DRIVERS OF FOOD PRICE INFLATION IN TURKEY

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Acknowledgements

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Executive Summary

Food price inflation has increased persistently in recent years in Turkey with a widening divergence from international food price inflation. In Turkey, food price inflation has grown at an average rate of 11.5 percent since 2011 and reached its peak in 2019 at an average rate of 30 percent. Starting in 2012, Turkish food price inflation began to diverge from international food price inflation. As world prices reached their peak in 2011 and started leveling off, increases in Turkish food prices accelerated.

Three interlinked dynamics characterize food price development in Turkey, with a magnitude not seen in other markets: (i) domestic food price inflation that is consistently above core inflation; (ii) unprocessed foods, and, particularly, fresh vegetables and fruits, that drive food price inflation; and (iii) high food price volatility. While none of these characteristics are unusual in and of themselves, their magnitude in Turkey when compared to other countries, makes them highly unusual.

High food prices and price volatility bear welfare implications for both consumers and agricultural producers. For consumers, food prices carry considerable weight in their expenditure baskets—up to 29 percent for the lowest income group in Turkey. Rising food price inflation reduces the purchasing power of Turkish households, if all else remains equal. On the producer side, high food prices can potentially create incentives for increased productivity and raise farmers' incomes and competitiveness. However, as this study shows, higher consumer prices largely do not pass through to producers in Turkey. As input prices have been growing at a rate higher than that of food price inflation, Turkish agricultural producers find themselves in a difficult situation as their profit margins are squeezed between high input costs and low farm-gate prices.

Against this background, the study analyzes the main inefficiencies in the Turkish agricultural sector through the lens of food price formation and discusses the policy actions needed to strengthen the sector's competitiveness. This is done through a series of econometric exercises aimed at empirically testing the factors that drive food price inflation at the national level and a deep dive into the price formation and transmission for table tomatoes, green peppers, and dry onions, the top three fresh vegetables produced in Turkey, across country regions to identify inefficiencies in these selected value chains that contribute to rising prices.

The results of the analysis show that inefficiencies in agricultural markets, augmented by macroeconomic factors, have put food prices on an upward trajectory. The depreciation of the Turkish lira and inflation expectations, demand-side pressure from a growing population, changing consumer preferences, and supply-side elements such as low productivity, constitute the mix of factors that are driving food price inflation over the long run. These factors exist alongside short-run supply and demand imbalances at the local level that are driven by seasonality as well as limited spatial and vertical market integration, and lead to increased price variability across the country. Particularly troubling is the increasing divergence between producer and consumer prices that implies that producers do not receive market price signals due to structural inefficiencies along value chains and limited cross-regional linkages. Short-term positive price shocks stemming from such inefficiencies can further exert upward pressure on price levels over time.

The report findings underscore the need to move away from short-term policy responses to a broader policy strategy aimed at stabilizing prices through increased productivity and improved market linkages. A reevaluation of investment priorities and the feasibility of agricultural state support must be undertaken in light of price developments and must be accompanied by stronger efforts to boost agricultural productivity growth in order to mitigate any longer-term rise in food prices. In the short term, better access to credit and better extension services can help improve productivity. In addition, incentives to implement environmentally sustainable practices need to be introduced to decrease the current and future implications of natural resource depletion. In the medium and long term, state expenditures in agriculture should be repurposed toward the provision of public goods. Improving market transparency and linkages are other priorities for policymakers to improve market efficiency and allow market participants to respond to existing arbitrage opportunities in a timely manner. Limited domestic market integration exacerbates seasonal price fluctuations and results in Turkish farmers not benefitting from price increases. This reduces their welfare and limits their incentives to invest in productivity-enhancing technologies. The digitalization of agriculture offers great promise to alleviate some of the friction that exists in Turkish value chains and increase the efficiency of agricultural production and distribution. Ultimately, higher productivity growth and more efficient markets would allow for not only stabilizing food prices, but also for making agricultural markets more resilient to any broad-based price pressures that may emerge from additional external shocks, such as climate change variability or the COVID-19 aftermath.

Introduction

Turkish food price inflation has greatly outpaced world price inflation since 2012. A general upward trend in global food prices began in 2006 and reached its peak during 2011, after which prices began to level off. Turkish food price levels, in contrast, kept steadily rising. Between 2012 and 2019 average food prices in the international markets declined by 17 percent while they increased by 130 percent in Turkey.

Domestically, food price development in Turkey is characterized by three interlinked dynamics: domestic food price inflation that is consistently above core inflation; unprocessed foods, particularly, fresh fruits and vegetables, that drive food price inflation; and high food price inflation volatility. In almost all years since 2003, the inflation rate of food and non-alcoholic beverages exhibited a positive divergence from core inflation. Between January 2003 and February 2020, yearly food price inflation averaged 10.6 percent compared to average core inflation of 8.3 percent, and this divergence has increased in recent years. Unprocessed foods exhibit higher inflation levels and volatility than processed foods with the divergence far exceeding those in comparator countries. Food price levels in Turkey have also been increasingly volatile over the past several years. Between 2003 and 2007, average annual food price inflation volatility levels were equal to 0.87 percent (after accounting for seasonality and time trends), while in 2014–2018, the comparable average amounted to 1.25 percent. None of these dynamics are unusual in themselves, what makes them so in the Turkish context is their magnitude when compared to other countries, including the European Union and the United States.

High food price inflation can have a major impact on low-income households that spend a large share of their income on food. A median Turkish household devoted, on average, 20.3 percent of its expenditures to food and non-alcoholic beverages (Turkstat, 2018). This share is higher for low-income groups at 28.7 percent. Rising food price inflation reduces the purchasing power of Turkish households, all else being equal, while increases in price volatility translate into larger fluctuations in purchasing power.

High food prices and volatility also have important consequences for the welfare of producers. Higher agricultural prices can raise farmers' incomes, improve competitiveness and stimulate investment for longer-term economic growth. However, the potentially positive impacts of high prices in the long term depend critically on whether appropriate policies and infrastructure are in place to allow the producers to benefit from higher prices. High price volatility, on the other hand, bears negative implications for producers as it creates uncertainty, and can negatively affects farmers' decisions to invest in productivity improvements.

Rising food price inflation and volatility necessitate an understanding of the mechanics of food price formation in Turkey. The objective of the study is to conduct an in-depth analysis of the main inefficiencies in the Turkish agricultural sector through the lens of food price formation and formulate policy actions to strengthen the sector's competitiveness. This is done through a series of econometric exercises aimed at empirically testing the factors that may be driving food price inflation at the national level. In addition, a deep dive into the price formation and transmission for tomatoes, green peppers, and dry onions—the top three fresh vegetables produced in Turkey—across the country's regions was conducted to identify inefficiencies in these selected value chains that have contributed to rising price levels.

The report is structured as follows: Section One presents an overview of food price dynamics across different agricultural commodities and regions. Section Two analyzes various factors that drive food price inflation in Turkey at the national level, grounded in econometric analyses and a literature review. Section Three includes an in-depth analysis of regional price formation and transmission for tomatoes, green peppers, and dry onions. Section Four presents policy recommendations aimed at tackling the existing inefficiencies in Turkey's agricultural sector that are contributing to rising food prices.

I. Food Price Development – Variations Across Agricultural Products and Regions

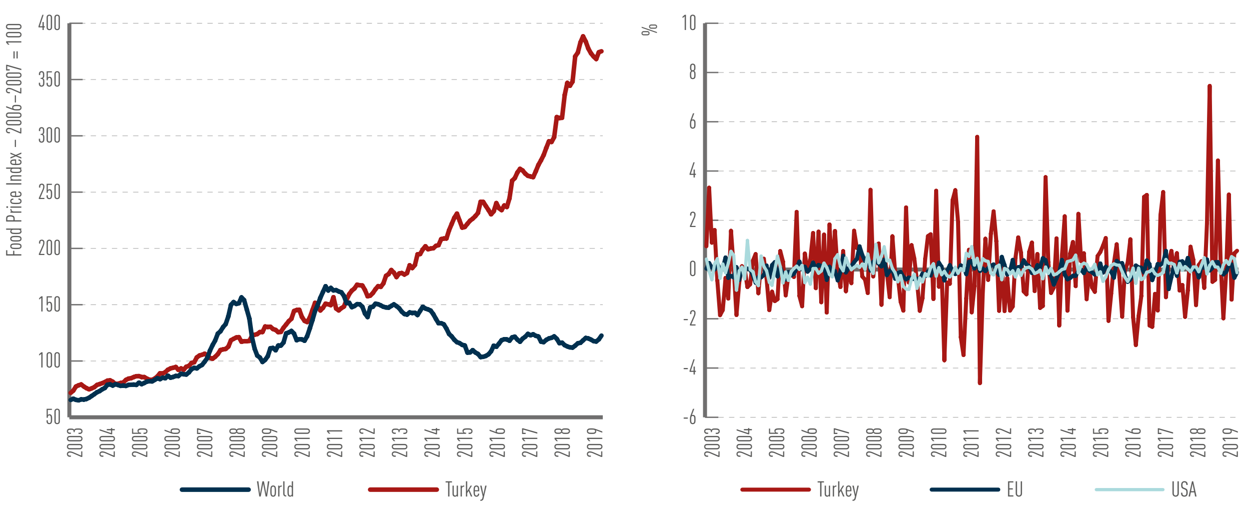
The divergence between Turkish and international food price levels has been increasing, largely driven by the depreciation of the Turkish lira (Figure 1A). During the world price spikes of 2007–2008, international food prices increased by 68 percent on average, compared to 17 percent in Turkey. However, as international food prices returned to their pre-crisis levels by August 2009, Turkish food prices continued to increase. The situation repeated itself during the 2011–2012 international food prices surge. Once again, international food prices increased much faster than those in Turkey, but the subsequent price decline observed in the international markets was not experienced in Turkey. From 2012 to 2019, average food price levels in the international market declined by 17 percent while in Turkey food prices increased by 130 percent. Akcelik et al. (2016) show that the upward trend in food prices in the European Union ended after 2009, whereas in Turkey food prices kept rising. Similarly, since about 2007, Turkish inflation started exhibiting greater volatility compared to both the European Union and the United States (Figure 1B).

A comparison of the growth rates for food price indices with the depreciation of the Turkish lira suggests that the exchange rate has been an important driver of the divergence between Turkish and world prices (Figures 2A and B). Ozmen

Figure 1. **Turkish, European Union and United States Food Price Inflation**

A) Turkish domestic and international food price indices, 2003–2019

B) Monthly change in food price index (de-trended and de-seasoned)

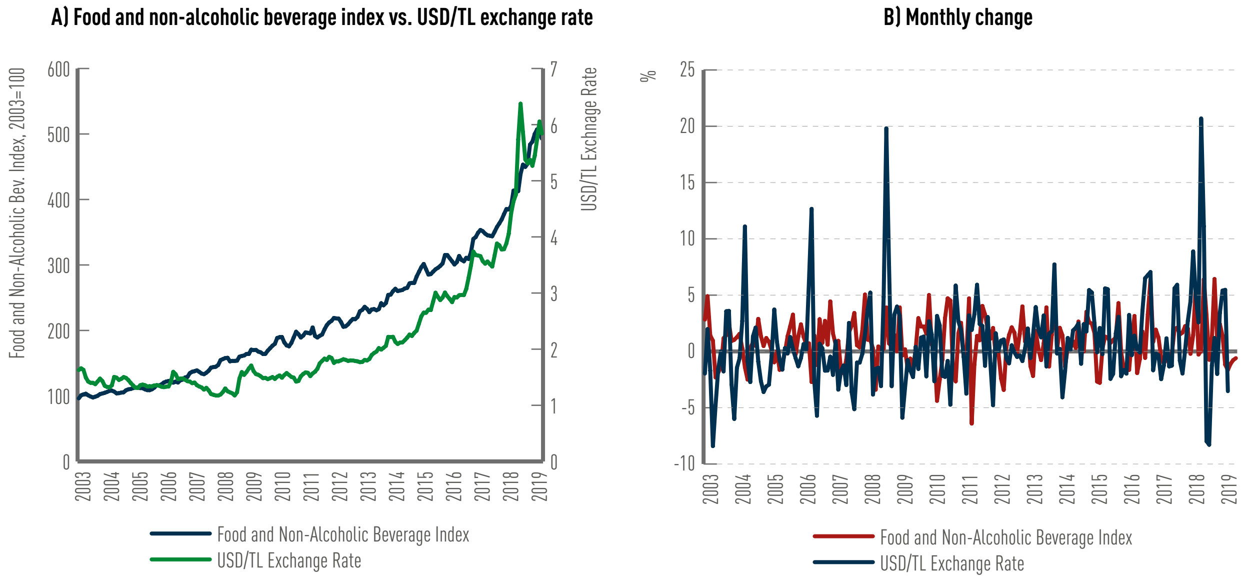


Source: FAOSTAT, 2019

Note: Food price indices are calculated in national currencies.

Source: Cakmakli, C. et al., 2019

Figure 2. **Monthly Food Inflation and USD-TL Exchange Rate Change**



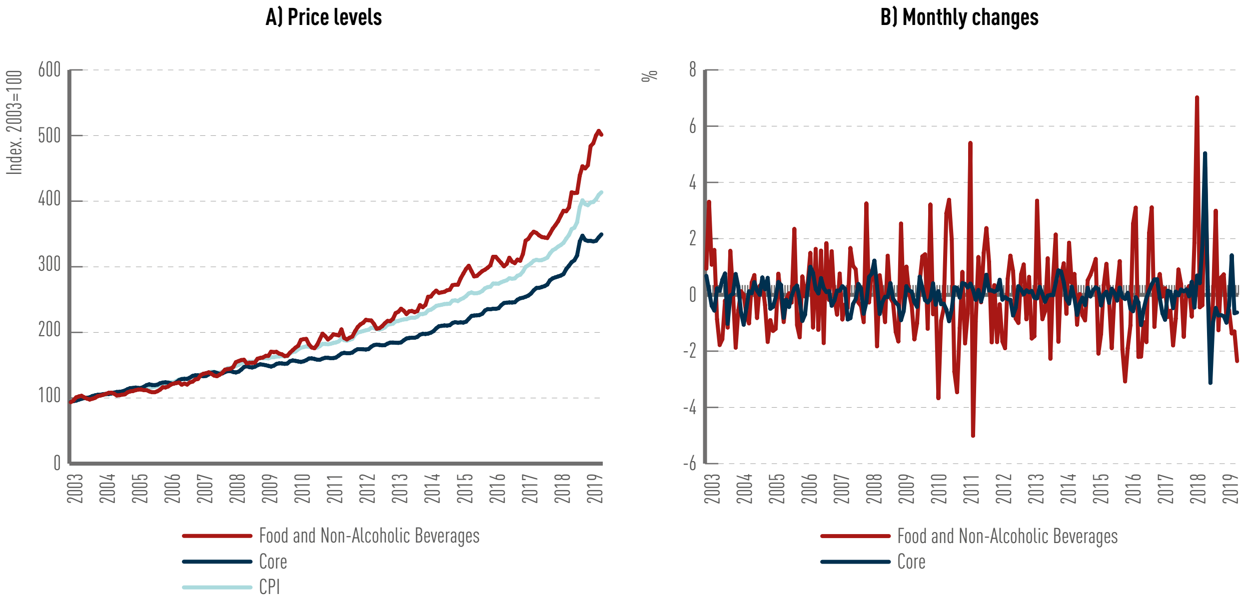
Source: Central Bank of Turkey, 2019

Source: Çakmaklı, C. et al. based on data from the Central Bank of Turkey, 2019

and Topaloglu (2017) analyze the pass-through of import prices and exchange rate into inflation for Turkey over the sample period of 2005–2015 taking the heterogeneous nature of the CPI into account. Their results show that the exchange rate pass-through to processed and unprocessed food prices has been one of the highest (23 and 27 percent, respectively) among CPI components. Campa and Goldberg (2005) provide evidence that countries with higher exchange rate volatility have higher pass-through elasticities of import prices. Two additional studies, Kara and Ögünç (2008, 2012) and Kara et al. (2017), also confirm exchange rate spillovers as significant international sources of inflation in Turkey. Exchange-rate pass-through into food prices can be channeled through both the imports of final food products and of intermediate materials used for production. Between 2012 and 2018, Turkish imports of agri-food products (HS1-24) increased by 19.6 percent, reaching $12.8 billion in 2018. Cereals, oilseeds, and live animals accounted for 44.3 percent of total imports in 2018.

At the same time, Turkey's food prices have been increasing faster and displaying higher volatility than overall prices in the domestic market. Since 2003, Turkey's food and non-alcoholic beverages index—the measure of overall food price inflation used in this report—increased much faster and displayed higher volatility than core inflation and the overall consumer price index (CPI). From 2003 to 2019, food price inflation averaged 10.6 percent, which was higher than core inflation, at 8.3 percent, and headline inflation, at 9.4 percent (Figure 3A). In recent years the divergence has increased. The food sub-index that accounts for 93 percent of the food and non-alcoholic beverages index, is the primary driver behind the increasing divergence from core inflation. Similarly, volatility in food price inflation exceeds volatility in the core inflation index (Figure 3B). After de-trending and de-seasoning the indices, core inflation does not exhibit much volatility over time, except for the wild swings that occurred in September and October 2018 when Turkey experienced a significant currency depreciation. Food price inflation, in contrast, exhibits a much higher volatility and has been increasing over time. The behavior of domestic food prices, when compared to non-food prices in the country, suggest that there are underlying domestic factors that are exerting upward pressure on food price levels and volatility.

Figure 3. **Comparison of Food and Core Price Inflation**



Source: Central Bank of Turkey, 2020

Source: Cakmakli, C. et al., 2019

Food price inflation levels and volatility can vary significantly across regions[1] **within Turkey.** As of June 2019, the aggregate Turkish food price index stood at 501. Regionally, the highest level of food price inflation was observed in Izmir with the highest recorded index level of 552, followed by Artvin, Giresun, Gümüşhane, Ordu, Rize, and Trabzon at 534. The lowest food index was observed in Edirne, Kırklareli, and Tekirdağ at 479.

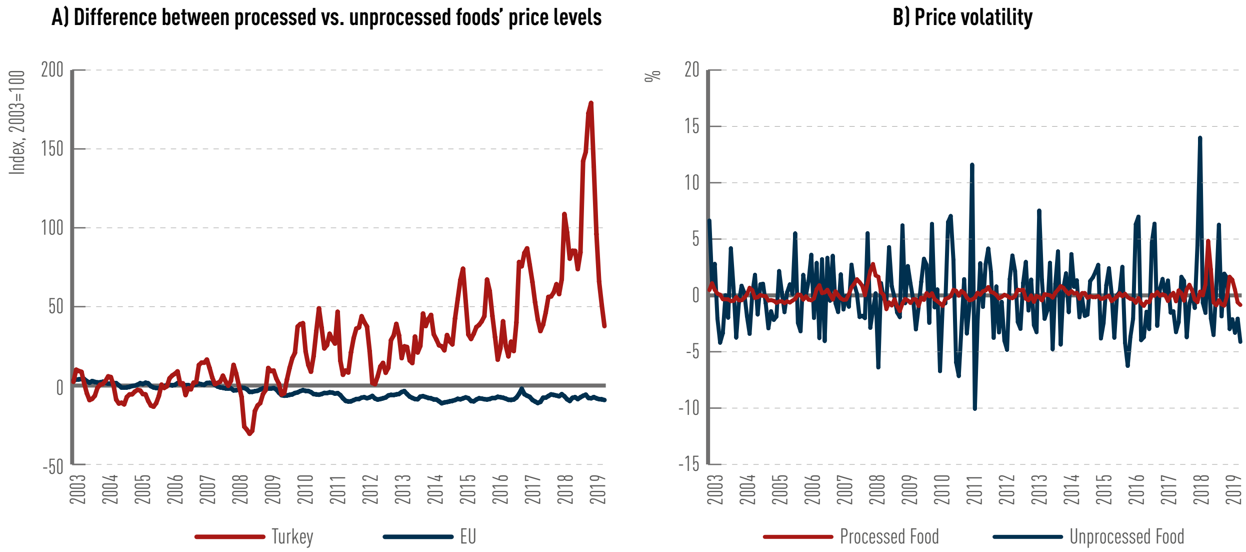
The unprocessed food price index exhibits higher levels and volatility than the processed foods price index (Figure 4B). Between January 2004 and June 2019, yearly unprocessed food price inflation averaged 11.6 percent, compared to 9.9 percent for processed food. The divergence between the two has accelerated since 2017. In addition, monthly changes in the unprocessed food category exhibit greater volatility, even after controlling for trends and seasonality. If compared to the European Union, the divergence in price levels between the two types of food indices is significantly higher for Turkey (Figure 4A).

Within unprocessed foods, fresh fruits and vegetables are driving the volatility (Figure 5). A visual comparison of the price index volatility of fresh fruits and vegetables and other unprocessed foods leads to the conclusion that the variability in fresh fruits and vegetables is driving the overall volatility of unprocessed foods. Hence, understanding the reasons behind the limited transmission of volatility between processed and unprocessed foods may lie in the analysis of the transmission of volatility between processed and unprocessed fruits and vegetables. For fresh tomatoes and green peppers, which this study analyzes in depth, 31.5 percent and 39 percent of production, respectively, goes into processing, while the rest is consumed fresh or exported. Vegetables produced for processing are priced through contract farming arrangements and are less variable, while the price of vegetables for fresh consumption is determined by market forces, resulting in higher price volatility.

Vegetables, fruits and meat push the food index to higher levels. Jointly, these three indices constitute 45.8 percent of the food index (meat: 18.2 percent; vegetables: 18.1 percent; and fruits:

[1] See Appendix 1 for details on Turkish regions (NUTS-2 classification).

