or measure role variability. FRE is the transmitter with industrial measures including production and capacity, were acting as receiver within prices and inventories.

When these analyses are compared to reveal the relations between food and transportation, results show that transportation plays two roles in the food industry. While it has mostly a transmitter role with the food industrial activities, other analyses emphasize that transportation is mostly receiver for food prices indexes. Thus, results provide to see that food and transportation connects as bidirectional and affect each other depending on the activities.

6. CONCLUSION

As distinct from the vast of the literature, this study contributes to the interaction between transportation and food measures by using a dynamic connectedness approach in the U.S. for the period covering January 2000 to October 2021 with monthly data. The freight transportation services index is used for mobility and eleven food indexes are used as food measures. The connectedness framework of Diebold and Yilmaz (2012 and 2014) enhanced by Antonakakis et al. (2020) leads to dynamic analysis.

The significance of empirical findings on the interaction between food and transportation is twofold. Firstly, measures from different angles of the food industry and transportation were investigated by the connectedness analysis to reveal the role played as receiver or transmitter. Some results indicated that freight transportation is mostly formed of a transmitter to food industry measures and some opposite direction. Second, it was examined with food indexes to emphasize whether freight transportation activities affect the food price indexes or vice versa. According to the analysis, it is found that there is a significant and close connection between the food price indexes and transportation.

The results also support the relationship between the food industry and transportation in the U.S. real economic activities. The reason is that transportation consists of one of the important steps in terms of maintaining the food supply. Besides, the U.S. is among the leading countries in the food industry and continues to grow with production and trade. The food production process and supply need a well-designed freight transportation planning for satisfying the demand of the consumers. Therefore, a positive or negative development between transportation and food activities affects each other bilaterally. As it was emphasized in the study, industrial changes and food prices are directly connected with freight transportation.

This study also sheds light on some vital policy implications for the industries. It must be given priority to transportation in the food supply chain by policymakers. The reason is that food products distribute to many different geographic locations via transportation services. Economic, social, or environmental factors are affected food delivery and it is also reflected in food prices depending on changing transportation costs.

Recently, the coronavirus disease Covid-19 pandemic, which causes closure of the boundaries and damages to the transportation system, shows us the importance of freight transportation to the countries. Depending on the inconveniences in food transportation, economic activities have slowed down, and food trade has been restricted. Even though the negative effects of the pandemic on the economy started to decrease with interventions compared to the first time, the pandemic continues, and measures are of great importance for the economy to hold stably, including the U.S. Therefore, it must be tended to transportation policies that will come up with a solution. Establishing the strong relationship between food transportation and price in terms of both the producer and the consumer will ensure being precluded economic losses.

The study allows another perspective for the U.S. economy in terms of taking some inferences for the real activities conducted in the food system. Results show that transportation is an important indicator for industries. This relation has been proved by previous workings. The U.S. Department of Agriculture emphasized that transportation and food ranked second and third respectively among the U.S. household expenditure in 2020 (USDA, 2020). Besides, when economic activities are based on the study, it has been understood that two industries affect each other, depending on changes in economic and social factors such as prices and the Covid-19 pandemic.

Future studies need to pay attention to the data availability of high-frequency transportation measures from different countries. This kind of cross-sectional data with a large time dimension is important for empirical analysis in transportation economics but not easily obtained. Modes, infrastructure, and other transportation-related variables could be considered for each perspective and different variables may be decisive for other outcomes.

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