Figure 4. **Price Inflation and Volatility of Processed and Unprocessed Food**

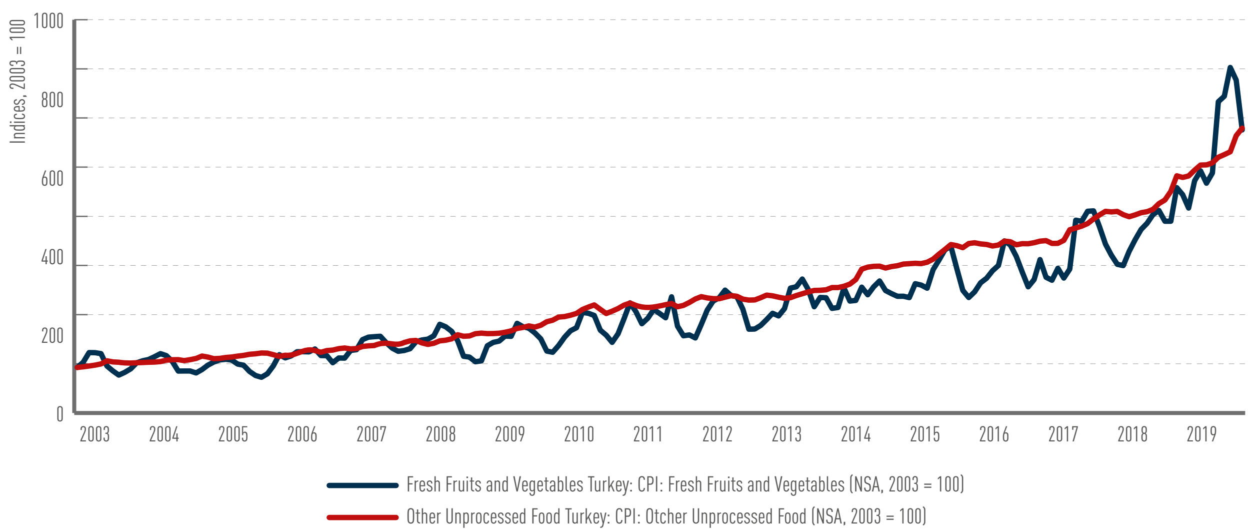


Source: Central Bank of Turkey, 2020

Note: de-trended and de-seasoned

Source: Cakmakli, C. et al., 2019, based on data from the Central Bank of Turkey, 2019

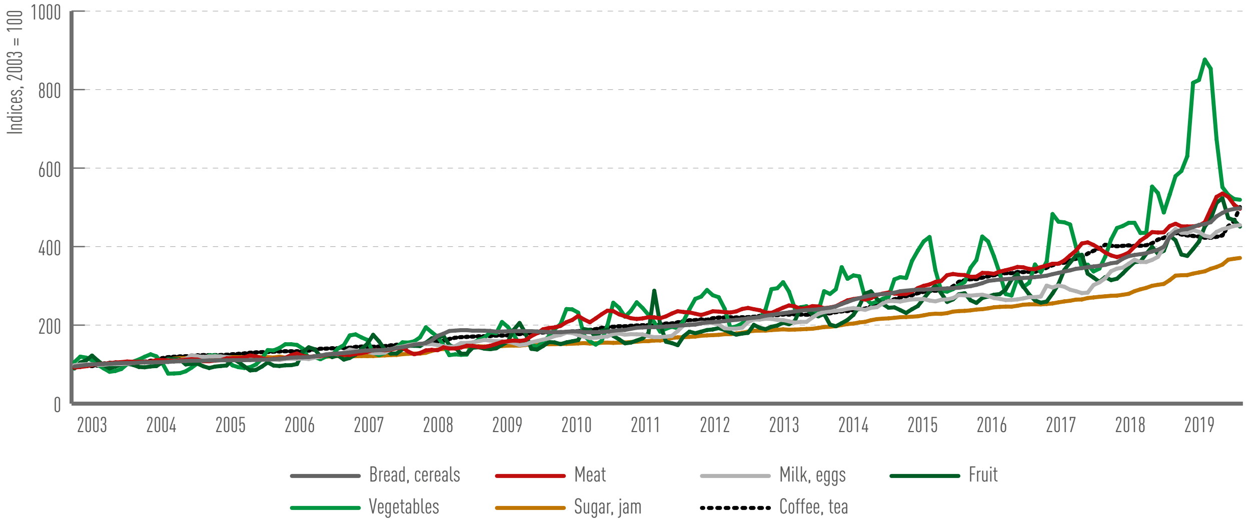
Figure 5. **Price Dynamics of Unprocessed Food Components**



Source: Central Bank of Turkey, 2019

9.5 percent). The lowest price levels are observed for the sugar, jam, honey, chocolate, and confectionery sub-index. On a yearly basis, the major drivers of food inflation vary. In 2006–2007, food price volatility was driven by vegetable and fruit prices, in 2009 by meat prices, and in 2018–2019 by animal products and vegetables. However, all sub-item food prices went up quite sharply in the latter period due to a sharp depreciation in the exchange rate (Figure 6).

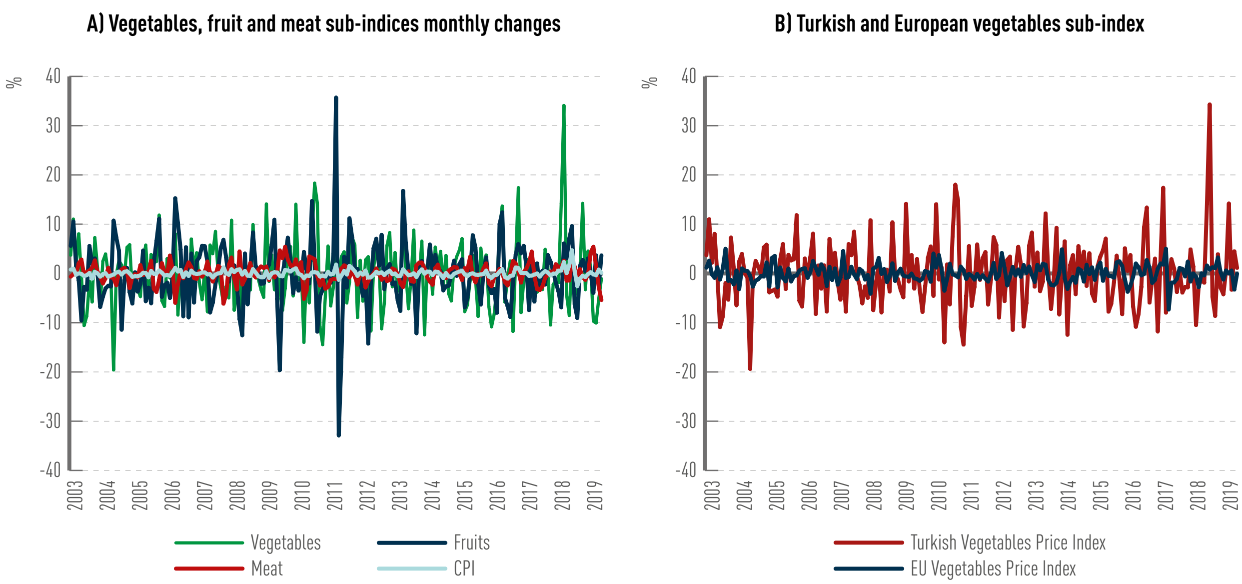
Figure 6. **Dynamics of Food Price Sub-Indices**



Source: Central Bank of Turkey, 2019

Prices for vegetables have been highly volatile when compared to other food groups. Between January 2004 and September 2019, yearly vegetable price inflation averaged 14.0 percent while price inflation for both fruits and meat averaged 10.8 percent, and overall food inflation averaged 10.7 percent. For vegetables, the highest year-on-year inflation levels were observed in April 2019 (96.3 percent), March 2019 (90.2 percent), and January 2019 (80.6 percent).

Figure 7. **Food Price Volatility Dynamics**



Note: de-trended and de-seasoned.

Source: Central Bank of Turkey, 2020

Note: de-trended and de-seasoned.

Source: Cakmakli, C. et al., 2019, based on data from the Central Bank of Turkey, 2019

The highest month-on-month changes in the vegetable sub-index occurred in January 2017 (33.5 percent), January 2019 (29.7 percent), and September 2018 (29.0 percent). For fruits, the highest monthly changes occurred in May 2011 (60.7 percent), May 2006 (31.0 percent), and May 2009 (19.2 percent). These numbers are very high for monthly inflation levels. After 2013, monthly volatility in fruit prices decreased while volatility in vegetable prices increased, indicating that vegetable products are the main driver of the variation observed in overall food inflation (Figure 7A). Vegetable prices in Turkey show a more pronounced volatility as compared to price variations in the European Union (Figure 7B). The price swings first increased after 2009 and became more pronounced after 2016.

Fresh vegetables such as tomatoes, cucumbers, and dry onions have the highest weights in this sub-index and therefore determine most of the increases in vegetable prices. The vegetable sub-index consists of 34 products. Vegetables with the highest weights (2019 est.) include (weights in the CPI basket are shown in parenthesis) tomatoes (0.82), potatoes (0.51), cucumbers (0.30), onions (0.23), and green peppers (0.19). Many vegetables have recorded very high annual changes, in some cases surpassing 100 percent. These price changes, in return, affect the inflation rate in Turkey. For instance, a 100-percent increase in tomato prices translates to an approximate 0.815-percent increase in the overall inflation level. Vegetable prices also vary significantly from region to region and price dispersion increases over time. For example, in May 2019, tomato prices ranged from Turkish lira 4 (TL) to TL 5.4 per kilogram (kg), potato prices ranged from TL 3.8 per kg to TL 5.1 per kg, cucumber prices ranged from TL 2.3 per kg to TL 4.1 per kg, and onion prices ranged from TL 2.6 per kg to TL 4.4 per kg across different regions (TURKSTAT, 2020).

II. Drivers of Food Price Inflation

Demand and supply dynamics in the agriculture sector determine the stability of food prices. Due to the nature of agricultural production, price stability requires that either demand or supply are elastic. Generally, for any given geographic region, there are relatively few shifts in the demand function in the short run, although exceptions exist stemming from speculative behavior or policy interventions. Market prices are generally influenced by the supply function that is shaped by long-term, less variable drivers or short-term dynamics due to, for example, the seasonality of production and weather patterns. Table 1 summarizes key supply and demand drivers of food prices according to their predictability, such as whether the drivers are low variance and easy to predict or high variance and difficult to predict. Low variance drivers evolve over time and affect food supply and demand in the long run. On the supply side, these center around factors determining productivity in the sector, including investments in research and development (R&D), level of depletion of natural resources, climate change patterns, and an overall approach to agricultural and trade policies. Population and income growth as well as dietary changes and tastes, such as increasing consumption of proteins and vegetables, determine long-term demand-side pressures.

High variance drivers of food prices are more of a short-term nature and, hence, have the potential to change price formation equations rapidly and unexpectedly. These have mainly to do with the inherent to agriculture production variability due to weather conditions, seasonality, pests and diseases, or a human factor, such as short-term policy interventions in the sector or trade, speculative behavior in the market or hoarding.

Table 1. **Supply and Demand Drivers of Food Prices**

	Supply	Demand
Low variance	Research and development Productivity levels Climate change Environmental sustainability Agricultural and trade policies (long-term)	Population growth Income growth Dietary changes and tastes
High variance	Weather Seasonality of production Pests and diseases Input costs Agricultural and trade policies (short-term) Imports	Speculation Panic or hoarding Government trade and inventory policies Exports

Source: Adapted from Timmer (2018)

Variability in trade both on the import and export sides can further contribute to short-term fluctuations in the supply of and demand for food. The remainder of the section focuses on the key supply and demand drivers of food price formation in the context of Turkey's rising food price inflation levels.

Long-run demand drivers

On the demand side, growing population in Turkey has been the key driver behind the long-run food demand growth. Turkey's population has grown by 10.5 million people over the past ten years. Between 2012 and 2019, Turkey has also welcomed approximately 3.7 million refugees, representing an increase in total population of 4.5 percent. Consequently, overall demand for food has increased in Turkey. Turkish consumers, following global trends, have also increased their demand for healthier foods, such as fresh vegetables. Between 2010/11 and 2018/19, per capita consumption of vegetables increased from 269 kg to 274 kg, and of fruits – from 93 to 99 kg.

A second component of demand—agri-food exports—rose by 15.9 percent between 2012 and 2018 and reached a total value of $17.7 billion. Turkey is a net exporter of agricultural products with a strong net positive position for processed foods (Figure 8). Between 2005 and 2011, the value of agri-food exports grew by 11 percent annually while food price levels were relatively stable. Between 2012 and 2019 export value growth decreased to only 3.1 percent, likely driven by currency depreciation with unprocessed exports growing faster than processed exports. However, in terms of volume, exports doubled between the 2010/11 and 2018/19 marketing years. The fastest growth in exports was observed for unprocessed foods, such as oilseeds, pulses and cereals; vegetable exports increased by 15 percent during this period. However, exports of tomatoes, a vegetable playing an important role in food price inflation growth, increased only slightly between 2010/11 and 2018/19 from 1.1 million tons to 1.2 million tons (UN COMTRADE, 2020).

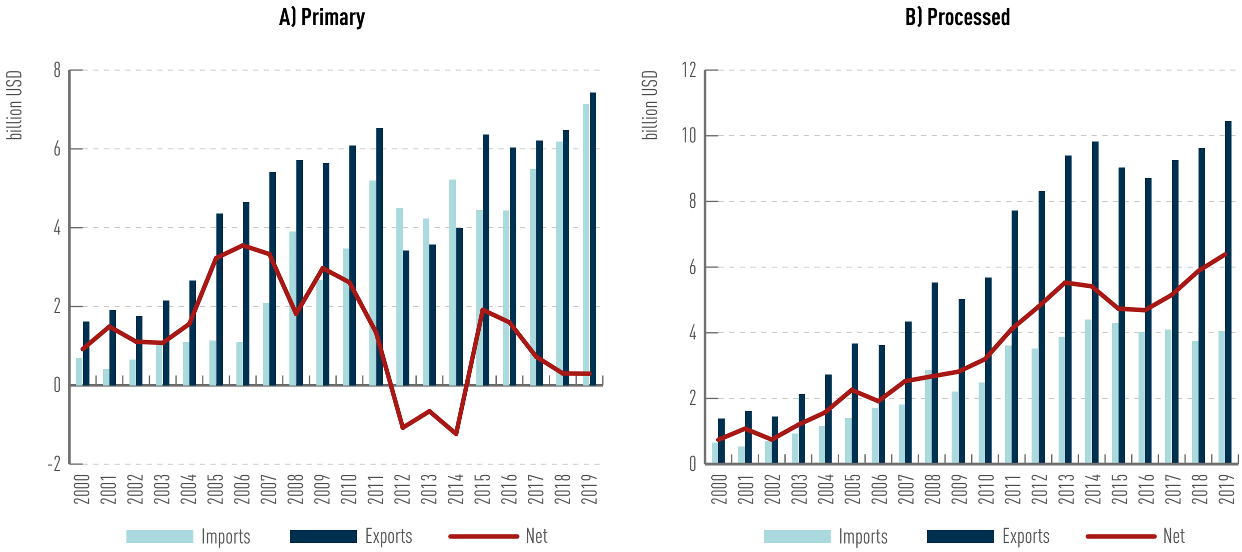
Productivity levels

Low productivity levels constrain food supply growth. Despite increasing since 2010, per capita food supply remains below the levels recorded in the mid-1990s, putting pressure on food prices. Both low agricultural productivity levels and high levels of import protection contribute to such dynamics. Research shows that there is a strong link between land productivity and food price inflation; food price inflation is lower in provinces where land productivity growth is higher (Table 2).

Land productivity and the consumer price of tomatoes and dry onions in Turkey are negatively correlated (Figure 9). Provinces where productivity is higher had lower producer prices. Differences in productivity could be associated with quality, but the data do not allow for the identification of variations in quality of tomatoes across regions in Turkey. As discussed in the next section of the report, tomato, green pepper, and onion yields in Turkey are much lower than in comparator countries—increases in yields can help balance vegetable price growth.

Labor productivity is also low in the country. The productivity gap between workers in

Figure 8. **Processed vs. Primary Food Trade, Billion USD**



Source: UN COMTRADE, 2020

agriculture and in other sectors in Turkey is high, particularly given the level of Turkey's economic development. As shown in Table 3, the ratio of labor productivity in agriculture relative to the service sector stood at only 34 percent in Turkey, based on 2012–2016 averages. This is much less than in countries such as Russia and Ukraine as well as many European Union countries.

In Turkey, agricultural producers do not always receive market price changes or competitive pressures, which results in low incentives for them to invest in productivity growth. The extent to which policies create disincentives for producers to change their production practices can be gauged by looking at the importance of the mix of policy instruments used in agriculture. In Turkey, the producer support estimate[2] as a percentage of gross farm receipts is close to 15 percent (Figure 10), which is lower than in the European Union. But in terms of the instrument mix, agricultural support in the country is skewed towards measures which may distort the market—payments based on outputs and on input use. These are designated as area-based payments as described in the next section of the report. Such payments account for more than 62 percent of total support payments in agriculture. By comparison, the comparable share in the European Union is 18 percent and 38 percent in the United States.

Table 2. **Impact of Land Productivity on Food Price Inflation**

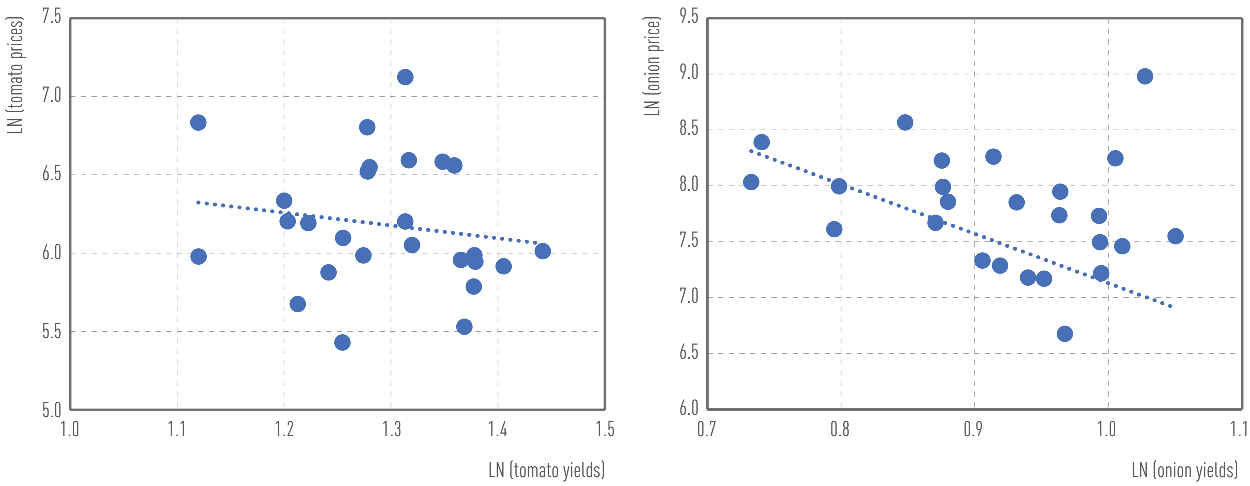
	(1)	(4)
Land productivity	-0.307***	-0.318***
	[0.039]	[0.039]
Non-food consumer price index (%)	0.349**	0.338**
	[0.132]	[0.133]
Agriculture as a % of total land area		-5.560
		[6.343]
Constant	2.191**	3.574*
	[1.017]	[1.988]
Observations	312	312

Notes: Standard errors in brackets, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Dependent variable: Food price inflation. Fixed-effects estimates using NUTS2 data MOFAL and TURKSTAT from 2005 to 2016. The model includes time dummies.

Source: World Bank (2018)

Figure 9. **Correlation Between Consumer Prices and Productivity Levels for Tomatoes and Dry Onions**



Source: Authors

2 The producer support estimate is an indicator of the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm gate level, arising from policy measures that support agriculture, regardless of their nature, objectives, or impacts on farm production or income.

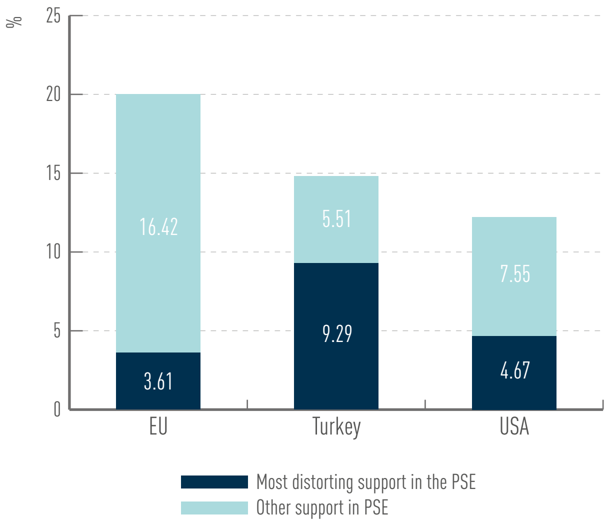
Table 3: **Relative Labor Productivity in Service and Industry Sectors, Selected Countries**

Country/Region	Agriculture/Service	Agriculture/ Industry	Per capita GDP
Europe & Central Asia average	0.22	0.24	24,505
Greece	0.27	0.33	22,599
Turkey	0.34	0.36	13,249
Italy	0.51	0.63	34,135
France	0.57	0.65	41,522
Ukraine	0.59	0.67	3,034
Russian Federation	0.66	0.49	11,542
Spain	0.66	0.55	29,991
Hungary	0.74	0.79	14,090
Netherlands	0.85	0.63	50,872

Note: Based on average values, 2012–2016. Value-added are expressed in $ (2010=100).

Source: WDI (2018).

Figure 10. **Producer Support Estimate as % of Gross Farm Receipts**



Source: OECD, 2020

There exists room for improvement in investments in R&D and other public goods in agriculture to further increase productivity growth potential. Currently, Turkey spends less than one percent of its aggregate value of agricultural production on the General Services Support Expenditures[3] (GSSE) (Figure 11). The main element is financing the development and maintenance of infrastructure, which accounts for approximately 75 percent of the GSSE. At the same time, while expenditure for the agricultural knowledge and innovation system increased in the last decade, its share in GSSE expenditure has remained around 5 percent during the 2016–2018 period.

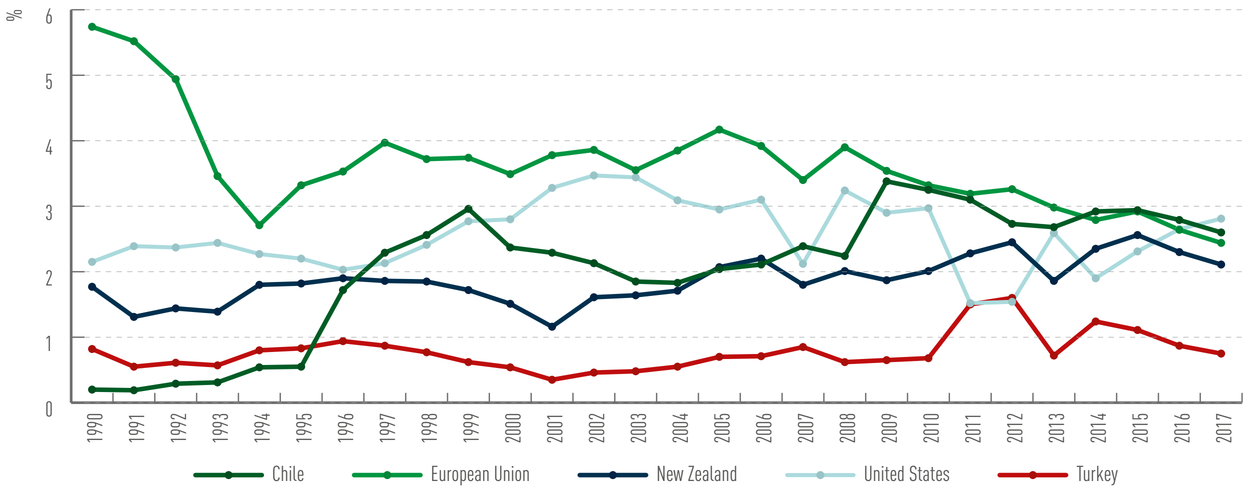
Another risk factor for productivity growth potential is the depletion of natural resources, particularly in the context of climate change. Many regions in Turkey suffer from high levels of soil erosion (Figure 12) and high levels of water stress (Figure 13). Both have negative implications for yields. For example, the correlation between yields and levels of soil erosion in Turkey (per estimates in Figure 12) are -.30 for tomatoes, -.29 for onions, and -.21 for green peppers.

Input prices

Rising input costs have caused the producer price index (PPI) of agricultural products to increase faster than overall prices in Turkey.

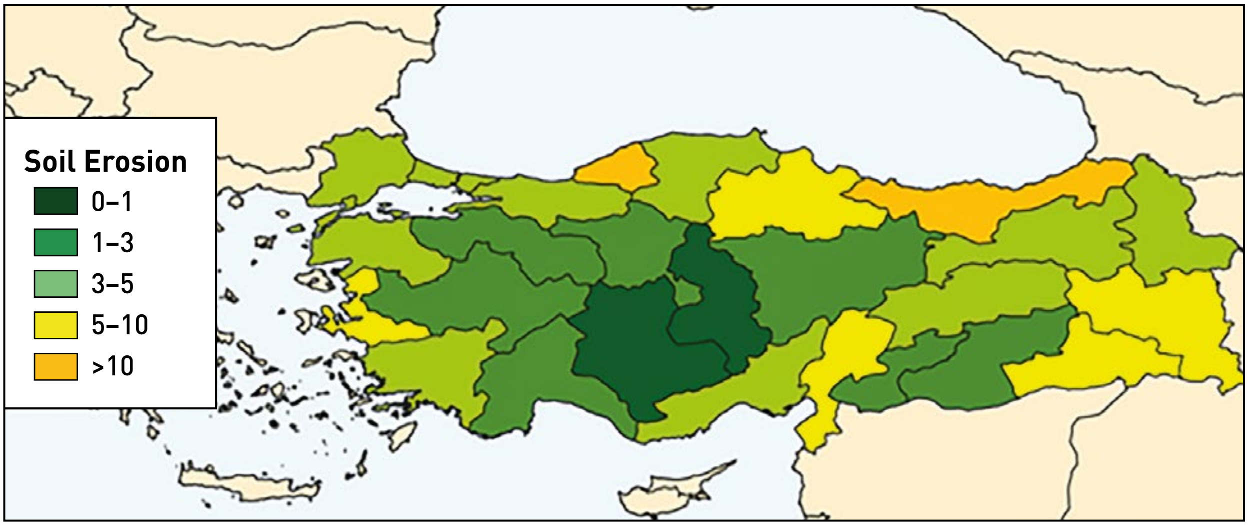
[3] The General Services Support Estimate (GSSE) is an indicator of the annual monetary value of gross transfers to services provided collectively to agriculture and arising from policy measures which support agriculture, regardless of their nature, objectives, and impacts on farm production, income, or consumption of farm products.

Figure 11. **GSSE to Agriculture Relative to the Aggregate Value of Agricultural Production**



Source: OECD, 2020

Figure 12. **The Spatial Pattern of Soil Erosion Across Regions, Mg/Ha per Year**



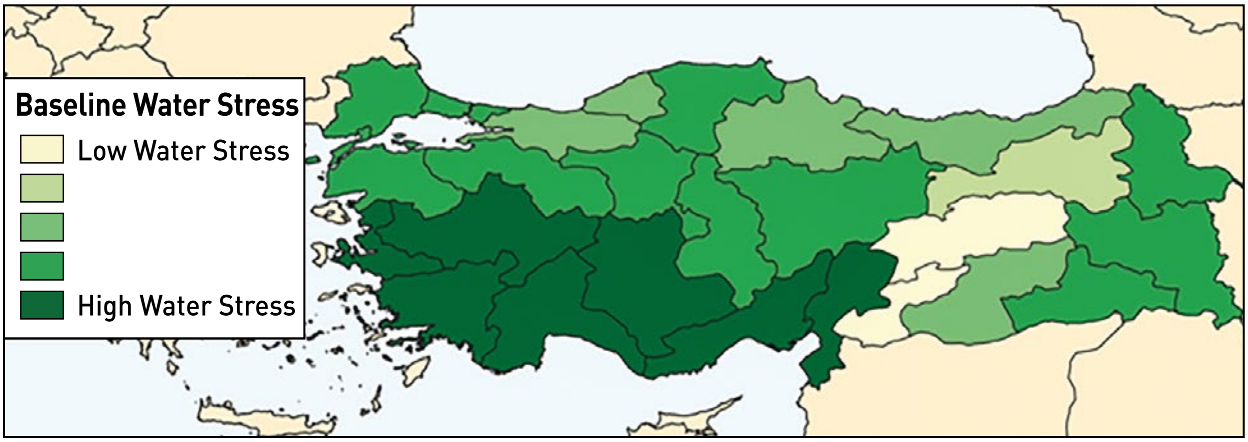
Note: for methodology of soil erosion assessment, see Borrelli et al. (2013). https://www.nature.com/articles/s41467-017-02142-7

Source: Authors, using Global Soil Erosion data from the Joint Research Centre of the European Commission

From 2003 to 2017, the PPI of agricultural products increased on average 8.2 percent per year as compared to the food and non-alcoholic beverages index that increased by 7 percent (Figure 14). Monthly changes in the agricultural PPI and the food price index are strongly correlated.

Prices of agricultural inputs have a strong positive effect on food price increases in Turkey. Research by Eren et al. (2017), who utilized a panel vector autoregressive VAR model to investigate the impact of producer prices, quantity of production, and export and import quantities on consumer food prices, suggests that

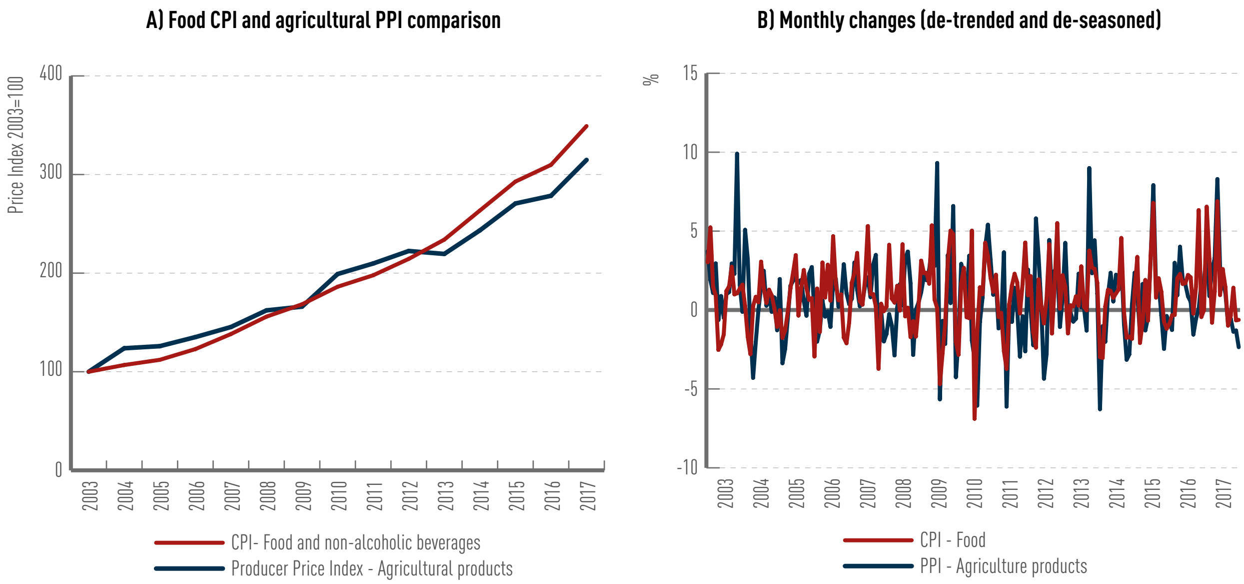
***Figure 13.* Water Stress Assessment Across Regions**[4]



Note: for more detailed methodology on water risk indicators, see Hofste et al. (2019).[5]

Source: Authors, using data from Hofste et al. (2019)

***Figure 14.* Comparison of Agricultural PPI and Food Price Index**



Source: Central Bank of Turkey, 2017

consumer food prices are affected mostly by producer prices and quantity of production supplied to the domestic market over the 1996–2016 period. Earlier research by Ciplak and Yucel (2004) that applied VAR to examine the relationship between agricultural and consumer prices in

[4] This data set shows the percentage of total crop production in areas facing different levels of water stress. Crop production data is overlaid with the baseline water stress indicator, a measure of demand and supply for water in a given area.

[5] https://www.wri.org/publication/aqueduct-30

Turkey over the 1994–2003 period also suggests that a 10-percent increase in agricultural prices resulted in a 5.1-percent increase in food prices within six months.

The causality between rising prices of agricultural inputs and rising food prices can be explained by growing demand for inputs and their share in production costs. Between 2015 and 2017, the use of pesticides increased by 38.6 percent, from 39,000 tons to 54,000 tons. The use of chemical fertilizers per hectare of land increased by 24 percent during 2016–2017. In the cost structure of tomatoes, fuel/electricity, seedlings, fertilizer, and pesticides account for 48.5 percent of total production costs (Table 4). Interviews with farmers showed that there are no problems in terms of availability of quality inputs in the country (EBRD, 2018). It is rather the issue of access that constitutes a serious problem for them. Input prices tend to change almost immediately with exchange-rate changes and energy price fluctuations, confirming high levels of exchange-rate pass-through into the inputs markets as discussed earlier. As input sellers are well-organized in the form of associations, they pass on price increases to farmers, but not price decreases. Overall, input prices globally tend to grow faster than prices of agricultural and food products. And while collective action may help decrease the level of input price pass-through from input dealers to farmers, a more robust strategy for farmers to deal with rising input prices would be to increase agricultural productivity, as global practice shows.

The Turkey Economic Monitor (October 2019) highlights that producer prices tend to be more responsive to exchange rate movements compared to consumer prices. Currency depreciation can lead to higher producer prices, which, in turn, tend to be passed on to consumers to recover the producers' costs. On average, the pass-through from producer prices to consumer prices in Turkey has increased in recent years from 35 percent in 2003–2013 to 48 percent in 2013–2019. Overall, Turkey is import-dependent for most of the major agricultural inputs used in production—fertilizer, chemicals, animal feed, fuel, and machinery. For example, between 2013 and 2018, fertilizer imports (HS 31) on average accounted for $1.2 billion, with an average trade deficit for fertilizer in the same period of $1.1 billion. Similarly, over the same period, the import value of insecticides (HS 3808) was $313 million with a trade deficit of $238 million. In 2017, Turkey imported 85 percent of its total chemical fertilizer consumption with 74 percent of total fertilizer imports being nitrogen-based fertilizers. Machinery and equipment in the agriculture sector are also affected by exchange rate volatility due to their high imported input material content. Finally, both currency depreciation and the rise in international oil prices fed into diesel and gasoline prices that, in turn, translated into higher expenses for farmers.

Table 4. **Tomato Cost Structure, TL/Ton**

Cost element	Average amount	Share in total cost, %
Energy (Fuel/Electricity)	19.01	10.55
Female labor	39.75	22.06
Male labor	15.22	8.45
Fertilizer cost	22.77	12.63
Seedling cost	35.91	19.93
Pesticides cost	9.69	5.38
Water price and amortization	7.98	4.43
Land rent	29.88	16.58
Total Production Cost	**180.22**	**100.00**

Source: EBRD, 2018

Import protection policies

Turkish agri-food products have historically been the most protected group of goods in the country, resulting in upward pressure on the food supply (Table 5). Animal products[6] have experienced the highest applied most-favored nation (MFN)[7,8] tariff rates, ranging from 121.5 percent in 2010 to 28.5 percent in 2018. Vegetables[9] are the second most protected category. In 2018, the applied MFN tariff rate on vegetables accounted for 23.5 percent; for tomatoes it was even higher at 48.6 percent. The applied MFN tariff rate for food products[10] other than for animal products and vegetables is lower but above MFN rates for other product (non-food) groups. Similar dynamics are observed in the Turkish fruit markets. Ad valorem tariff[11] rates are higher for fruit products compared to vegetables. The highest applied tariff is for bananas, at 146 percent. Most other major fruits such as apples, melons, citrus fruits, and grapes have tariff levels ranging from 54 percent to 86 percent. Nuts have a relatively lower tariff rate among these products.

Turkey's agricultural markets are also among the most protected in the world. Turkey has historically had high import tariffs on vegetables (Figure 15)[12,13] The difference between the MFN rates for vegetables imposed by Turkey and other regions around the world consistently increased between 2009 and 2018, when Turkey lowered its applied MFN rate. For example, in 2013, Turkey's rate was 49 percentage points higher than the average for the North American countries. While empirically, it is difficult to establish the causality between the price levels for selected food products and the level of import tariffs, fruits and vegetables that have high applied MFN rates also exhibit higher than average price levels in Turkey. As an example, tomatoes, onions, cucumbers, and potatoes, which drive price inflation for vegetables, have an average applied MFN rate of 36.8 percent, as compared to an average rate of 25.7 percent applied to all vegetables (HS group 17). While Turkey is a net exporter of many agricultural products, import restrictions make the supply curve less elastic, leading to more variable price responses. Furthermore, the price impact that stems from seasonal shortages of various agricultural products, such as

Table 5. **Product Groups with the Highest MFN Tariff Rates Applied by Turkey, 2005–2018**

Product group	2005	2010	2013	2018
Animals	53.7	121.5	56.2	28.5
Vegetables	22.5	26.5	51.5	23.5
Food products	15.7	15.1	13.4	17.3
Footwear	11.6	11.0	11.4	12.0
All others	<10	<10	<10	<10

Source: WITS, 2019

6 HS 01-05.

7 The applied MFN tariff is a normal non-discriminatory tariff charged by one World Trade Organization (WTO) member on imports from other WTO members (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas).

8 Most-favored-nation treatment (GATT Article I, GATS Article II and TRIPS Article 4), the principle of not discriminating between one's trading partners.

9 HS 06-15.

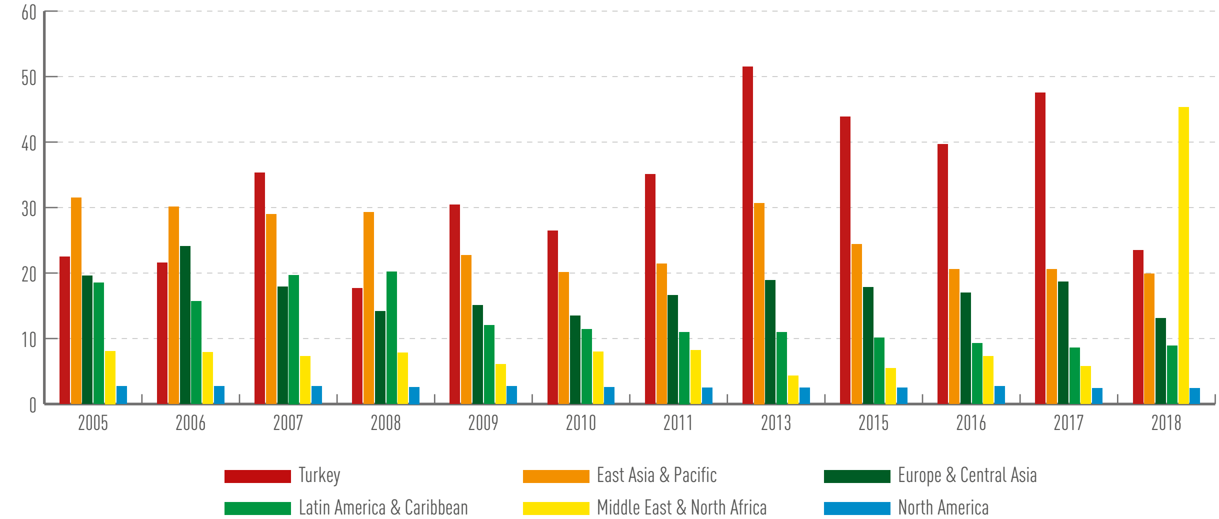
10 HS 16-24.

11 Ad valorem tariff measures tariff rate charged as percentage of the price.

12 Data for 2012 and 2014 is not available for Turkey.

13 The Europe and Central Asian region includes Turkey.

Figure 15. **MFN Rates Applied to Vegetable Imports**

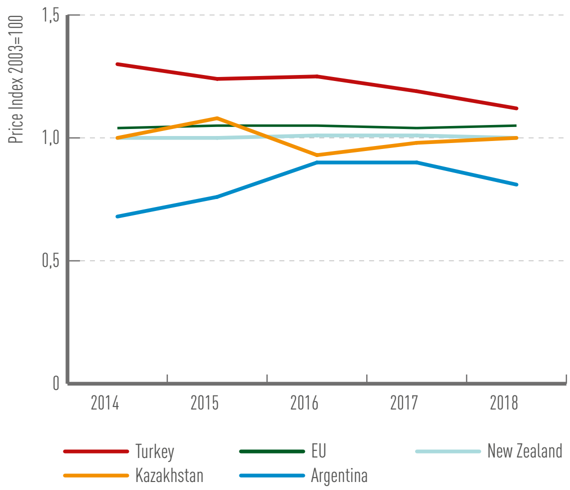


Source: WITS, 2019

vegetables or fruits, may be exacerbated by restrictions on the import side.

Over the long run, import protection may have significant impact on the efficiency and competitiveness of the sector, as it shields domestic producers from the need to respond to competitive pressures. The extent to which domestic producers are protected from international price fluctuations can be measured by a nominal protection coefficient (NPC) that is measured as the ratio between the average price received by producers (measured at the farm gate), including net payments per unit of current output, and the border price (measured at the farm gate). In Turkey, was 1.12 (2018 est.), which suggests that Turkish farmers, overall, received prices that were 12 percent above international market levels. While the NPC in Turkey has been gradually decreasing over time, it remains higher than in comparator countries (Figure 16).

Figure 16. **Nominal Protection Coefficients Comparison**



Source: OECD, 2020

III. Regional Price Formation and Transmission: The Case of Table Tomatoes, Green Peppers and Onions

Vegetable price index levels have been much higher than all the other food indices, particularly after mid-2018, and have been driving the overall food price index up. To understand the drivers of price inflation for vegetables, an in-depth analysis of the price formation and transmission for table tomatoes, green peppers, and dry onions[14] (the most produced fresh vegetables in Turkey) has been undertaken across country regions to identify inefficiencies in these selected value chains, and how these have contributed to rising price levels.

Overview of Price Dynamics for Table Tomatoes, Green Peppers and Dry Onions

Table tomatoes

Between 2005 and 2019 tomato prices have increased fivefold with growing monthly fluctuations in recent years (TURKSTAT, 2020). Tomato prices have increased from TL 1.5 per kg in January 2005 to TL 4.8 per kg in May 2019, with a peak price of TL 6.7 in April 2019. Overall, the price growth has accelerated since November 2017. Monthly fluctuations measuring year-to-year changes have also been significant for tomatoes during the analyzed period, ranging from -50 to 117 percent,[15] and have increased since November 2017 with an average monthly change of 54 percent (between November 2017 and May 2019), as compared to 13 percent between June 2008 and October 2017.

Tomato price variation can be significant across the regions of Turkey, with price levels and volatility negatively correlated with production levels. Tomato prices vary from region to region, ranging from 4 TL per kg to 5.1 TL per kg (May 2018–April 2019 average) (Figure 17[16]). Some of these price differences can be attributed to transportation costs, however, a visual analysis of prices across regions does not support the notion that transport prices are the sole reason for regional price differences. Overall, prices increase from South to North and the peak values are observed in the Northeast and Northwest. The opposite pattern is observed when we look at tomato production, with South and Southwestern cities producing the bulk of tomatoes. A negative correlation is observed between production and price levels (-0.17) and between production levels and price volatility (-0.30). It is also informative to look at the price changes at the highest point in the last year (between May 2018 and April 2019) which occurred in January 2019. Overall, prices increased around 51 percent during that month, but regional price increases were between 36.9 percent and 65.3 percent, with the highest increase in the tomato deficit regions of Erzurum, Izmir and Gaziantep.

Green peppers

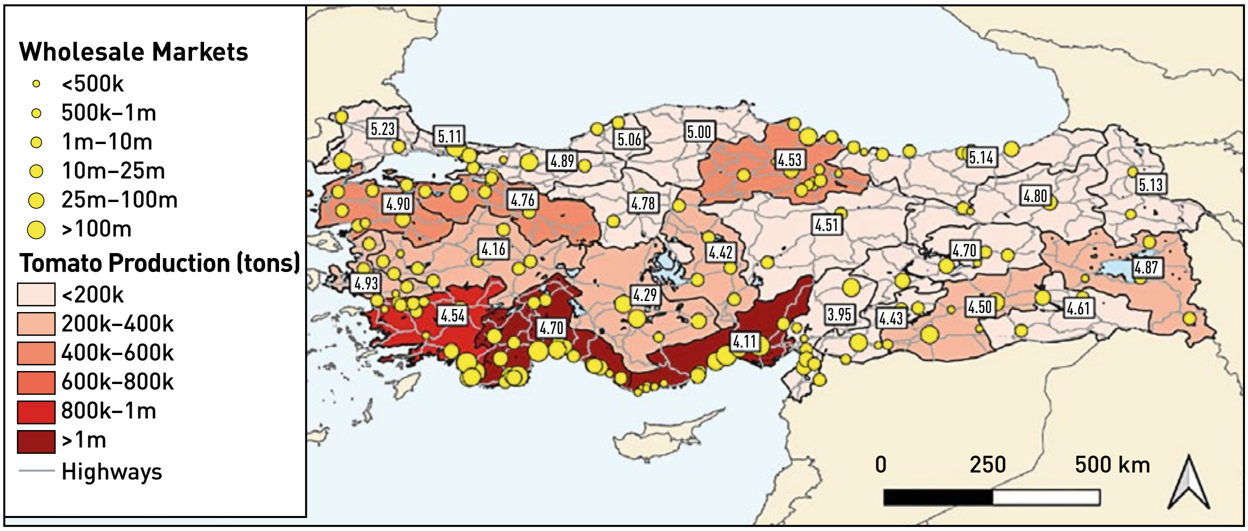
Green pepper prices have been increasing at a slower rate compared to tomato prices, but have been more volatile. Since 2005 green pepper prices increased from 1.34 TL per kg in

[14] The report focuses on table tomatoes, green peppers, and dry onions for fresh consumption. Jointly these vegetables account for 50 percent (or 12.8 million tons) of fresh vegetable production (2019 est.) in Turkey.

[15] Not including the price spike in October 2010.

[16] See Appendix 8 for additional details.

Figure 17. **Regional Differences in Tomato Prices**



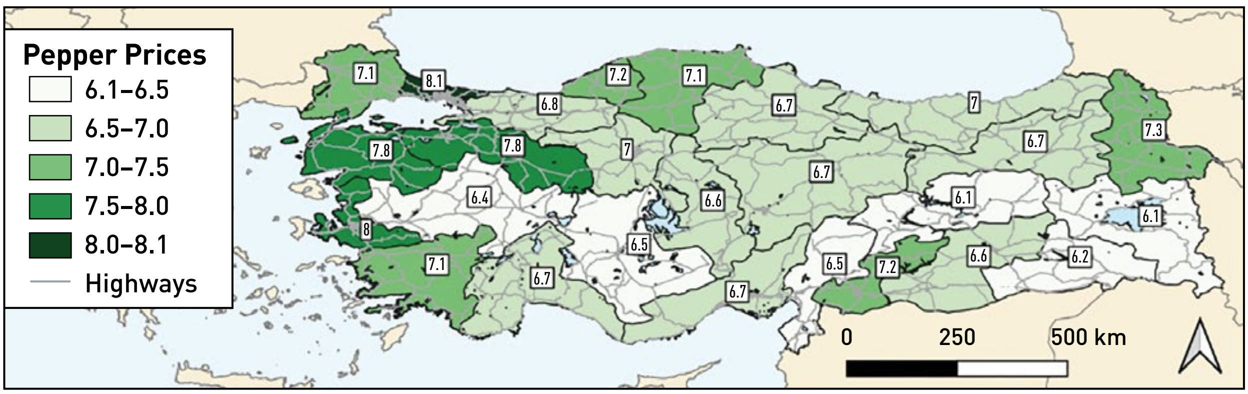
Note: Numbers on the map reflect average tomato prices during May 2018–April 2019.

Source: Authors, based on statistics from TURKSTAT

January 2005 to 4.57 TL per kg in May 2019. However, prices experienced a significant spike between January and April 2019, reaching on average 11 TL per kg. In general, price growth has accelerated since about January 2017.

There is also a significant price variation in green peppers across regions (Figure 18). Between May 2018 and April 2019, average prices for green peppers across the regions ranged from 5.78 TL per kg in Malatya to 7.31 TL per kg in Istanbul. Unlike in the case of tomatoes, there is no significant correlation between production and price levels; however, there is a strong positive correlation (0.45) between consumption estimates and price levels. Just as in the case of tomatoes, analysis of the price changes during March 2019, when the highest prices were observed, show that price changes are uneven across the regions. In March 2019, prices on average increased by

Figure 18. **Regional Differences in Green Pepper Prices (Sivri Variety)**



Note: Numbers on the map reflect average green pepper prices during May 2018–April 2019.

Source: Authors, based on statistics from TURKSTAT

32.3 percent, ranging from a 20-percent increase in Hatay to a 48-percent increase in Malatya.

Dry onions

Dry onion prices have increased drastically since June 2018. Between January 2005 and May 2019, onion prices increased from TL 0.4 to TL 3.3 per kg. The peak in price levels was observed in April 2019 at TL 5.9 per kg. The fluctuation in onion prices significantly increased in 2018 with overall monthly changes ranging from 50 percent to 80 percent. Overall, onion prices are much less volatile than those of table tomatoes and green peppers.

Regional variability in prices also exists for dry onions, as in the case of tomatoes and green peppers (Figure 19). Between May 2018 and April 2019, onion prices ranged from TL 2.6 to TL 4.4 per kg. Prices were higher in Western and Northeastern Anatolia. There is a strong negative correlation between production volumes and prices and between production volumes and price volatility, -0.38 and -0.44, respectively. In June 2018, when the highest average price increase of close to 83 percent was observed, regional price increases ranged from 61 percent to 105 percent. The largest price increase was observed in the Balıkesir region (104.6 percent), followed by the Aydın and Muğla regions. The lowest price increase of 61 percent was observed in Ağrı. Other regions in Eastern Anatolia also exhibited relatively lower increases.

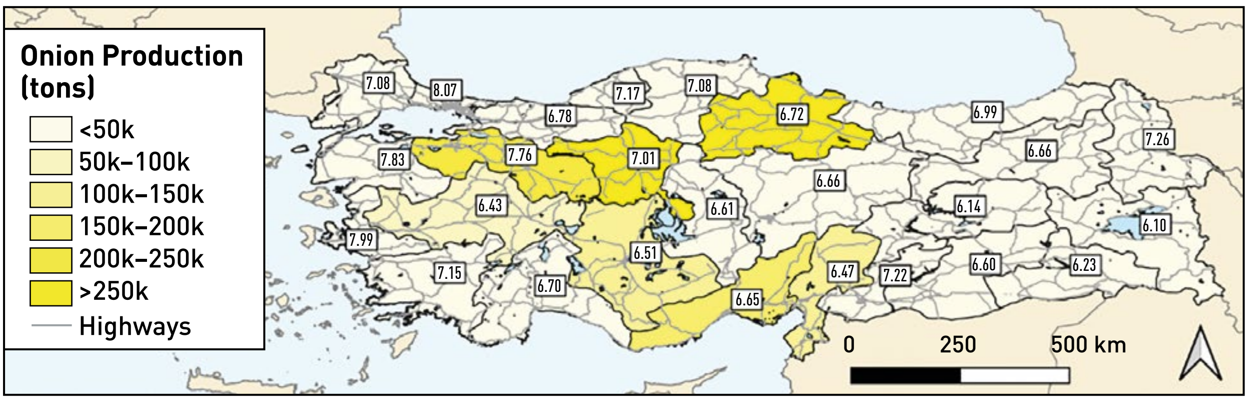
Between 2005 and 2018, price dispersion[17] **across the regions has steadily increased for all three vegetables**—from 0.18 to 0.61 for green peppers, 0.14 to 0.43 for tomatoes, and 0.05 to 0.34 for dry onions. Increasing regional food-price dispersion points to a deterioration in regional integration or market segmentation stemming from inefficiencies in food distribution supply chains, as is discussed in more detail in this section. Policies and strategies aimed at linking farmers to local and national markets and facilitating access to storage and distribution systems may contribute to a reduction in food price dispersion across the regions of Turkey.

An Overview of the Tomato, Green Pepper and Onion Sub-Sectors

Tomatoes (For Fresh Consumption and Processing)

Turkey is the fourth largest producer of tomatoes in the world. In 2018, its production accounted for 12.2 million tons (Table 6), or 5 percent of total world production, behind only China (61.6 million tons), India (19.4 million tons), and the United States (12.6 million tons). While the share of Turkey's tomato production in total world production remained

Figure 19. **Regional Differences in Dry Onion Prices**



Note: Numbers on the map reflect average dry onion prices during May 2018–April 2019.

Source: Authors, based on statistics from TURKSTAT

[17] Price dispersion is calculated using the standard deviation of prices for each crop across 26 regions.

***Table 6.* Global Tomato Production (For Fresh Consumption and Processing), Tons**

Countries	2009	% of total (2009)	2018	% of total (2018)
China	45,365,542	23%	61,631,581	25%
India	11,148,800	6%	19,377,000	8%
USA	15,457,480	8%	12,612,139	5%
Turkey	10,745,572	5%	12,150,000	5%
Egypt	10,278,539	5%	6,624,733	3%
Other	107,678,210	53%	131,492,588	54%
World Total	200,674,143	100%	243,888,041	100%

Source: FAOSTAT

stable, in absolute terms, tomato production has increased by 13.1 percent, from 10.7 million tons to 12.3 million tons. About 70 to 75 percent of total tomato production in Turkey is consumed fresh and 25 to 30 percent of production is processed.[18] Approximately 80 percent of tomatoes produced for processing are used to produce tomato paste, 15 percent is used for canned tomatoes, and the rest is used for ketchup, tomato juice and other products (Fidan, 2002; Sarisaçli, 2005).

Tomato production (for fresh consumption and processing) accounted for 34 percent (12.8 million tons[19]) of all fresh vegetable production in the country. Table tomato production accounts for 8.8 million tons. While climatically tomatoes can be grown anywhere in Turkey, commercial production is concentrated in the coastal regions[20] of Adana and Antalya (Figure 20). Jointly they produce over 4 million tons of tomatoes (2019 est.). Tomato production usually starts with seed sowing and continues with sapling plantation. The most suitable time for seed sowing is the beginning of spring with a high concentration in March and April. Harvesting takes place around June and July. Alternative greenhouse production methods for year-round production are developing, such as the high-altitude greenhouse production in Antalya, Erdemli, and Mersin. Vegetable producers in Turkey are usually small and medium-scale farmers, albeit large-scale investments in vegetable production have been increasing in recent years. An average farm size for vegetable producers, including tomatoes, is 1 hectare (EBRD, 2018).

Table tomatoes in Turkey are produced both in open fields and in greenhouses. In 2019, greenhouse production of table tomatoes accounted for 4.1 million tons (or 46.1 percent of total table tomato production). The share of table tomatoes produced in greenhouses has increased by 25 percent between 2009 and 2019. Greenhouse production activities are mainly clustered in the coastal regions. Antalya is the largest greenhouse producer region—greenhouse production accounts for 94 percent of total production (2019 est.)—followed by Zonguldak (56 percent) and Adana (41 percent). Nearly all open-field table tomato production goes to domestic markets and consumption; greenhouse production is mainly targeted towards exports.

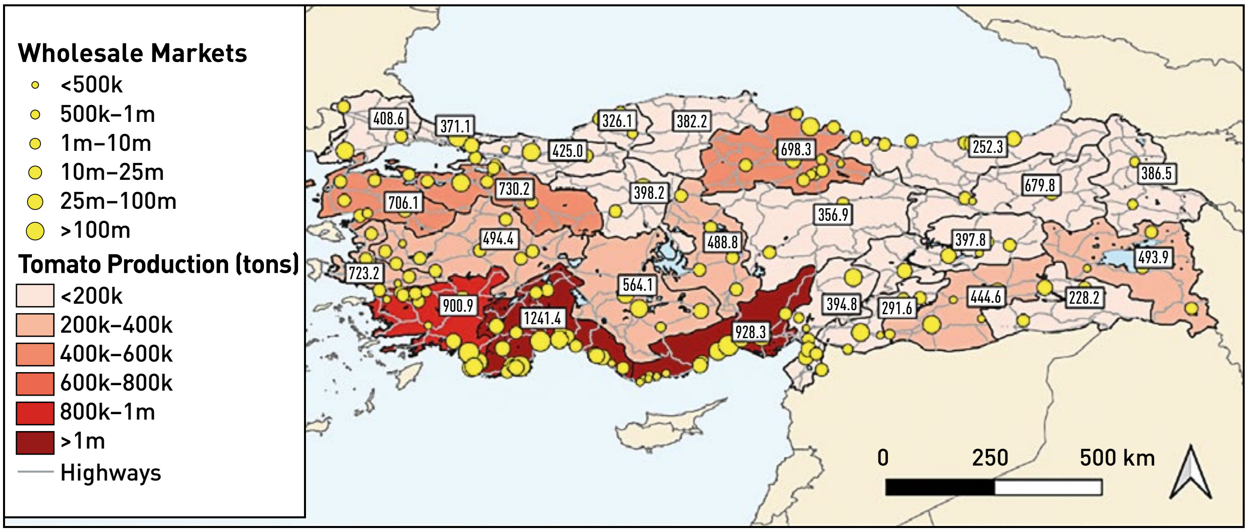
Table tomato yields have been consistently increasing in Turkey but remain significantly behind those observed in the United States and the European Union. The average table tomato yield in Turkey is 5.3 tons/decare (2019 est.), but varies greatly across the regions (Figure 21), ranging from 2.3 tons/decare in the marginally producing region of Mardin to 12.4 tons/decare in Antalya. Yields for tomatoes grown in greenhouses tend to be higher than those grown in open fields. The correlation between tomato yields and share

[18] This report focuses on tomatoes for fresh consumption.

[19] 2019 est.

[20] Throughout the report the regions refer to statistical regions defined in accordance with the European Union's Nomenclature of territorial units for statistics (NUTS).

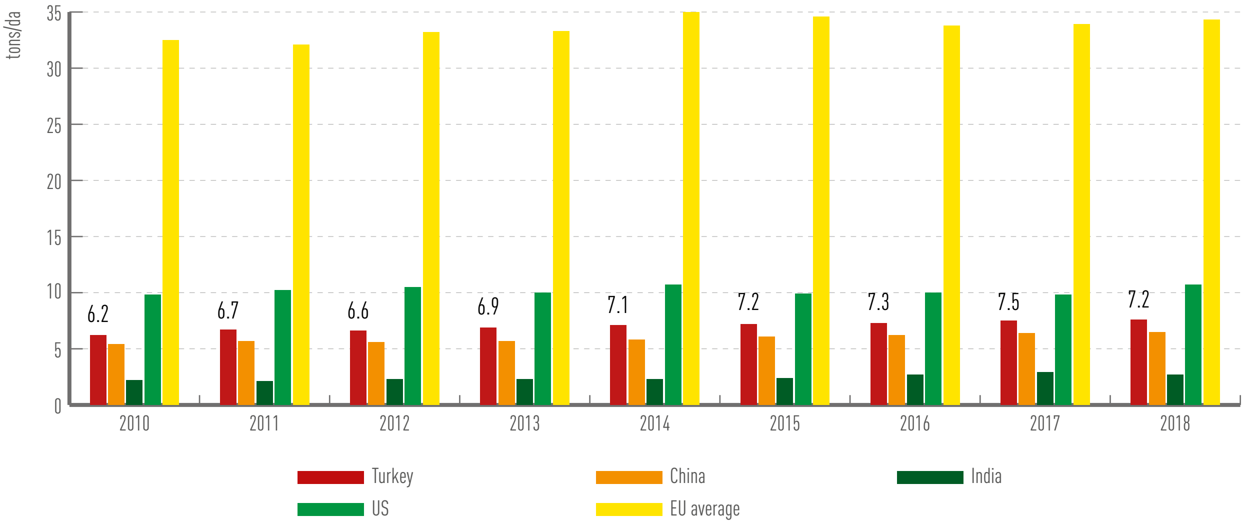
Figure 20. **Regional Table Tomato Production, Production and Yields**



Note: Numbers on the map reflect average regional yields, kg/decare (2019 est.).

Source: Authors, based on statistics from TURKSTAT

Figure 21. **Comparison of Turkish Tomato Yields with the Yields in Comparator Countries**



Source: FAOSTAT

of greenhouse production across the regions is 0.64. Overall, tomato yields have been increasing over time, but remain lower than those observed in leading tomato producing countries, such as the United States and countries in the European Union.[21] Specifically, according to FAOSTAT,[22]

[21] Some of the differences in yields may be attributable to differences in tomato varieties.

[22] There is a certain discrepancy between the FAOSTAT and TurkStat numbers on tomato yields. This report uses the TurkStat estimates; FAOSTAT estimates are used solely for the purpose of international comparisons.

Turkey's yields (7.6 tons/decare, 2018 est.) are higher than those for China (6.5 tons/decare) and India (2.7 tons/decare), two of the largest world producers of tomatoes, but are significantly lower than yields in the United States (10.7 tons/decare) or yields in the largest tomato producing European Union countries (an average of 34.3 tons/decare[23]).

Several factors contribute to relatively low tomato yields in Turkey. One of the reasons for lower yields, as compared to the European Union, is the limited adoption of improved production techniques by growers. As the bulk of production occurs on small farms, sowing or planting seedlings, maintenance, and harvesting are generally done by hand, and mechanization levels remain much lower than in the European Union. Country-wide producer organizations representing the interests of producers in the subsector are largely nonexistent. At times, the lack of unions and organized production along with limited stock capacity lead to price fluctuations with producers having to sell below production costs (Erturk & Çirka, 2015). While drip irrigation and fertigation methods are the norms in greenhouse tomato production, in open field production row irrigation is the most common irrigation method and the use of fertilizers is still based on farmer habits rather than soil analysis (Abak, 2016).

Tomato consumption has been relatively stable in Turkey over recent years with a slight decrease in 2018 (Table 7). In 2018, Turkey per capita consumption amounted to 109.9 kg. This is a slight decrease from the preceding years: between 2014 and 2017, average consumption was close to 118 kg per capita.

***Table 7.* Tomato Consumption in Turkey (Fresh and Processed)[25]**

Year	Per capita (kg)	Total (MT)
2014	119.5	9,285,983
2015	118.6	9,340,969
2016	116.3	9,284,769
2017	116.9	9,443,060
2018	109.9	9,013,786

Source: Turkstat, 2020

Turkey is a net exporter of tomatoes, realizing no sizeable imports. In 2019, Turkey exported $303 million worth of tomatoes and ranked as the fifth largest tomato exporter[24] in the world after Mexico ($2.16 billion), Spain ($1.03 billion), Canada ($379 million), and Belgium ($306 million) (UN Comtrade, 2020). Between 2014 and 2018, the average value of Turkish fresh tomato exports amounted to $322.4 million, which constitutes 31 percent of the value of total fresh vegetable exports in the country (UN Comtrade, 2020). However, both in absolute and relative terms, the value of fresh tomato exports in US dollar equivalent has been decreasing, primarily driven by currency depreciation and the loss of the Russian market post-2015 (Figure 22). In terms of volume, exports of tomatoes (fresh and processed) remained relatively stable in the last five years (see Appendix 2), between the 2013/14 and 2018/19 marketing years, with Turkey exporting about 10 percent of its annual production volume. In 2016–2018, the largest importers of Turkish fresh tomatoes have been Romania, Belarus, Ukraine, and Saudi Arabia. In 2018, there was some recovery in exports to Russia and these exports accounted for $30.5 million (or 10 percent of total fresh tomato export value). In comparison, in 2015, prior to the Russian ban on imports of Turkish tomatoes, Turkey exported $258 million worth of tomatoes to Russia (or 71 percent of its total fresh tomato export value).

Green peppers

Turkey is the third largest producer of green peppers in the world. In 2018, its production accounted for 2.5 million tons (Table 8), or 5 percent of total world production, behind only China (18.2 million tons) and Mexico (3.4 million tons). While the share of Turkey's green pepper production in total world

[23] Average calculated for Portugal, Spain, France, Germany, Austria, Ireland, the United Kingdom, Denmark, Finland, Sweden, Belgium and the Netherlands, as the largest tomato producers in the European Union.

[24] Historically, Turkey has been a top ten world exporter of table tomatoes.

[25] There are no separate statistics available on fresh tomato consumption in Turkey.

Figure 22. **Fresh Tomato Exports Compared to Total Fresh Vegetable Exports**

Source: UN Comtrade, 2020.

Table 8. **Global Chilies and Pepper Production, Tons**

Countries	2009	% of total (2009)	2018	% of total (2018)
China	14,520,301	34%	18,214,018	33%
Mexico	1,941,564	4%	3,379,289	6%
Turkey	1,837,003	4%	2,554,974	5%
Spain	932,191	2%	1,275,457	2%
Egypt	792,836	2%	713,752	1%
Other	23,256,601	54%	28,848,004	53%
World Total	43,280,496	100%	54,985,494	100%

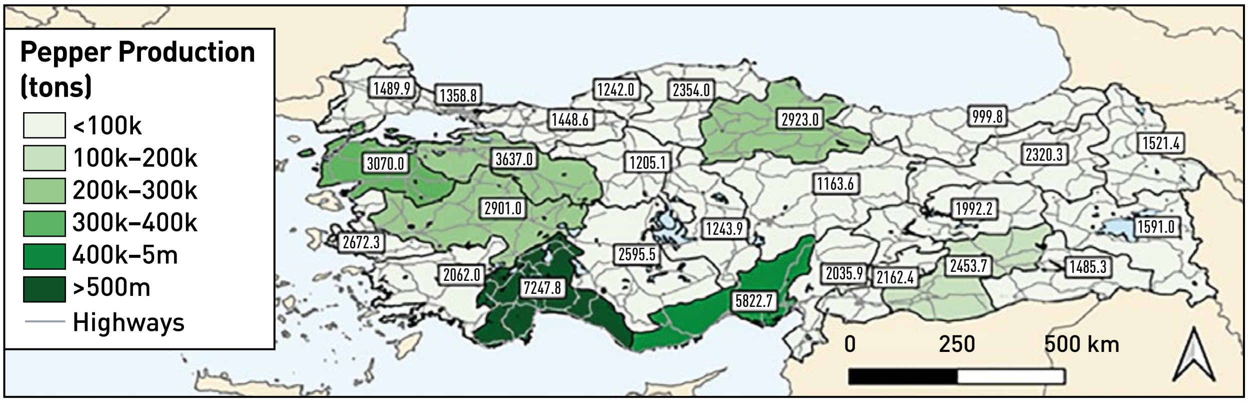
Source: FAOSTAT, 2020

production increased by one percentage point between 2009 and 2018, in absolute terms green pepper production increased by 39.1 percent from 1.8 to 2.5 million tons. About 55 percent of total green pepper production in Turkey is consumed fresh and 45 percent of production is processed. Approximately 80 percent of green peppers produced for processing is used to produce pepper paste and 20 percent is used for dried spices.

In 2019, Turkey's green pepper production accounted for 5 percent (2.6 million tons) of all vegetable production in the country. Among the four types of green peppers produced in Turkey, capia peppers make up 47 percent of total production and are produced for processing whereas long green peppers (34 percent), bell peppers (14 percent), and banana peppers (5 percent) comprise the rest of the production and are consumed fresh. The largest production of green peppers in the country is concentrated in the regions of Adana, Antalya, Balikesir, Bursa, and Manisa (Figure 23). Jointly they produce 1.7 million tons of green peppers or 65 percent of total green pepper production in the country. Green pepper seedlings are planted towards the end of April. Harvesting starts at the end of June and early July and continues until mid-October.

Just as in the case of tomatoes, green peppers are produced both in open fields and in greenhouses, however, greenhouse production remains limited. Currently, greenhouse production

Figure 23. **Regional Green Pepper Production and Yields (All Pepper Varieties)**



Note: Numbers on the map reflect average regional yields, kg/decare (2019 est.).

Source: Authors, based on statistics from TURKSTAT

of green peppers accounts for 749,000 tons (or 29 percent of total green pepper production). Of the four types of green peppers, greenhouse production of long green peppers accounts for 41 percent of total production. The share of long green peppers produced in greenhouses has increased by 6.9 percent (or 104,000 tons) between 2009 and 2019. Greenhouse long green pepper production activities are mainly clustered in the coastal regions. Adana is the largest greenhouse producer region and accounts for 70 percent of total long green pepper production (2019 est.), followed by Antalya (56 percent), and Zonguldak (22 percent).

Green pepper yields remain significantly behind those observed in the European Union. Average green pepper yield (all varieties) in Turkey is 2.3 tons/decare (2019 est.) but varies across the regions (Figure 23), ranging from 0.9 tons/decare in the marginally producing region of Trabzon to 7.2 tons/decare in Antalya. Overall, green pepper yields have been increasing over time, but remain lower than those observed in comparator countries[26] (Figure 24). According to FAOSTAT,[27] yields in Turkey (3.1 tons/decare, 2018 est.) are higher than those in China (2.6 tons/decare) and Mexico (2.4 tons/decare), two of the largest world producers of green peppers, but are lower than yields in the United States (3.6 tons/decare) and significantly lower than yields in the largest green pepper producing European Union countries (an average 12.1 tons/decare[28]).

Green pepper consumption trended slightly upward in Turkey over recent years. The consumption of green peppers has increased from 23.4 kg per capita in 2014 to 25.3 kg per capita in 2018 (Table 9).

Turkey is a net exporter of green peppers, and has no sizeable imports. In 2019, Turkey exported $124 million worth of green peppers and ranked as the fifth largest green pepper exporter[29] in the world after Mexico ($1.37 billion), Spain ($1.32 billion), Canada ($439 million), and the United States ($252 million) (UN Comtrade 2020). Between 2014 and 2018, the average export value of Turkish green peppers (HS070960) amounted to $92.5 million, which constitutes

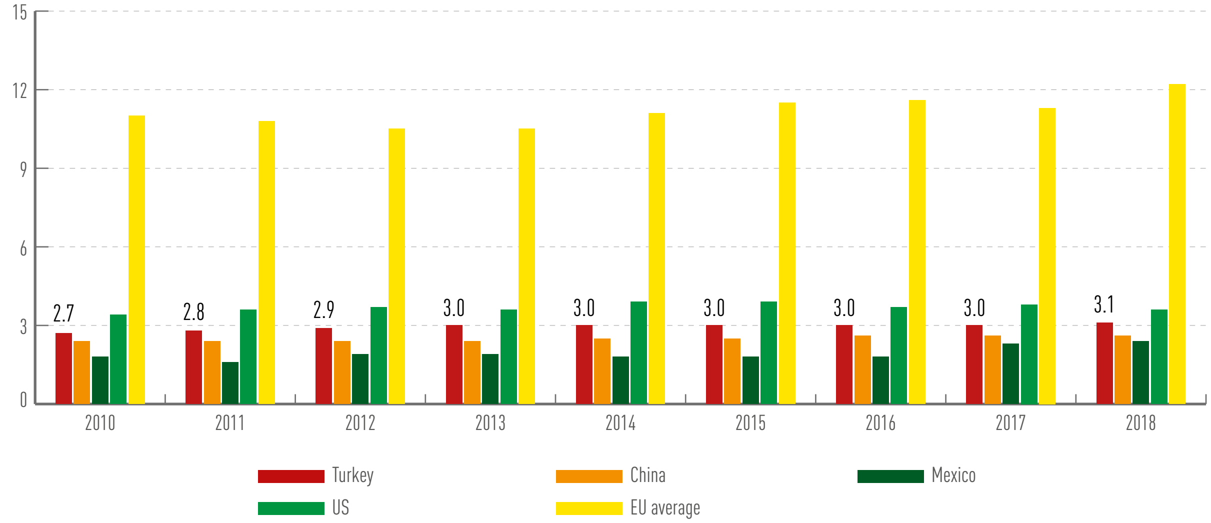
[26] Some of the differences in yields may be attributable to differences in green pepper varieties.

[27] There is a certain discrepancy between the FAOSTAT and TurkStat numbers on green pepper yields. This report uses the TurkStat estimates; FAOSTAT estimates are used solely for the purpose of international comparisons.

[28] Average calculated for Spain, the Netherlands, Italy, Romania, Greece, Hungary, Bulgaria, France, the United Kingdom and Belgium.

[29] Historically, Turkey has been a top ten world exporter of green peppers.

Figure 24. **Dynamics of Regional Green Pepper Yields (All Pepper Varieties)**



Source: FAOSTAT

Table 9. **Green Pepper Consumption in Turkey (Fresh and Processed)**[30]

Year	Per capita (kg)	Total (MT)
2014	23.4	1,818,086
2015	23.1	1,817,878
2016	23.4	1,865,358
2017	26.2	2,113,574
2018	25.3	2,072,161

Source: Turkstat

9 percent of the value of total fresh vegetable exports in the country, and has been increasing since 2010 (Figure 25) (UN Comtrade, 2020). In terms of volume, exports of green peppers have also been increasing over the last five years except for a slight decrease in 2017 (see Appendix 2). In 2016–2018, the largest importers of Turkish green peppers have been Germany, Romania, the Netherlands and Bulgaria. In 2018, there was some recovery in exports to Russia, reaching $11.3 million (or 9.6 percent of total green pepper export value). In 2015 Turkey exported $11.1 million worth of green peppers to Russia (or 14 percent of total green pepper export value). In 2016, Russian imports plummeted to $2.2 million (2.46 percent) and in 2017, they fell further to just $760,000 (0.8 percent).

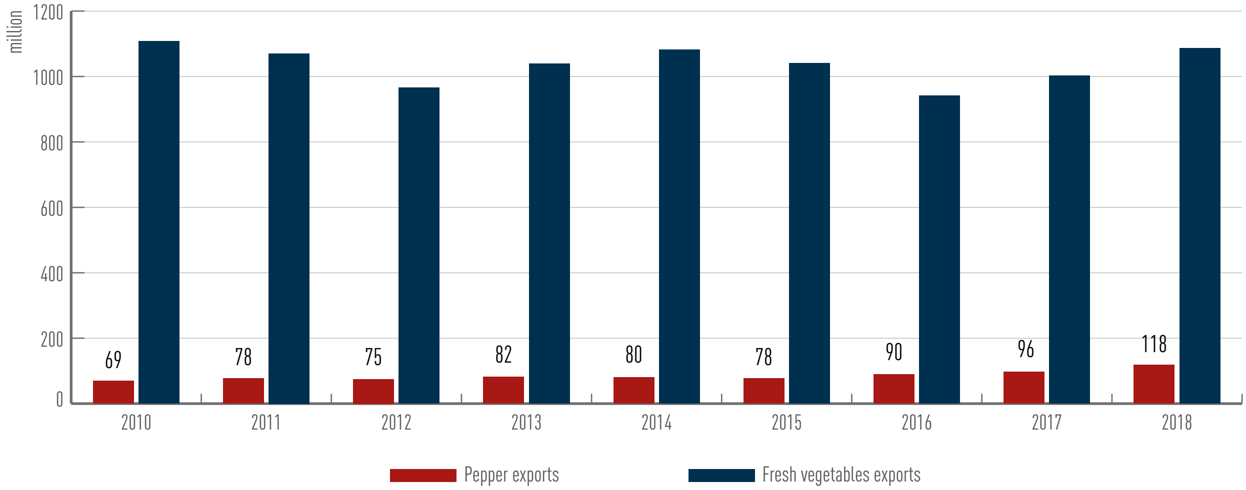
Dry onions

Turkey is the sixth largest producer of dry onions in the world. In 2018, its production accounted for 1.9 million tons (Table 10), or 2 percent of total world production, behind China (24.8 million tons), India (22.1 million tons), the United States (3.3. million tons), Egypt (2.9 million tons), and Iran (2.4 million tons). While the share of Turkey's onion production in total world production remained stable, in absolute terms onion production has slightly increased from 1.8 million tons to 1.9 million tons. The area used in onion production has been consistently decreasing over time, from 788,000 decares in 2004 to 614,000 in 2019.

In 2019, dry onion production accounted for 7.1 percent (2.2 million tons) of all vegetable production in the country. Dry onion production is concentrated in the regions of Ankara, Samsun, Bursa, Adana, and Hatay (Figure 26). Jointly they produce nearly 1.8 million tons of onions (2019 est.). Onions are produced in open fields in Turkey through three

[30] There are no separate statistics available on fresh green pepper consumption in Turkey.

Figure 25. **Share of Green Pepper Exports in Total Fresh Vegetables Exports**



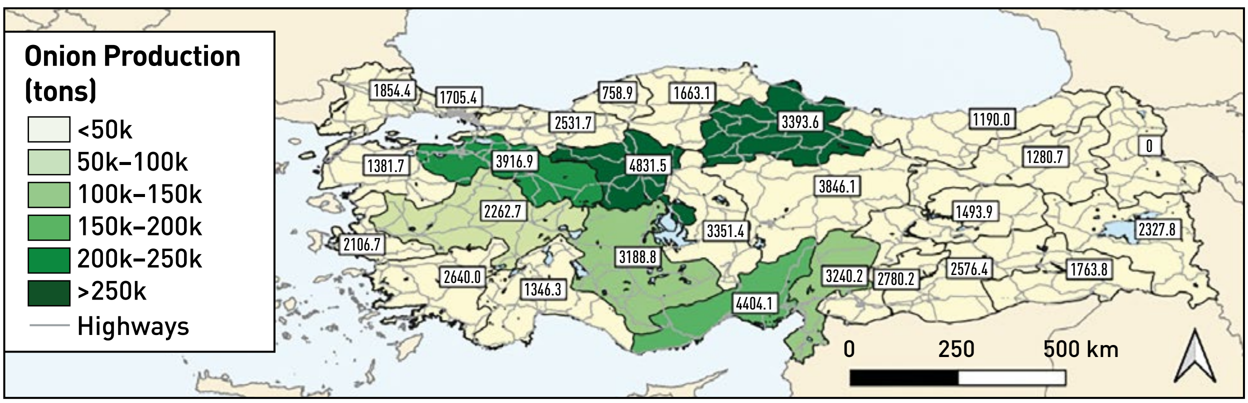
Source: UN Comtrade, 2020

Table 10. **Global Dry Onion Production, Tons**

Countries	2009	% of total (2009)	2018	% of total (2018)
China	21,046,969	22%	24,775,344	20%
India	12,158,800	13%	22,071,000	18%
USA	3,429,100	4%	3,284,420	3%
Egypt	2,128,580	2%	2,958,324	2%
Iran	1,529,996	2%	2,406,718	2%
Turkey	1,849,582	2%	1,930,695	2%
Other	52,958,262	55%	63,750,477	52%
World Total	95,485,707	100%	121,549,161	100%

Source: FAOSTAT

Figure 26. **Regional Dry Onion Production and Yields**

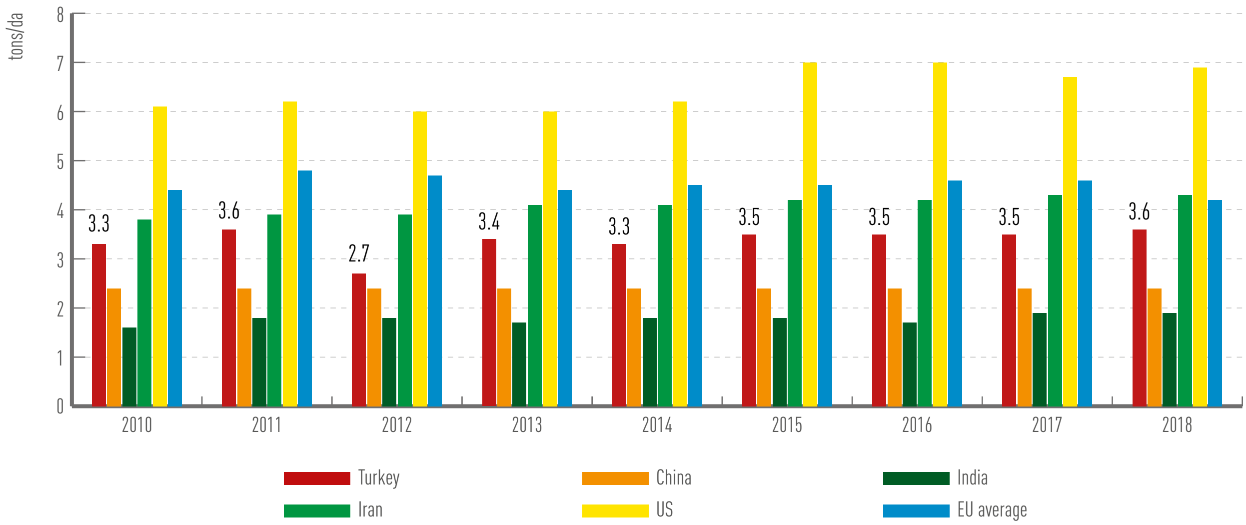


Note: Numbers on the map reflect average regional yields, kg/decare (2019 est.).

Source: Authors, based on statistics from TURKSTAT different methods: direct seed sowing, seed sowing for shallots and re-sowing these and saplings. Seed sowing produces yields in 5 to 6 months and is the most common while shallot production (producing shallots in the first year then re-sowing the shallots) and saplings are also practiced. The most suitable season for seed sowing is during autumn in general. For early maturing types, seed sowing begins from mid-August and ends in mid-October. Harvesting differs according to the production method and place of production, but direct seed sowing is harvested within 5 to 6 months of sowing.

Dry onion yields in Turkey are significantly lower than those in many of the large onion producing countries. The average onion yield in Turkey is 2.5 tons/decare (2019 est.) but varies across the regions (Figure 26), ranging from 0.8 tons/decare in the marginally producing region of Zonguldak to 4.8 tons/decare in Ankara. According to FAOSTAT,[31] Turkey yields (3.6 tons/decare, 2018 est.) are higher than those for China (2.4 tons/decare) and India (1.9 tons/decare), two of the largest world producers of onions, but are lower than the United States (6.9 tons/decare), Iran (4.3 tons/decare), and in the largest onion producing European Union countries (4.2 tons/decare[32]) (Figure 27).

Figure 27. **Dynamics of Regional Dry Onion Yields[33]**



Source: FAOSTAT, 2018

Onion consumption has been increasing in Turkey over the past few years, although there was a slight decrease in 2018 (Table 11). Between 2014 and 2017, dry onion consumption gradually

Table 11. **Dry Onion Consumption in Turkey**

Year	Per capita (kg)	Total (MT)
2014	18.19	1,413,481
2015	19.49	1,534,975
2016	20.70	1,651,785
2017	22.37	1,807,980
2018	21.75	1,783,426

Source: Turkstat

[31] There is a certain discrepancy between the FAOSTAT and TurkStat numbers on onion yields. This report uses the TURKSTAT estimates; FAOSTAT estimates are used solely for the purpose of international comparisons.

[32] Average calculated for France, Germany, Greece, Italy, the Netherlands, Spain,and the United Kingdom.

[33] Some of the difference in yields may be attributable to differences in onion varieties.

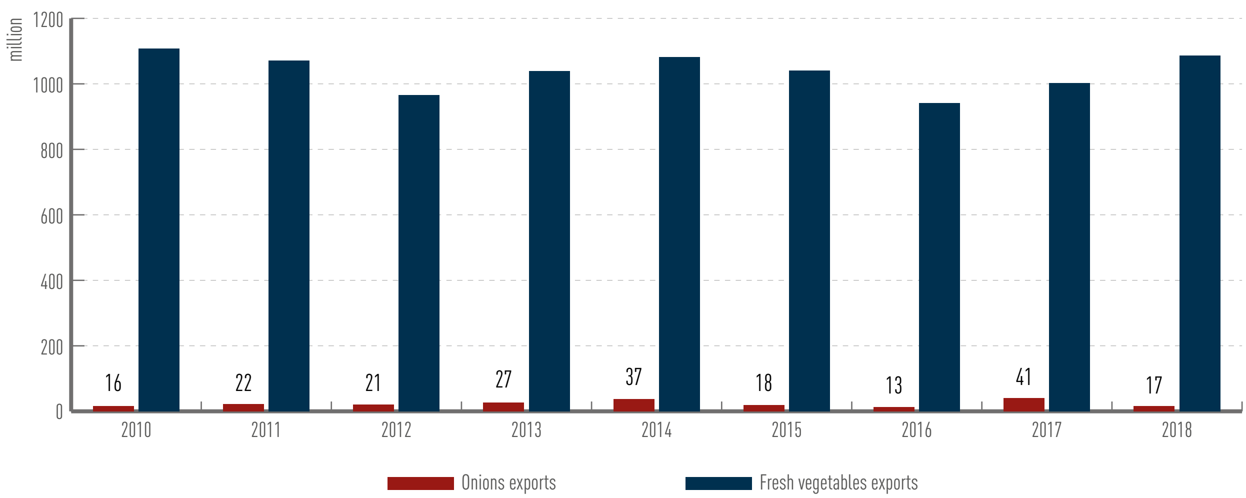
increased from 18.19 to 22.37 kg per capita. In 2018, it slightly decreased, if compared to 2017, to 21.75 kg per capita.

Turkey is a net exporter of dry onions. Between 2014 and 2018, the average value of Turkish onion (HS 70310) exports were equal to $29.8 million, which on average accounted for 2.4 percent of total fresh vegetable exports over the same period (Figure 28). In 2019, Turkey ranked as the ninth largest dry onion exporter in the world after India ($367 million), Mexico ($356 million), the United States ($288 million), Egypt ($244 million), Spain ($213 million), New Zealand ($115 million), Poland ($104 million), and Pakistan ($67 million). Between 2010 and 2018, the largest importers of Turkish onions were Russia (an average of 47 percent of total exports or $10.9 million) and Iraq (23 percent or $5.4 million). Georgia is ranked the third or the fourth largest importer depending on the year and accounted for about 7 percent of total exports (or $1.5 million) (UN COMTRADE, 2020). Turkey's imports of onions tend to be low (an average of $45,000 between 2014 and 2018), however, in 2019, the country imported $33 million worth of onions due to the lower than usual production resulting from unfavorable weather conditions, shrinkage in the production area, and product loss due to disease and improper storage techniques. To counteract rising onion prices in 2019, the government lowered the import tariff on onions from the usual 49.5 percent to 0 percent, which resulted in a surge of onion imports that year.

Agricultural and trade policy environment for tomatoes, green peppers and onions

The agricultural support programs for crop production can be clustered into four categories: (a) area-based payments, (b) biological and biotechnical support payments, (c) deficiency/compensatory payments, and (d) other agricultural subsidies. *Area-based payments* cover diesel, fertilizer, soil analysis, organic agriculture, good agricultural practices, small-scale family farmer supports payments, and specific subsidies for hazelnut production and olive gardens rehabilitation. *Biological and biotechnical support payments* aim to reduce the use of chemicals in crop production and to protect human health and maintain the natural balance by dissemination of alternative techniques instead of chemicals. *Deficiency/compensatory payments* are used to balance the supply of products. Compensatory payments are used to encourage farmers to produce alternative products by avoiding the production of surplus crops, while deficiency payments are used to encourage the production of supply deficit crops. Farmers also receive *other agricultural subsidies* including certified seed and sapling support payments, CATAK (Environmentally Protected

***Figure 28.* Share of Dry Onion Exports in Total Fresh Vegetable Exports**



Source: FAOSTAT, 2018

Agricultural Land) payments, agricultural extension and consultancy services support, and R&D project support. In addition, since 2017, the Ministry of Agriculture and Forestry (MOAF) has implemented an agricultural basin-based model that focuses on 21 crops[34] that are eligible for four different types of subsidies.[35] The program aims to establish an efficient agricultural inventory by determining agricultural basins, planning production based on demand, supporting basin-based production, and providing efficient and rational usage of supports. Ziraat Bank is the main financial institution that provides support payments to farmers. The total agricultural support program budget of MOAF was increased to TL 22 billion in 2020 from TL 12.9 billion in 2017. From 46 percent to 51 percent of each year's budget was allocated for crop production supports between 2017 and 2020.

For tomatoes, green peppers, and onions, state support has remained relatively consistent in terms of composition since 2015, while the amounts of outlays have been slightly increasing for most of the support types (Table 12). Tomatoes, green peppers, and onions benefit from some of the subsidies under the *area-based payments*, *biological and biotechnical support payments and other agricultural subsidies*. However, *deficiency/compensatory payments* are not used for vegetables. Under the area-based payments system, tomato, pepper, and dry onion producers can benefit from six different payments, three of which cover the cost of inputs such as diesel, fertilizer, and soil analysis. These subsidies constitute the primary form of support for vegetable production in Turkey and cover up to 60 percent of the cost of production expenses. To be eligible to receive the payments, farmers must be registered in the Farmer Registry System (FRS). In addition, fruit and vegetable producers who have less than 5 decares of agricultural land can benefit from small-scale family farmer support.

Farmers can apply for organic agriculture and good agricultural practices payments for tomatoes, green peppers, and onions which are also considered area-based payments. The aim of organic and good agricultural practices support is to expand sustainable agricultural practices while improving traceability and food safety. Farmers must be registered with the FRS and the Organic Agriculture Information System (OAIS) to be eligible to receive payments as of 2019. Eligible tomato, green pepper, and onion producers receive organic agricultural support at the highest rates for fruits and vegetables.

In addition to area-based payments, tomato, green pepper, and onion farmers can receive biological and biotechnical support payments. These support payments aim at scaling up the biological and biotechnical ways of production and decreasing chemical residues stemming from the use of pesticides for improved human health. Support payments differ in open fields and greenhouses. A separate Greenhouse Cultivation Registry System keeps track of greenhouse producers, and greenhouse tomato and green pepper farmers must be registered with this system to benefit from the subsidies. Open field producers must be registered for the regular FRS.

Tomato, green pepper, and onion producers are also eligible for Farm Accounting Database System Participation support. The payments are based on participation and aim to collect detailed accounting information from farmers to monitor the country's overall agricultural performance. Farmers must be registered in the FRS or any other relevant administrative registry of the Ministry in order to be eligible. Participation in the system requires the farmers to periodically share accounting information during the year through surveys. Farmers registered in the database receive payments the year after their compliance is verified by the responsible unit in the Ministry. Payments have been increasing since 2014. In 2019, eligible farmers received 600 TL per year.

Agricultural Extension and Consultancy Services support is another subsidy available for tomato, green pepper, and onion producers. This type of

[34] Wheat, barley, rye, paddy, corn, triticale, oats, lentils, chickpeas, haricot beans, cotton, soy, oily sunflower, canola, safflower, tea, hazelnut, olive oil, potato, onion (dry) and forage crops.

[35] Diesel-fertilizer payments, certified seed use, deficiency payments, and forage crops payments.

***Table 12.* Summary of State Support Payments for Tomatoes, Green Peppers, and Onions**

Support Programs	Unit	2015	2016	2017	2018	2019
I. Area-Based Payments						
a. Soil Analysis Support	TL/analysis	125	0	40	40	40
b. Diesel Support*	TL/ha	33–79	110	51.9–373.6	68.1–454	80–660
c. Fertilizer Support*	TL/ha	47.5–82.5		40	40	40
d. Small-scale Family Farmer Support	TL/ha	N/A	1000	1000	1000	1000
e. Organic Agriculture Support by Years						

Category Type (2)	Unit	2015 (3)	2016	2017	2018	2019	
						IC	GC
Category Type 1	TL/ha	700	1000	1000	1000	700	350
Category Type 2	TL/ha		700	700	700	400	200
Category Type 3	TL/ha		300	300	300	100	50
Category Type 4	TL/ha		100	100	100	No C4	
f. Good Agricultural Practices Support by Years(4)							

Cultivation Type	Certification Type	Unit	2015	2016	2017	2018	2019 (5)			
							C1	C2	C3	C4
Total Package for Open Fields	IC	TL/ha	500	500	500	500	500	400	300	100
	GC	TL/ha			400	400	250	200	150	100
Total Package for Greenhouse Cultivation	IC	TL/ha	1500	1500	1500	1500	1500	No greenhouse cultivation		
	GC	TL/ha					750			

II. Biological and Biotechnical Struggle Support							
Cultivation Type	**Support Type**	**Unit**	**2015**	**2016**	**2017**	**2018**	**2019**
Total Package for Open Fields	Biological	TL/ha	350	350	350	500	500
	Biotechnical		350	350	450	500	800
Total Package for Greenhouse Cultivation	Biological		3500	3500	3500	4000	4000
	Biotechnical		1100	1100	1100	1200	1200
III. Differentiation/Compensatory Payments (are not used for fruits and vegetables)							
IV. Other Agricultural Subsidies							
a. Farm Accounting Database Participation		TL/agribusiness	475	425	500	600	600
b. Agricultural Expansion and Consulting		TL/year	600	20,000	35,000	38,000	46,000

* *Support payments differ across product groups*

Notes: (1) Diesel support payments for onions accounted for 170 TL/ha in 2019. (2) There are four categories of agricultural commodities for the purposes of organic farmer support. Tomato and pepper are in the first category and dry onion is in the third category. (3) There was no category distribution in 2015. Crops were classified as fruits and vegetables and field crops. Pepper, tomato and dry onion are all in the F&V. (4) Onions do not qualify for greenhouse production support due to the open field nature of their production. (5) Peppers and tomatoes are in C1, but dry onions are in C2 in 2019. IC: Individual Contract. GC: Greenhouse Contract.

Source: MOAF Support Programs Bulletins, 2015–2019.

support aims to increase agricultural productivity through the dissemination of information. To be eligible, farmers must be registered with FRS. Other requirements for eligibility vary according to the type of farming. For farmers engaged in rain-fed farming, the minimum requirement is

100 decares of land under cultivation. For those engaged in both rain-fed and irrigated farming, the minimum requirement is 100 decares with at most 50 decares irrigated, while for those engaged in irrigated farming only, the minimum required land is 50 decares. The minimum requirement for greenhouse production is two decares of land under cultivation. The extension and consulting services subsidy also covers organic farmers engaged in all of the above, and the minimum land under cultivation required is half of each category discussed. The services can be provided by agricultural consultants/consultancy companies or associations authorized by the Ministry, producer organizations, and Chambers of Agriculture. The services are officiated by contracts based on Ministry guidelines and signed between the provider and the farmers. Until 2016, 600 TL per year was paid in two installments for each consulting farmer to the authorized company/organization for up to eight agricultural consultants. In 2016, there was a significant jump in payments for extension services (Table 12). In 2019, 46,000 TL per year was designated to be paid in two installments for each consultant hired in one of the authorized consulting organizations for up to five consultants. Payments for 2019 are planned to be made in 2020. The payments are made in full provided that the consultants are retained for 12 months.

From the standpoint of trade policy, vegetables in Turkey enjoy high import protection rates. In 2018, the applied MFN tariff rate on vegetables was 23.5 percent, including 48.6 percent for tomatoes, 19.5 percent for green peppers, and 49.5 percent for onions (WITS data). While the applied MFN rates have been at the same level for the select vegetables over the last decade, the overall MFN rate for vegetables has increased since 2016. In 2019, the Government of Turkey lowered import tariffs on onions to zero percent, triggering large import inflows to the country.

Agricultural and trade policy have implications for vegetable price levels. Although the causality between agricultural policies and the prices of tomatoes, green peppers, and onions was not tested empirically, it is plausible to conclude that there is no strong direct causality between the two. Such a causality can primarily stem from either the magnitude of support that can significantly distort prices or uncertainty associated with frequent policy change. As shown above, neither factor is attributable to the current policy situation in the vegetable markets. The indirect impact of support payments on rising food prices, however, may come from the sub-optimal allocation of resources in the vegetable sector and limited incentives for farmers to increase their productivity. In terms of trade policy, high import protection rates reduce the elasticity of the vegetable supply curve. While Turkey is a net exporter for all three vegetables, the price impact that stems from seasonal shortages of supplies of these vegetables may be exacerbated by the restrictions on the import side. In addition, import tariffs limit incentives for producers to improve their productivity and slow down the exit of inefficient producers from the sector, lowering the sector's overall competitiveness.

An Econometric Analysis of Price Formation and Transmission in Table Tomato, Green Pepper and Onion Markets

Determinants of price formation in fresh vegetable markets

One way to better understand the dynamics of price formation is to decompose it into separate cycles and trends of different frequencies. This allows for a more granular distinction between permanent and transitory price shocks.[36] Specifically, for the purposes of this analysis, price variances for the three vegetables of interest were decomposed into three components: seasonal component, cyclical component and a long-term trend as per the following equation:

$$p_t \equiv T_t + C_t^{[1,k]} + C_t^{[0,1]}, \text{ where}$$

$C_t^{[0,1]}$ captures short-term cyclical movements with a periodicity of less than one year to capture the

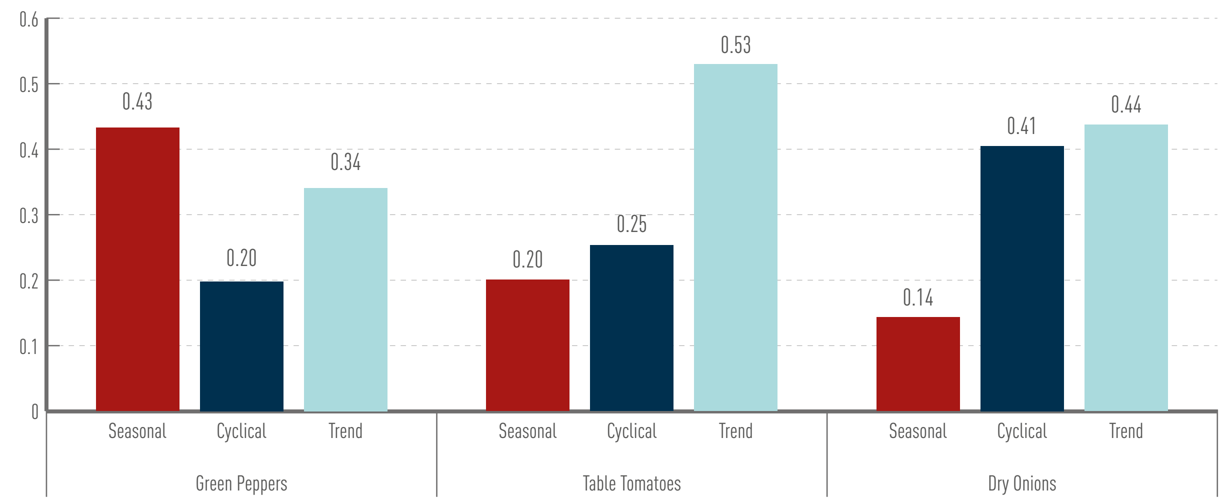
[36] Baffes and Kabundi, 2020, forthcoming.

seasonality influence on food prices arising from the harvest cycles.[37] T_t captures a long-term trend that reflects general price level changes over time. Lastly, $C_t^{[1,k]}$ accounts for cyclical patterns in economic activity that separate seasonal drivers from a long-term trend. For the purposes of this study, $C_t^{[1,k]}$ is aligned with a duration of a traditional business cycle associated with economic activity with periodicity of 2–8 years, following NBER's traditional definition (Burns and Mitchell 1946); hence, k = 8.

Decomposition of the monthly prices for tomatoes, green peppers, and dry onions into seasonal and cyclical components, and a long-term trend over the period from January 2005 to December 2019 unmasks the heterogeneity of their formation (Figure 29). Specifically, in the case of green peppers, the seasonal component, on average, accounts for over 43 percent of price variability across all regions, followed by a long-term trend that drives 34 percent of price variability. For tomatoes, the long-term trend is the main driver of price variability, accounting for 53 percent, followed by the cyclical component with 25 percent. In the case of onions, the cyclical component and the long-term trend account for 84 percent of price variability.

The current production and trade structures can help explain the role of the seasonal component in the price formation of selected vegetables. Both tomatoes and green peppers share a similar open-field growing season. However, most of the green pepper production in Turkey is open-field. On average 29 percent (749,000 tons) is produced in greenhouses, ranging from 14 percent for capia peppers to 76 percent for banana peppers. The share of greenhouse production for tomatoes is much higher at 46 percent. This extends the overall growing season for tomatoes. In addition, as alternative greenhouse production methods for year-round production of tomatoes are developing, tomato production will become even less prone to seasonal price variability. At the same time, unlike tomatoes and green peppers, dry onions can be stored for up to 12 months, so seasonal variation in prices is less likely as is confirmed by the analysis. On the trade side, tomatoes are the most exported vegetable

Figure 29. **Share of Price Variance Explained by Seasonal and Cyclical Components, and a Trend**



Note: The results presented in the figure reflect an average across all the regions in the country. For a more detailed regional analysis, see Appendix 4. Source: Authors.

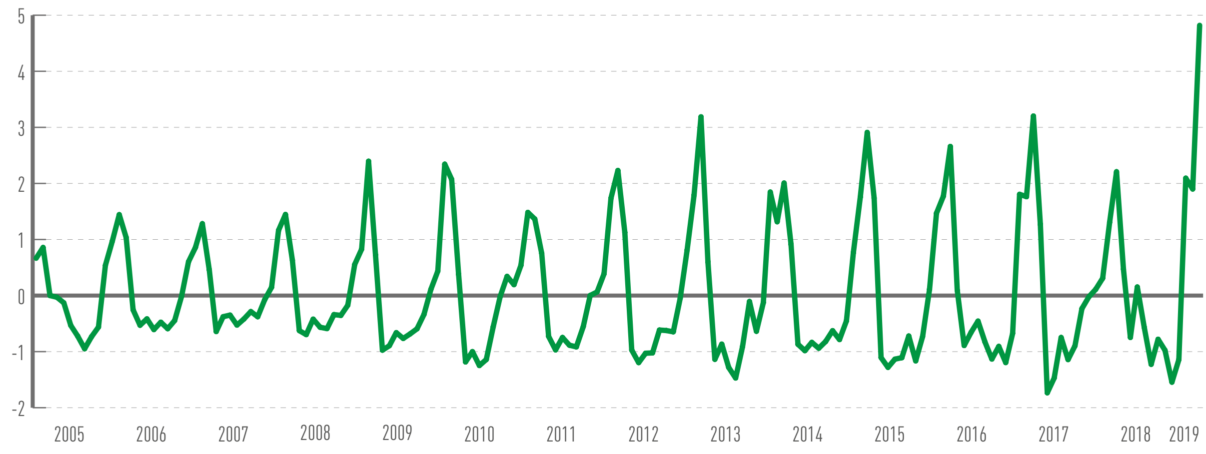
[37] Evidence in support of seasonal influences on food price variability is well documented in the literature. See Baffes et al. (2015), Sahn et al. (1989), and Kaminski et al. (2014).

in Turkey – 31 percent of total vegetable exports, compared to 9 percent for green peppers and 2.4 percent for dry onions. Such trade dynamics decrease the supply-side downward pressure on tomato prices at harvest time as there is large foreign demand for tomatoes.

A more detailed analysis of the price variance driven by the seasonal component offers additional insights into seasonal influences on the prices of green peppers and tomatoes. In the case of green peppers, the seasonal pattern is relatively consistent since 2005 (Figure 30) – with prices decreasing at harvest time and rising in the off-season. More so, over time, the amplitude of price variability caused by seasonality has increased, with price increases becoming more pronounced. While it is difficult to be sure which factors are causing this dynamic, it is plausible to assume that it may be driven by a growing demand for fresh vegetables, including green peppers, during the off-season months. What is clear, however, is that the market is increasingly unable to deal with balancing supply and demand for green peppers in the off-season due to a short production cycle, poor handling and packaging techniques, and inadequate storage capacity. As vegetable production is dominated by small-scale farmers, they often lack appropriate on-farm storage techniques and facilities to safeguard production. Lack of enough cold storage and refrigerated trucks further decreases the shelf-life of the fresh produce.

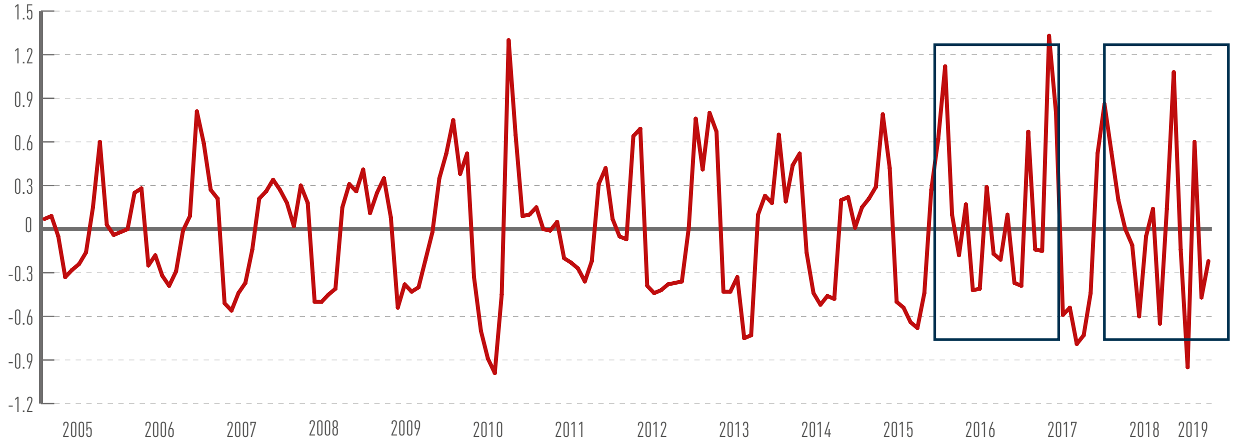
Like green peppers, tomato price dynamics also followed a relatively consistent seasonality pattern between 2005 and 2015 (Figure 31). However, peaks and troughs in tomato prices are much less pronounced than in the case of green peppers, which can once again be largely explained by the high share of greenhouse production and large export share that smooth supply and demand pressures. The analysis shows that the consistency of the seasonality pattern gets disrupted in two instances, which sheds light on the contributing factors to tomato price formation in recent years. The first disruption occurred in late 2015/early 2016, likely driven by Russian restrictions on Turkish imports, including tomatoes. The second disruption occurred in the summer of 2018 when prices rose during the harvest season. A similar situation occurred in the summer of 2019. Turkey experienced economic turmoil in mid-2018, with a significant exchange rate depreciation and a subsequent increase in input costs that led to a rise in tomato prices. To control price spikes, the government through municipalities started to sell tomatoes and other vegetables at a lower price in specific places in cities. While the volume of vegetables sold through these channels was limited, it did signal market uncertainty. Finally, in December 2018 and January 2019 floods devastated greenhouses in several districts of the

***Figure 30.* Seasonal Component of Green Pepper Prices**



Source: Authors

***Figure 31.* Seasonal Component of Table Tomato Prices**



Source: Authors

Antalya region, causing an additional supply shock. As a result, tomato price variability significantly increased in this period, as can be seen in Figure 31.

The effects of macroeconomic fundamentals on cyclical components differ across all three vegetables, ranging from 19 percent for green peppers to 62 percent for dry onions. The duration of a cyclical component in this analysis to a large extent mimics a business cycle. As such, it is expected that macroeconomic fundamentals play an important role in price formation within such cycles. The results obtained from a linear regression confirmed that macroeconomic fundamentals explain a varying share of price variability within a cyclical component for the three vegetables. Specifically, macroeconomic factors[38] explain 62 percent of price variance under a cyclical component for onions, 55 percent for tomatoes, and 19 percent for green peppers.

The analysis of price co-movement[39] across frequencies highlights the difference in price cohesion for seasonal and cyclical components across the three vegetables. Several results emerge from the co-movement analysis.[40] First, within-group correlations are high, especially for the cyclical component. Second, cross-commodity correlations are low compared with the within-group classification. Third, cyclical components score high in correlation with seasonal components. The findings suggest that macro fundamentals serve as a cohesion force for price movements across different commodities.

Implications for policymakers. The analysis of the impacts of the seasonal component on the price formation of green peppers and tomatoes suggests the possibility of significant gains for farmers from better post-harvest storage techniques that would allow farmers to take advantage of seasonal price differentials. There are also potential gains from lengthening the production season through investments in greenhouse production. Policy interventions, such as creating an enabling environment for producers to access

[38] Macro fundamentals used in regressions include: *for onions* – core inflation, energy prices, real effective exchange rate advanced economies, minimum wage, industrial production and trade activity (exports and imports of goods) *for onions*; core inflation, energy price, USD, minimum wage; *for tomatoes* – core inflation, energy prices, real effective exchange rate advanced economies, minimum wage, industrial production and trade activity (export and imports of goods); and *for green peppers* – core inflation, energy price, USD, minimum wage, industrial production and trade activity (exports and imports of goods). A dummy was added to reflect the import embargo imposed by Russia on Turkey in November 2015.

[39] See Appendix 3 for a detailed methodology on price co-movement analysis.

[40] For this analysis, monthly price data for the period from January 2005 to December 2019 was used.

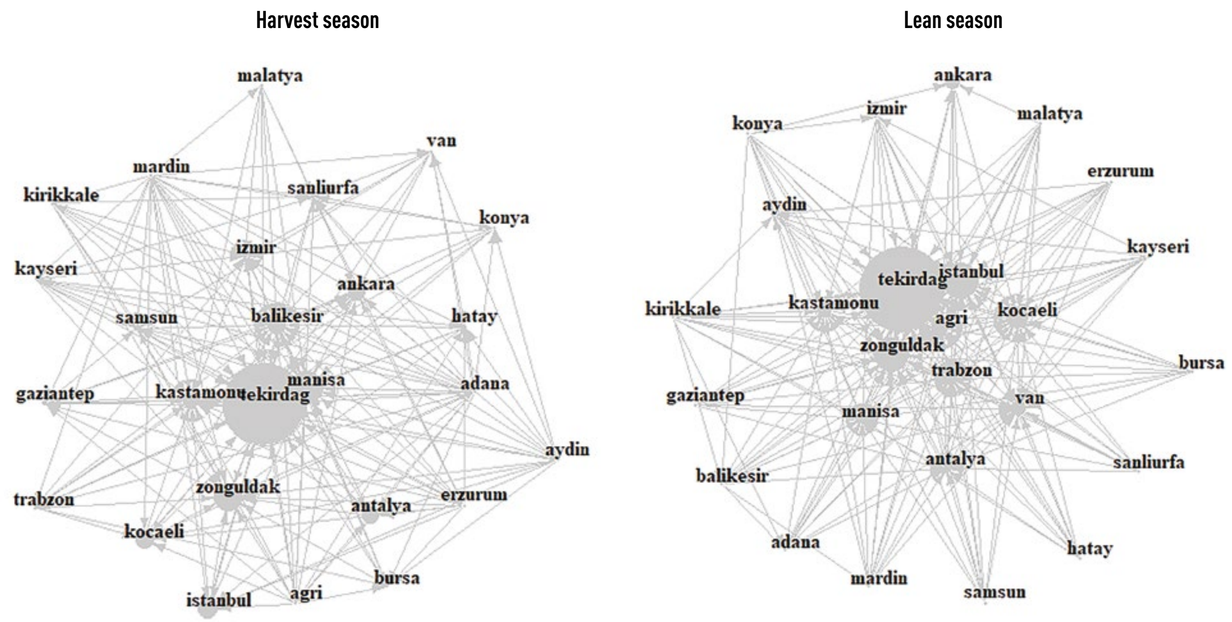
finance and strengthen collective action in the sector can help small-scale farmers access the more advanced storage technologies, greenhouse production as well as enhance marketing opportunities for smallholders, particularly into the more lucrative formal retail markets. In addition, training and educating farmers through extension services, including e-extension, can increase farmers' knowledge on post-harvest handling and storage of vegetables.

Origins of vegetable price shocks

Another important way to analyze the drivers of price variability across the regions is by identifying the origin of price shocks in the country and their transmission across the regions. To do so, we first apply a bivariate error correction model to determine the direction of price influence across the regions, following the analysis framework from Baffes (1991), Baffes et al. (2019), and Baffes and Kshirsagar (2019). For each analyzed pair or regions, a region that adjusts to the lagged spread between two cointegrated price series is the endogenous (i.e. a price follower) market with regards to that pair. If it does not adjust, it is considered exogenous (i.e. price leader) and is considered to lead the price formation. In the following step, a network centrality is estimated that allows for the identification of the sources of demand and supply shock for each vegetable of interest and, consequently, the channels through which they influence domestic prices (see Appendix 5 for a more detailed methodology).

For tomatoes, the Tekirdag region is the most influential market during both harvest and lean seasons, pointing to the role of tomato exports in Turkish tomato price formation (Figure 32).[41] While Tekirdag in itself is a region with small levels of tomato production and relatively low average yields (Figure 17), it borders Greece and Bulgaria, and provides access to the European Union and

Figure 32. **Table Tomato Price Structure During the Harvest and Lean Seasons**



Note: The size of the circles indicates the relative importance of a market. The direction of the arrows should be interpreted as 'influenced by'. For example, in the Istanbul-Aydin pair during the harvest season, the arrow points towards Istanbul. It means that the Aydin price is 'influenced by' the Istanbul price.

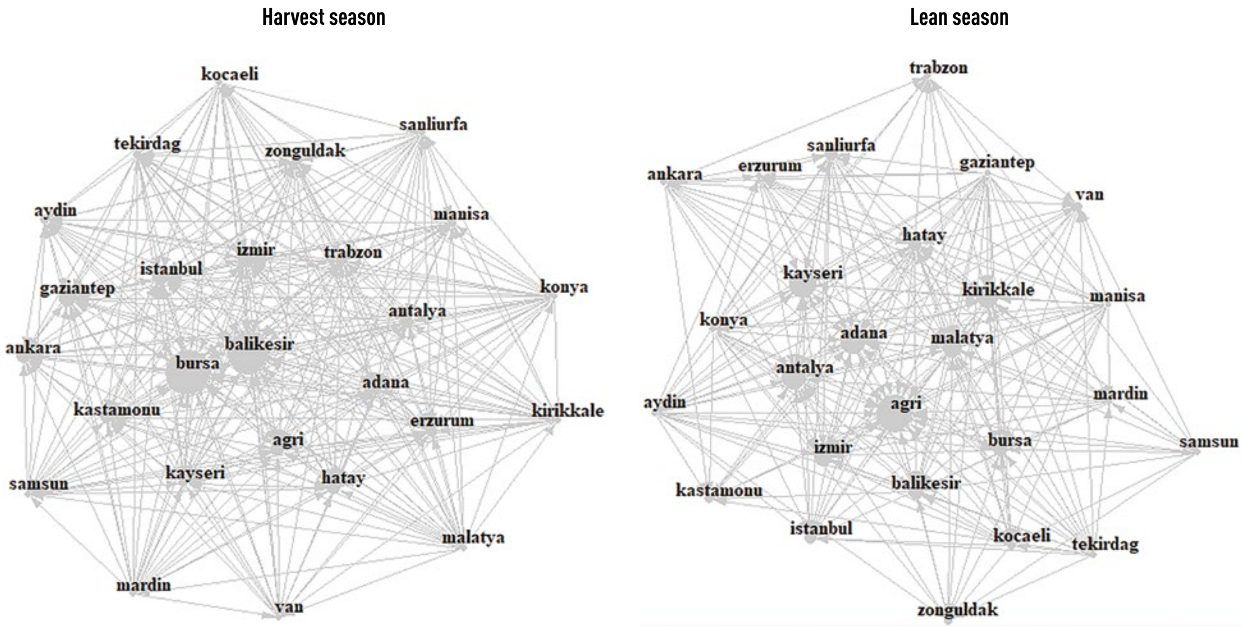
Source: Authors.

41 See Appendix 7 for more detailed results.

Eastern European markets that serve as the key importers of Turkish fresh tomatoes. All the major road routes used to transport Turkish cargo to this region start out in Bulgaria and continue to Romania, Moldova, Ukraine, Belarus and Russia. For Russia, another route involves ferries travelling straight to Novorossiysk, but it is not popular due to a limited ferry schedule and low capacity. As mentioned previously, in 2016–2018, Romania, Belarus, and Ukraine were the largest importers of Turkish fresh tomatoes, and prior to 2016 Russia was the largest importer. Exports remain consistently high during the entire year, which explains the importance of the Tekirdag region in price formation in both lean and harvest seasons. As such, between 2015 and 2018, Turkey on average exported $25.0 million worth of tomatoes per month, ranging from $16.4 million during the summer and early fall months to $33.6 million during the late fall to early spring months. Given that the regions responsible for influencing most domestic tomato markets are located close to the border with access to the largest importers, one can infer that the domestic pricing mechanism for these two commodities is largely influenced by export demand pressure from these countries.[42]

For green peppers, regional price linkages reflect the highly seasonal nature of production. During the harvest season, Balikesir and Bursa serve as the most influential markets (Figure 33).[43] Both regions are among the largest producers of green peppers, accounting for 18.4 percent of total production, pointing to the downward supply pressure on prices during harvest. In contrast, during the lean season, deficit markets, such as Agri, Kayseri, and Kirikkale become important for price formation, exerting an upward pressure on the prices of peppers. At the same time, the largest greenhouse pepper producing regions, Adana and Antalya, provide an annual supply of peppers, counterbalancing the existing deficit in the lean season. The findings reconfirm an earlier conclusion that there are significant gains for farmers from applying better post-harvest storage

Figure 33. **Green Pepper Price Structure During the Harvest and Lean Seasons**



Source: Authors.

[42] This association is conjectural. To formally test it we would need similar price series for the corresponding markets in the neighboring countries. (See Baffes and Kshirsagar, 2020 for an example.)

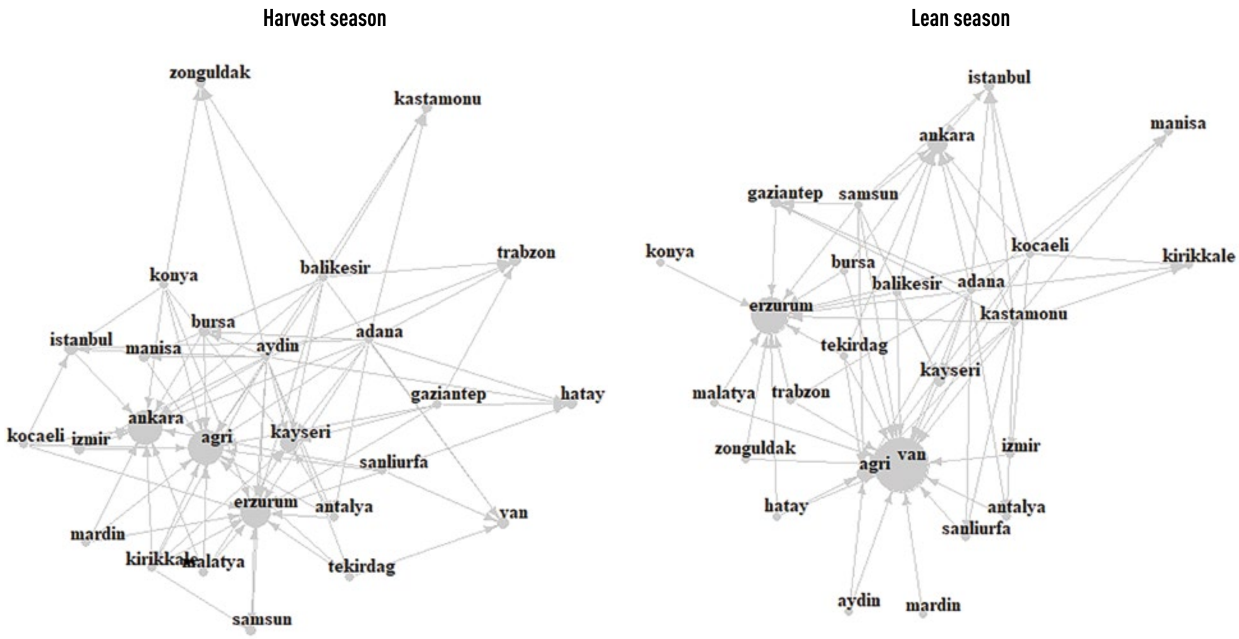
[43] See Appendices 7 and 8 for more detailed results.

techniques and extending the production season through greenhouse production to take advantage of seasonal price differentials.

Both cross-regional supply and demand imbalances and export demand play a role in the price formation of dry onions. In the harvest season, regions driving the price formation are a surplus region: Ankara, which is one of the largest producers of onions in the country; and two deficit regions: Erzurum and Agri (Figure 34).[44] Both regions produce very limited volumes of onions and have the lowest yields in the country. In addition, Agri borders Georgia, which historically has been one of the three largest importers of Turkish onions, exerting additional demand pressure on the region. Historically, more than 60 percent of onion trade with Georgia took place between May and July. In the lean season, price formation is primarily driven by the region of Van that borders Iraq, the second largest importer of Turkish onions. Between 2010 and 2018, Iraq on average imported $5.4 million worth of onions from Turkey annually with more than 90 percent of imports taking place from October to March.

Implications for policymakers. The network centrality analysis highlights the important role played by border markets in price formation for onion and tomato markets, as well as the important role of seasonal demand and supply imbalances across selected regions for green peppers. Apart from the need to reduce the effects of seasonality of production on market prices that is discussed in more detail in the previous section, an important implication of the analysis of demand and supply shocks presented here is the need to strengthen agricultural market information systems in the country. Such systems should offer just-in-time provision of supply, demand, and price information in order to enhance market transparency and point to existing cross-regional supply and demand imbalances. In turn, this would lead to a more efficient allocation of resources in vegetable markets. Creating an enabling environment for agricultural e-commerce

Figure 34. **Dry Onion Price Structure During the Harvest and Lean Seasons**



Source: Authors.

[44] See Appendices 7 and 8 for more detailed results.

is another avenue for the government to lower transaction costs that exist in vegetable markets by facilitating price discovery, helping match buyers and sellers, and reducing the cost and time of each transaction.

Transmission of prices across regions

Transmission of prices for commodities in markets separated by time, market form, and space are an important indicator of overall market efficiency and performance. The conceptual underpinnings of any price transmission model rely on arbitrage conditions which dictate that prices that wander too far apart trigger spatial activities that act to draw prices together (i.e., by buying where the commodity is cheap and selling where it is demanded). Thus, arbitrage ensures that price differentials (i.e., the difference between two prices at the same point in time) will be disciplined so as to not wander arbitrarily in excess of transport or processing costs. Adherence to perfect price transmission is often termed as the "Law of One Price" (LOP)[45] that implies perfect transmission of shocks and price and exchange rate transmission elasticities equal to one. Elasticity of less than one suggests some barriers to the transmission of price shocks. This may reflect policies, market infrastructure (i.e. storage, distribution), and shortcomings in transportation networks.

Three types of analyses were conducted to test market efficiency for table tomatoes, green peppers, and dry onions in Turkey. Spatial price transmission was tested across major wholesale markets[46] in the country and across several surplus and deficit markets for the analyzed vegetables. In addition, vertical price transmission between consumer and producer prices was tested for onion prices.[47] Consumer prices[48] were regressed on producer prices at each location. In both cases, the Engel-Granger cointegration procedure was used to estimate the long run cointegration relationship and the implied price transmission elasticities. In addition, for spatial price transmission, Johansen cointegration tests were conducted for each of the relevant pair-wise price comparisons (see Appendix 8 for more details on methodology). Finally, for the spatial price transmission analysis, multivariate VAR models containing the entire set of consumer prices for each individual commodity were analyzed to generate orthogonalized impulse response functions to test how each analyzed market responds to an exogenous shock (one standard deviation of the VAR error terms).

The results of the spatial price transmission analysis suggest that wholesale and consumer prices appear to move in a similar pattern in the long run.[49] The long-run price transmission was tested between two central markets, Istanbul and Ankara,[50] and a wide variety of "satellite" markets across the country. For the wholesale price transmission tests, such satellite markets included Adana, Antalya, Aydin, Manisa, Mersin, and Samsun. These are the regions that have the

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45 A typical specification of the LOP, given in logarithmic terms, is

$$p_t^i = \alpha_0 + \beta_1 p_t^j + \beta_2 \pi_t^{ij} + \varepsilon_t$$

where p_t^i is the logarithmic transformation of the price in market i and π_t^{ij} is the exchange rate for market j in terms of market i's currency. For prices quoted in the same currency, the logarithmic exchange rate is zero. Perfect market integration and adherence to the LOP is implied when $\alpha_0 = 0$ and $\beta_1 = 1$, reflecting the arbitrage condition of $p_t^i = p_t^j$. This condition, however, abstracts from trade and transportation costs, which may impose significant differences in regional market prices.

46 For this analysis, daily price data for the period from January 1, 2018 to December 31, 2019 was used.

47 Similar analyses were not conducted for table tomatoes and green peppers due to missing data in the corresponding price series.

48 For this analysis, monthly price data for the period from January 2005 to December 2019 was used.

49 Spatial trade is, by definition, a dynamic process since commodity exchanges across different markets likely involves delivery lags. This may suggest that deviations from a parity equilibrium exist but should not be persistent in the long run.

50 The choice of these two central markets, against which all satellite market prices are compared, is somewhat arbitrary. However, these two cities are the largest in Turkey and thus are likely to be important in the distribution of commodities to consumers. Ankara also plays an important role as a large producer of onions and tomatoes.

largest wholesale markets in the country. For the consumer price transmission tests, the satellite markets included Antalya, Bursa, Istanbul, Izmir, Konya, Samsun, Trabzon, and Van, representing a mix of surplus and deficit markets for tomatoes, green peppers, and onions located throughout the country. The results presented in Appendix 7 show that long-run price transmission elasticities, denoted as slope parameters, are always statistically significant and generally range from 0.60 to 1.0 for wholesale prices and 0.85 to 1.0 for consumer prices, suggesting that the markets are well-integrated. Additional Johansen trace cointegration test results further confirm that the logarithmic prices are cointegrated with some exceptions.

An analysis of the speed and magnitude of the transmission of short-term shocks confirms high levels of market integration across wholesale markets. Findings show that all analyzed markets respond to shocks in the central markets. For daily onion prices, Antalya, Manisa, and Mersin appear to have prominent interactions with the other markets in that exogenous shocks to these markets tend to result in statistically significant responses in most of the other markets. In the case of daily pepper prices, strong price leadership roles are exhibited by Adana, Istanbul, Mersin, and Samsun. In the case of daily wholesale tomato prices, the impulses again represent reasonably strong evidence of well-integrated markets. Exogenous shocks to most markets trigger statistically significant reactions in the other markets. In nearly every case, market shocks appear to trigger reactions in other markets. In all cases for wholesale prices, the adjustments to exogenous shocks are rapid and are only significant for the first few days after the shock.

For consumer prices, differences in transmission patterns across the regions point to the existence of market inefficiencies.[51] **For monthly consumer prices, for most of the analyzed regions** exogenous shocks again usually evoke adjustments that are complete on average after 0.5–1 month (see Appendix 7 for detailed results). However, some markets do not appear to be well-integrated in that exogenous shocks do not tend to affect other local markets. This is the case for the Izmir and Trabzon tomato markets, Van pepper markets, and Konya and Samsun onion markets.

While there is a relatively good, albeit not uniform, transmission in consumer prices across regions, the strength of the relationship is much weaker between consumer and producer prices. Data limitations resulted in a formal price transmission analysis to be conducted only for onions. The results presented in Table 13 show that price

Table 13. **Pairwise (Consumer and Producer) Cointegration Regression and Tests for Monthly Dry Onion Prices**

Market	Intercept		Slope		R Square	Johansen Trace
	Estimate	Std. Err.	Estimate[52]	Std. Err.		
Izmir	0.4021	0.0316	0.7440	0.0780	0.46	4.72
Bursa	0.5195	0.0567	0.5874	0.1722	0.10	8.06
Ankara	0.4811	0.0371	0.5355	0.0426	0.60	6.03
Konya	0.3970	0.0360	1.1290	0.1118	0.49	10.07
Isparta	0.2338	0.0211	1.2197	0.0854	0.66	5.74
Samsun	0.6239	0.0338	1.1161	0.0649	0.74	6.07
Trabzon	-0.0834	0.0722	0.6763	0.1361	0.19	2.56
Van	0.5690	0.0321	0.6964	0.0886	0.37	5.96

Source: Authors

[51] Results for wholesale and consumer price transmission cannot be directly compared due to differences in the length of the analyzed series. See footnote above.

[52] Greater than one price transmission elasticity points to a certain degree of "overshooting" in adjustment to price shocks at the producer level.

transmission elasticity, measured by a slope estimate, remains relatively low for most of the analyzed markets. This is also evidenced in the much lower R-square values, when compared to the results of the spatial price transmission. Adjustments to equilibrium shocks are also much slower than in the case of consumer prices. Here, the half-lives of price adjustments generally last around 3–4 months, which suggests that one-half of the deviation from equilibrium is eliminated over a 3- to 4-month period.

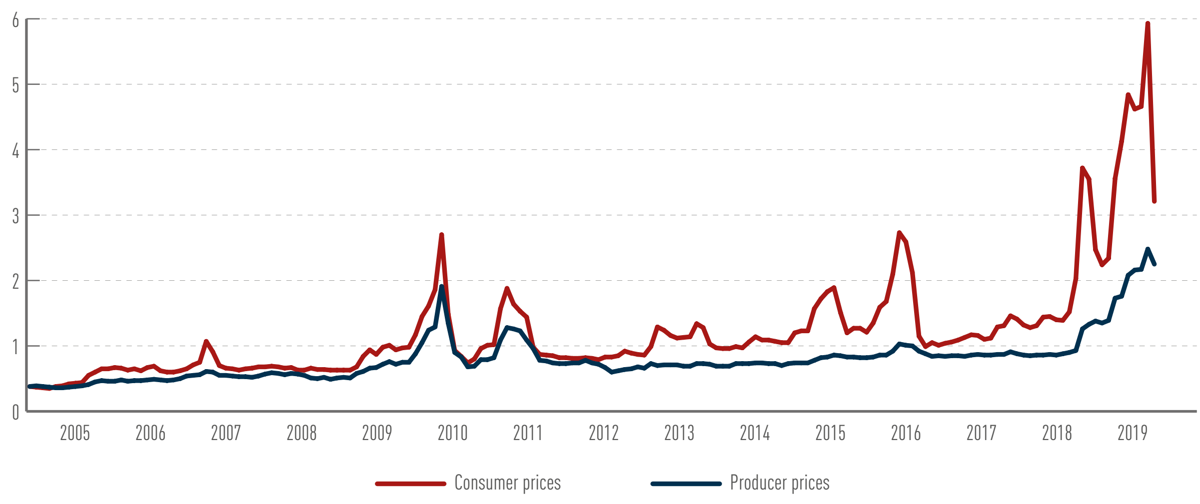
This is also reflected in the visual analysis of the onion prices over time (Figure 35). After 2012, producer prices for dry onions have been increasingly de-linked from consumer prices. This tendency increased in 2018, implying that onion producers do not benefit from high price signals paid by consumers. With an increase in input prices as shown earlier, the profit margins of the onion producers are squeezed between high input costs and low farm-gate prices.

Similar dynamics are observed for tomatoes (Figure 36). Consumer prices have been growing at a much higher rate than producer prices. In the Aydin region, a wedge between consumer and producer prices emerged in 2014 and has progressively increased since then, particularly since 2016. In the Antalya region a divergence in prices accelerated in late 2017 with a particularly sharp difference observed since the summer of 2018. The findings suggest that while food price growth has accelerated, price increases have not been passed through to producers, limiting their incentives to improve productivity.

An increasing wedge between producer and consumer prices for both onions and tomatoes in recent years is at least partially driven by supply shocks. The Aydin and Antalya regions were hit by severe floods in the summer of 2018, which had a devastating impact on tomato greenhouse production and led to price spikes that were absorbed by consumers. In the same year, production volumes decreased for onions, driven by unfavorable weather conditions, product loss due to diseases, and losses in warehouses as well as shrinkages in the production area due to decreasing profit margins for producers. This led to a sharp increase in consumer prices for onions that was alleviated in early 2019, when the government reduced import tariffs to zero, allowing onion imports. In both cases, the price increases were absorbed by consumers, but not transferred to producers.

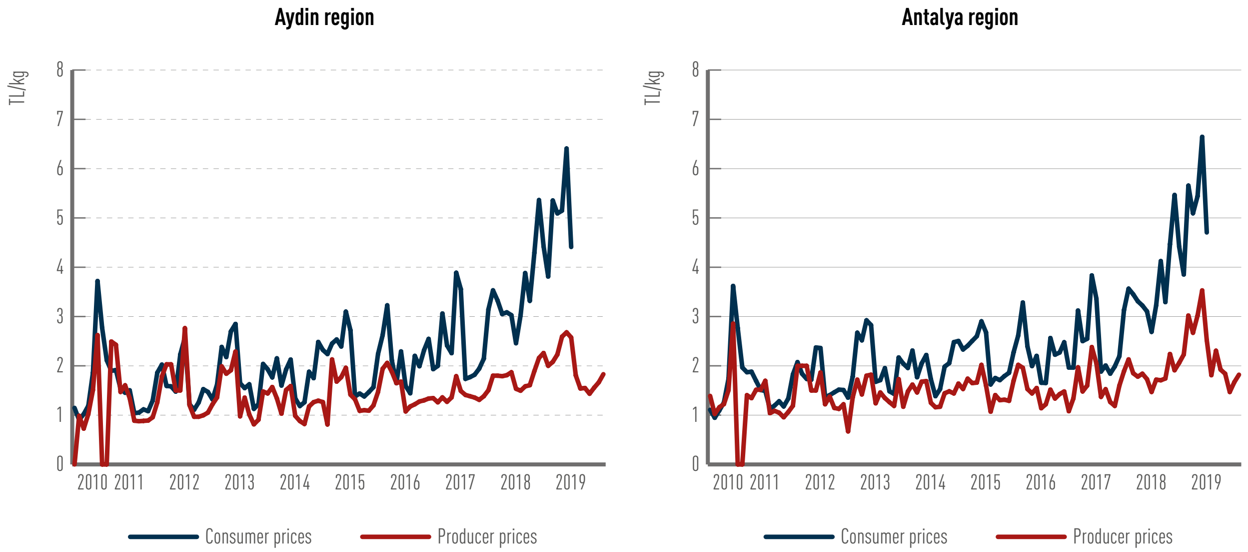
The current structure of the agri-food supply chains in Turkey is characterized by various factors that may be limiting vertical price transmission efficiency. A deeper look into the

Figure 35. **Comparison of Producer and Consumer Prices for Onions**



Source: TURKSTAT, 2019

***Figure 36.* Comparison of Producer and Consumer Prices for Table Tomatoes**



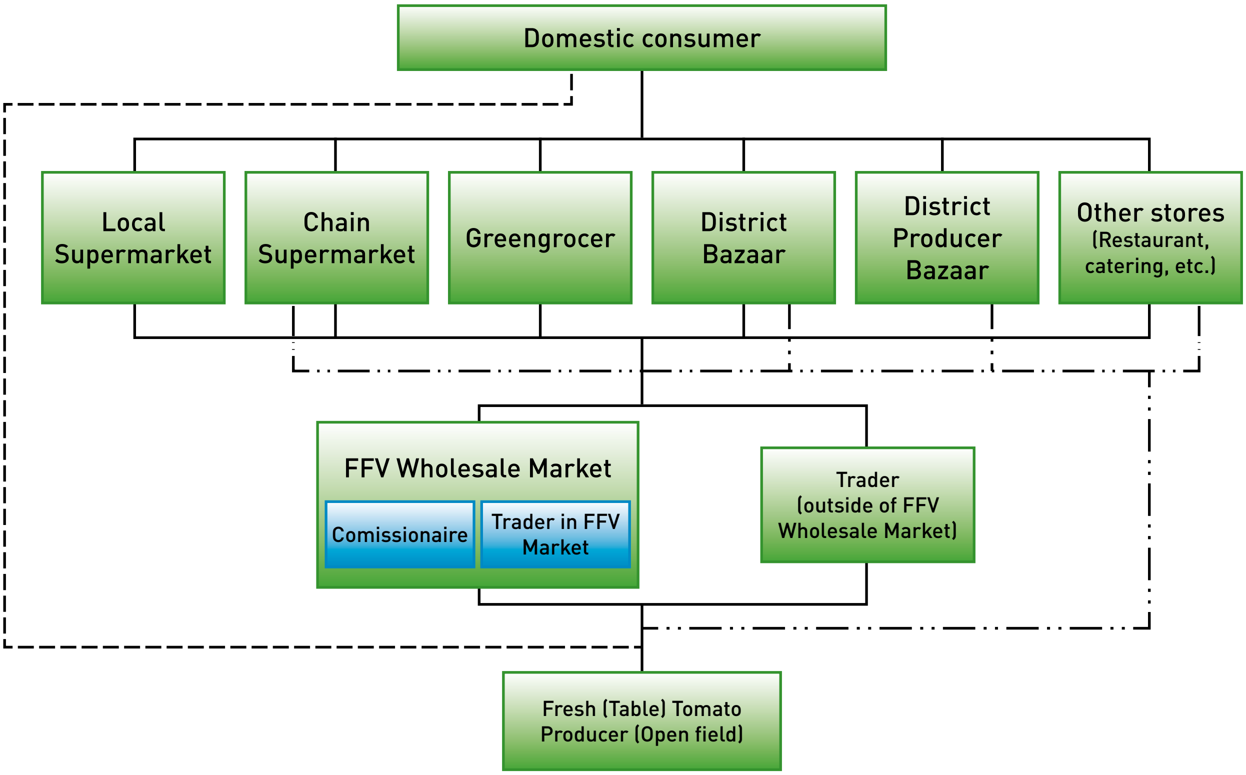
Note: Complete producer price data is only available for Aydin and Antalya where year-round tomato production in greenhouses takes place.

Source: TURKSTAT, 2019

structure of the tomato value chain (Figure 37) offers insights into where such inefficiencies may exist. Under Turkish Law, there are three types of wholesale activity: commissioner, trader, and producer groups. Commissioners mediate between farmer and retailer for a commission (up to 8 percent of the farm gate price) without owning the product (EBRD, 2018). Traders, on the other hand, buy the products from farmers and sell them to retailers. In general, the role of the local trader or commissioner is critical to the producer: they advance all liquidity needs in the crop cycle through cash, provide inputs, support the organization of manual labor, and offer technical crop and weather advice, which binds the farmers to directly sell to their specific buyer. Producer groups are generally not active in the fresh vegetable or fruit sectors. Two thirds of the fresh tomatoes produced in Turkey are sold through traders and commissioners while the remainder are sold by farmers directly to retail chains.

Tomato farmers have very limited bargaining power when dealing with both wholesalers and retailers. A study conducted by EBRD (2018) analyzed profit margins received by tomato farmers, wholesalers, and retailers in the Izmir region under three scenarios of marketing flows: 1) producer–wholesale commissioner–retailer; 2) producer–trader (registered/informal); and 3) producer–retailer. Under the first scenario, profit margins for farmers, commissioners, and retailers were 7, 8, and 13 percent, respectively. When the commissioner is replaced with an unregistered collector (trader), the price received by the farmer does not change, but the trader is able to sell tomatoes to retailers at a cheaper price, since s/he does not pay tax. This increases the profit margin of the retailer by 2 percent. In the third flow, supermarkets collect tomato harvests from the farmers directly. Under this scenario, farmers still receive the same price as in the previous scenarios, but supermarket profit margins increase to 21 percent. The analysis presented here indicates that domestic tomato price formation, in the case of consumer prices, is largely being driven by export markets. While profit margins were not estimated for a marketing flow scenario "producer–trader–exporter", given the price divergence in consumer and producer prices for tomatoes, it is plausible to assume that farmers have a limited bargaining power in this scenario as well.

Figure 37. **The Structure of the Fresh Tomato Value Chain in Turkey**



Source: EBRD, 2018

Implications for policymakers. Divergence between producer and consumer prices shows that producers do not receive the existing market price signals due to structural inefficiencies along the value chains and limited cross-regional linkages. Hence, any policy aimed at increasing productivity associated with the production cycle, that is extension, access to credit, etc., will have only a limited impact on farmers' incentives to improve productivity if they do not receive higher prices for their produce. Limited cross-regional price transmission further points to deficient market linkages resulting in an inefficient allocation of resources. Policies and strategies aimed at linking farmers to local and national markets through improved collective action, better market transparency and digital marketplaces, to name a few, will result in higher farm-gate prices and greater incentives for farmers to adopt productivity enhancing measures.

IV. Policy Recommendations

Food price inflation in Turkey is complex and driven by various interacting and interdependent factors. The depreciation of the Turkish lira and inflation expectations, demand-side pressures of a growing population, changing consumer preferences, as well as supply-side elements, such as low productivity, constitute the mix of factors that drive food price inflation in the long run. These factors work alongside short-run supply and demand imbalances at the local level and increase price variability across the country. Short-term positive price shocks can further impose upward pressure on price levels over time, if structural inefficiencies prevent such shocks from returning to their initial equilibrium.

Macroeconomic factors play an important role in driving price inflation, including food price inflation, in the country, hence, anchoring inflationary expectations and reducing currency volatility are of utmost importance to temper price level growth. Unanchored expectations can contribute to dollarization and capital outflows (or a slowdown in capital inflows); this can fuel inflationary pressures through exchange rate pass-through. Moreover, unanchored expectations can also fuel a wage-price spiral as wage adjustments factor in higher inflation expectations, becoming a self-fulfilling prophecy. In this regard, the most crucial elements of the monetary policy response to contain food prices in the short run should focus on strengthening external buffers, reducing market anxieties and managing inflationary expectations. This would help reduce exchange rate volatility and inflationary pressures.

Agricultural and trade policies also play an important role in addressing the issue of food price inflation: policies should aim to strengthen long-run productivity growth and reduce structural inefficiencies and seasonality of production to tackle short-term price variability. The various policy options which exist are summarized in Table 14 and categorized across low and high variance drivers of price inflation, as discussed in section two of the analysis. In the medium- to long-run the focus should be on bringing productivity and efficiency gains through the liberalization of imports and investments in agricultural R&D, logistics and distribution. In the short term, policy responses should focus on reducing short-term production shocks, including the seasonal variability of production, as well as strengthening farmers' skills for improved

Table 14. **Framework for Public Policy Options to Address High Food Price Inflation and Volatility**

	Areas for short-term policy response	Areas for medium-term policy response
Low Variance Drivers	Knowledge and skills Environmentally sustainable practices Access to credit	Investment in R&D Climate change adaptation and mitigation Trade policy
High Variance Drivers	Seasonality of production Market transparency Market linkages	Investments in logistics and distribution

Source: Authors

productivity and improving cross-regional market and supply chain linkages.

Strengthening long-run productivity

Increasing productivity and the resilience of food production in the country should be the priority of any policy response targeted at controlling food price inflation and volatility. As shown in sections two and three of the report, Turkey lags behind comparator countries in terms of land and labor productivity; yields for table tomatoes, green peppers, and onions remain well below their potential. For domestic supply to keep up with growing demand pressures, higher productivity growth needs to be achieved. Productivity gains can be achieved by increasing labor, land, and physical capital productivity under current uses, and by reallocating productive assets within the sector. In the short term, better access to credit and better extension services can help improve productivity. In addition, incentives to implement environmentally sustainable practices need to be introduced to decrease the existing and future implications of natural resource depletion.

In the medium term, state expenditures in agriculture should be repurposed toward the provision of public goods. Such public goods include R&D; pest-and-disease control; strong public and private food safety standards; and an enabling environment for private investment. Currently, Turkey spends 78 percent of total support in agriculture[53] on market price support and payments based on input use, which may have negative impacts on production (OECD, 2020). Spending on GSSE, on the other hand, accounts for only 15 percent of total agricultural spending and less than one percent of the aggregate value of agricultural production. Within this allocation, development and maintenance of infrastructure accounts for approximately 75 percent, while expenditure for agricultural knowledge and innovation systems averages only 5 percent.

In addition, medium-term policy should focus on import liberalization to drive competitiveness and efficiency gains in Turkey's agricultural sector. Turkey's agricultural markets are among the most protected in the world. In the short run, import restrictions make the supply curve less elastic, leading to more variable price responses. Over the long run, import protection may have significant impacts on the efficiency and competitiveness of the sector. Turkey's trade policy should focus on the gradual lowering of import tariffs to alleviate the short- and long-term implications of trade protection. This process, however, should be aided by supporting farmers to increase their productivity and thereby, competitiveness in international markets.

Reducing price variability associated with seasonality

The analyses of price decomposition and price shock origins highlighted the importance of seasonality in price formation for the analyzed vegetables, particularly green peppers. Significant gains can be made in the short run by supporting farmers with better post-harvest storage techniques that would allow farmers to take better advantage of seasonal price differentials. There are also potential gains from lengthening the production season through investments in greenhouse production. Policy interventions, such as creating an enabling environment for producers to access finance and strengthening collective action in the sector, can help small-scale farmers access more advanced storage technologies and greenhouse production methods as well as enhance marketing opportunities for smallholders, particularly into the more lucrative formal retail markets. In addition, training and educating farmers through extension services, including e-extension, can increase farmers' knowledge of post-harvest handling and storage of vegetables.

Improving market integration to facilitate price pass-through to producers

Low domestic market integration exacerbates seasonal price fluctuations, as the price transmission and price network analyses, highlighted in section three of the report, showed. In addition, if domestic markets are not well integrated, farmers may not benefit from price increases.

[53] Total support estimate.

This reduces the welfare of farmers and limits their incentives to invest in productivity-enhancing technologies. Several policy interventions can help improve market transparency and linkages.

Farmer organizations can play a critical role in facilitating farmers' access to markets. They can contribute to increasing farm productivity and supply by reducing production costs, helping meet market standards, adding value, and integrating small producers into value chains. Relevant international experience includes the histories of Land O'Lakes and Ocean Spray, large agribusinesses in the United States that are organized as cooperatives.

Currently, in Turkey, there exists room for improvement when it comes to the capacity of farmer organizations, including their access to finance. There is a need for strengthening supporting policy and enabling frameworks in order to increase the effectiveness of farmer organizations. A recent study (World Bank, 2018) offered guidance on how to facilitate the creation and functionality of farmer organizations by simplifying the relevant legal and regulatory frameworks. Key elements for regulatory and policy reforms include: (a) improving the legal/regulatory framework for farmer organizations modelled after global best practices and based on the principles of self-governance and entrepreneurship; (b) introducing an incentives framework that links access to finance with institutional development, including benchmarks towards professionalization, accountability, and market orientation; (c) providing technical assistance for capacity development for farmer organizations to achieve professionalization (through matching grants or direct support); (d) establishing an independent regulatory agency for farmer organizations; and (e) developing a knowledge management and training system for farmer organizations.

Enhanced agricultural market and price monitoring can reduce information asymmetries and improve market efficiency. For farmers, market information can improve their awareness of market opportunities and options and strengthen their bargaining power. For traders, market information can help them identify markets with good arbitrage opportunities.

Agricultural value chains can be made more efficient by simplifying regulations, eliminating entry restrictions, and allowing for more competition. The lack of competition and need for improving regulations at the wholesale and retail levels may be contributing to high food prices and limiting the pass-through of price signals to farmers. In addition to regulatory changes, policy should focus on making price formation more transparent at the wholesale market level by monitoring (a) transactions between commissioners and traders 'inside-the-zone' and 'outside-the zone'; (b) prices paid to farmers by commissioners and traders; (c) prices paid to commissioners and traders by retailers; and (d) volumes of trade and types of products sold between wholesale zones in different cities.

Digitalization of agriculture can serve as a tool for alleviating some of the frictions that exist in the Turkish value chains and increasing the efficiency of agricultural production. Digitalization can provide stakeholders along the value chain with better access to information about input and product markets; reduce reliance on intermediaries; and better align production with demand. Digital advisory services can improve the knowledge of agricultural producers by offering information on production and post-harvest methods, on-farm storage techniques, use of new technology, fertilizers and agro-chemicals, standards, and financial management. Accurate and timely market information through data collection, data analytics, and communication platforms offer great potential for more equitable market access for farmers. New digital platforms and applications can more efficiently link producers to consumers. Turkey has great preconditions for advancing the digitalization of agriculture, however, additional investments are needed (World Bank, 2020).

Policies, strategies, and investments aimed at linking farmers to local and national markets and facilitating access to processing, storage, and distribution systems can help reduce regional food price dispersion across Turkey. The government can address infrastructure bottlenecks by creating an enabling environment for private investment in processing, cold storage, and delivery systems to ensure quality and safety and stimulate public and private partnerships.

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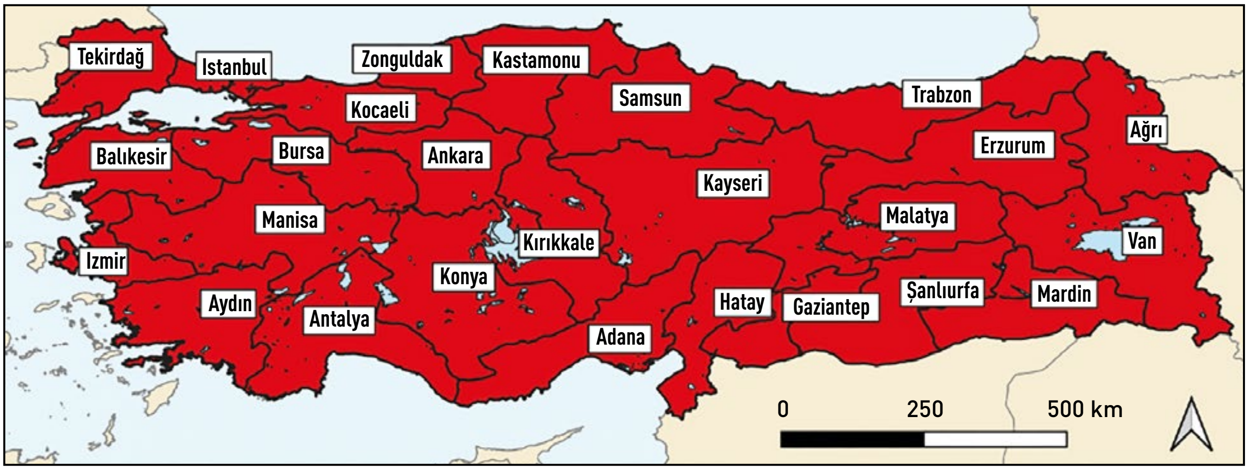
Appendix 1. Turkey Administrative Structure (NUTS-2)



Appendix 2. Supply and Demand Balances for Tomatoes, Green Peppers, and Dry Onions

Table A.2.1. **Supply and demand balances for tomatoes**

	Unit	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2017/18	2018/19	2019/20
Production	Ton	10,052,000	11,003,433	11,350,000	11,850,000	11,850,000	12,615,000	12,750,000	12,150,000	12,841,990
Harvest losses	Ton	351,820	385,120	397,250	414,750	414,750	441,525	446,250	425,250	449,470
Supply=Use	Ton	9,712,652	10,630,086	10,963,759	11,446,552	11,444,975	12,184,425	12,314,993	11,759,556	12,409,949
Supply										
Usable production	Ton	9,700,180	10,618,313	10,952,750	11,435,250	11,435,250	12,173,475	12,303,750	11,724,750	12,392,520
Imports	Ton	12,472	11,773	11,009	11,302	9,725	10,950	11,243	34,806	17,492
EU 27/28	Ton	4,090	5,092	6,736	4,658	7,060	7,710	8,915	9,661	9,327
Use										
Domestic use	Ton	8,672,133	9,513,286	9,848,760	10,187,265	10,317,759	10,989,375	11,109,482	10,604,454	11,189,964
Human consumption	Ton	7,804,920	8,561,957	8,863,884	9,168,539	9,285,983	9,340,969	9,443,060	9,013,786	9,511,470
Losses	Ton	867,213	951,329	984,876	1,018,727	1,031,776	1,648,406	1,666,422	1,590,668	1,678,495
Exports	Ton	1,040,519	1,116,800	1,114,999	1,259,287	1,127,216	1,195,050	1,205,511	1,155,102	1,219,985
EU 27/28	Ton	320,241	341,368	336,278	406,910	374,034	447,103	506,454	390,548	471,786
Change in stocks	Ton	–	–	–	–	–	–	–	–	–
Human consumption per capita	Kg	105.87	114.6	117.2	119.6	119.5	118.6	116.9	109.9	114.4
Degree of self – sufficiency	%	111.85	111.6	111.2	112.3	110.8	110.8	110.7	110.6	110.7

Table A.2.2. **Supply and demand balances for green peppers**

	Unit	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2017/18	2018/19	2019/20
Production	Ton	1,986,700	1,975,269	2,042,360	2,232,308	2,232,308	2,307,456	2,608,172	2,554,974	2,625,669
Harvest losses	Ton	37,699	37,379	38,679	42,137	42,137	43,500	43,500	47,975	49,122
Supply=Use	Ton	1,950,293	1,939,972	2,005,283	2,190,959	2,191,030	2,265,494	2,567,204	2,508,960	2,578,343
Supply										
Usable production	Ton	1,949,001	1,937,890	2,003,681	2,190,171	2,190,171	2,263,956	2,564,672	2,506,999	2,576,547
Imports	Ton	1,292	2,082	1,602	788	859	1,538	2,532	1,961	1,796
EU 27/28	Ton	395	74	47	121	134	224	793	850	340
Use										
Domestic use	Ton	1,772,422	1,795,117	1,845,886	2,020,095	2,019,864	2,072,620	2,348,415	2,302,402	2,342,505
Human consumption	Ton	1,595,180	1,615,605	1,661,298	1,818,086	1,817,878	1,865,358	2,113,574	2,072,161	2,108,255
Losses	Ton	177,242	179,512	184,589	202,010	201,986	207,262	234,842	230,240	234,251
Exports	Ton	177,871	144,855	159,397	170,864	171,166	192,874	218,789	206,558	235,838
EU 27/28	Ton	131,336	102,992	108,567	116,746	108,643	126,989	141,177	132,118	147,566
Change in stocks	Ton	–	–	–	–	–	–	–	–	–
Human consumption per capita	Kg	21.64	21.6	22	23.7	23.4	23.7	26.2	25.3	25.4
Degree of self – sufficiency	%	109.96	108	108.5	108.4	108.4	109.2	109.2	108.9	110.0

Table A.2.3. **Supply and demand balances for dry onions**

	Unit	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2017/18	2018/19	2019/20
Production	Ton	1,900,000	2,141,373	1,735,857	1,790,000	1,790,000	1,879,189	2,175,911	1,930,695	2,200,000
Harvest losses	Ton	79,800	89,938	72,906	75,180	75,180	78,926	91,388	81,089	92,400
Supply=Use	Ton	1,827,830	2,051,822	1,663,003	1,715,992	1,726,095	1,800,466	2,084,695	1,977,573	2,108,174
Supply										
Usable production	Ton	1,820,200	2,051,435	1,662,951	1,714,820	1,714,820	1,800,263	2,084,523	1,849,606	2,107,600
Imports	Ton	7,630	387	52	1,172	11,275	203	172	127,967	574
EU 27/28	Ton	0	–	–	–	1,313	–	0	0	0
Use										
Domestic use	Ton	1,726,189	1,908,142	1,551,875	1,513,156	1,641,045	1,763,017	1,927,428	1,899,486	1,864,166
Human consumption	Ton	1,614,800	1,786,288	1,445,388	1,413,481	1,534,975	1,651,785	1,807,980	1,783,426	1,746,414
Seed use	Ton	25,079	26,448	28,893	24,018	24,018	23,082	23,077	21,085	24,544
Losses	Ton	86,309	95,407	77,594	75,658	82,052	88,151	96,371	94,974	93,208
Exports	Ton	101,641	143,680	111,128	202,836	85,050	37,449	157,267	78,087	244,008
EU 27/28	Ton	12,926	3,235	3,588	31,017	8,973	10,912	1,535	25,256	22,676
Change in stocks	Ton	–	–	–	–	–	–	–	–	–
Human consumption per capita	Kg	21.90	23.9	19.1	18.4	19.8	21.0	22.4	21.7	21.0
Degree of self – sufficiency	%	105.45	107.5	107.2	113.3	104.5	102.1	108.2	97.4	113.1

Appendix 3. Methodology for Price Co-movement Analysis

To measure the price co-movement among prices of tomatoes, green peppers and dry onions, the following measure of dynamic correlation between two prices, p^i and p^j, at frequency λ has been applied as follows (Croux, Forni, and Reichlin 2001):

$$\rho_{p^i p^j}(\lambda) = \frac{C_{p^i p^j}(\lambda)}{\sqrt{S_{p^i}(\lambda) S_{p^j}(\lambda)}}.$$

$C_{p^i p^j}(\lambda)$, is the co-spectrum between p^i and p^j; $S_{p^i}(\lambda)$ and $S_{p^j}(\lambda)$ are spectral-density functions of p^i and p^j, and $-\pi \leq \lambda \leq \pi$, where $-1 \leq \rho_{p^i p^j}(\lambda) \leq 1$.

Equation (1) can be expressed within a given frequency interval, say $\Lambda_+ = [\lambda_1, \lambda_2]$, $0 \leq \lambda_1 < \lambda_2 \leq \pi$, in the multivariate framework as follows:

$$coh_{p^i p^j}(\Lambda_+) = \frac{\Sigma_{i=1}^{n} \Sigma_{j=1}^{m} w_{p^i} w_{p^j} \rho_{p^i p^j}(\Lambda_+)}{\Sigma_{i=1}^{n} \Sigma_{j=1}^{m} w_{p^i} w_{p^j}}$$

where p_t^i and p_t^j represent n- and m-vectors of time series, $p_t^i = (p_t^1, p_t^2 \ldots p_t^n)'$ and $p_t^j = (p_t^1, p_t^2 \ldots p_t^m)'$ and w_{p^i} and w_{p^j} denote vectors of non-normalized weights associated with p_t^i and p_t^j, respectively. Like the dynamic correlation, $-1 \leq coh_{p^i p^j}(\Lambda_+) \leq 1$, with the standard interpretation. This allows for estimating price co-movement at different frequencies using equal or different weights. Co-movement within the frequency domain is increasingly being used. See, for example, Igan et al. (2011), who analyzed co-movement of business cycles in house prices and several macroeconomic variables of 18 advanced economies during 1981–2006 as well Schuler, Hiebert, and Peltonen (2015) who undertook a cross-country co-movement analysis on the financial medium-term cycles.

Appendix 4. Price Decomposition Results for Tomatoes, Green Peppers, and Dry Onions

Table A.4.1. **Share of price variance explained by seasonal and cyclical components, a long-term trend, and cross-regional dynamics**

Region	Green Peppers			Table Tomatoes			Dry Onions		
	$C_t^{[0,1]}$	$C_t^{[0,8]}$	T_t	$C_t^{[0,1]}$	$C_t^{[0,8]}$	T_t	$C_t^{[0,1]}$	$C_t^{[0,8]}$	T_t
Istanbul	0.38	0.20	0.39	0.19	0.24	0.56	0.15	0.40	0.44
Tekirdağ	0.44	0.20	0.34	0.21	0.24	0.54	0.15	0.38	0.47
Balıkesir	0.36	0.20	0.42	0.22	0.23	0.53	0.12	0.40	0.47
Izmir	0.40	0.21	0.37	0.19	0.26	0.54	0.16	0.45	0.38
Aydın	0.42	0.19	0.37	0.22	0.28	0.49	0.15	0.45	0.38
Manisa	0.45	0.20	0.33	0.20	0.26	0.52	0.13	0.43	0.42
Bursa	0.36	0.19	0.42	0.22	0.26	0.51	0.13	0.40	0.45
Kocaeli	0.46	0.20	0.32	0.18	0.25	0.55	0.15	0.43	0.40
Ankara	0.42	0.15	0.40	0.21	0.22	0.57	0.16	0.39	0.43
Konya	0.47	0.22	0.29	0.20	0.25	0.53	0.16	0.42	0.41
Antalya	0.37	0.19	0.41	0.18	0.25	0.56	0.13	0.42	0.45
Adana	0.45	0.21	0.30	0.21	0.27	0.49	0.14	0.43	0.43
Hatay	0.42	0.19	0.34	0.22	0.26	0.49	0.15	0.39	0.45
Kırıkkale	0.46	0.23	0.29	0.19	0.26	0.53	0.14	0.44	0.41
Kayseri	0.42	0.20	0.35	0.20	0.26	0.53	0.13	0.41	0.44
Zonguldak	0.42	0.19	0.37	0.18	0.25	0.56	0.15	0.41	0.42
Kastamonu	0.38	0.19	0.40	0.17	0.23	0.59	0.13	0.41	0.44
Samsun	0.44	0.19	0.34	0.23	0.25	0.51	0.14	0.42	0.43
Trabzon	0.44	0.19	0.35	0.20	0.25	0.54	0.14	0.42	0.43
Erzurum	0.50	0.18	0.29	0.22	0.27	0.49	0.13	0.38	0.47
Ağrı	0.44	0.19	0.34	0.20	0.27	0.51	0.14	0.38	0.46
Malatya	0.51	0.21	0.26	0.21	0.24	0.53	0.16	0.39	0.43
Van	0.48	0.21	0.28	0.17	0.26	0.54	0.13	0.33	0.53
Gaziantep	0.43	0.21	0.30	0.21	0.27	0.50	0.15	0.40	0.43
Şanlıurfa	0.43	0.22	0.32	0.19	0.26	0.53	0.15	0.40	0.44
Mardin	0.49	0.21	0.28	0.20	0.26	0.53	0.16	0.37	0.46

Notes: T_t, $C_t^{[1-8]}$, and $C_t^{[0-1]}$ denote the trend, cyclical component, and seasonal component. The averages may not add up to 100 since the seasonal component moves from 2 months to 12 months. Hence, the remainder accounts for short-term variation of less than 2 months.

Appendix 5. Bivariate Error Correction and Network Centrality Methodology

The bivariate vector error correction model (Engle and Granger 1987) can be specified as follows. Let p_t^i and p_t^j be nominal (logarithmic) prices at time t for the relevant commodity (tomatoes, peppers or onions) for a pair of markets, i and j. Then, the following error-correction specification for each pair of markets is defined as:

$$\Delta p_t^i = \mu^i + \alpha^{ij}(p_{t-1}^j - p_{t-1}^i) + \gamma_1^i \Delta p_{t-1}^j + \gamma_2^i \Delta p_{t-1}^i + B^i F_t(\bullet) + u_t^i \quad (1)$$

$$\Delta p_t^j = \mu^i + \alpha^{ji}(p_{t-1}^i - p_{t-1}^j) + \gamma_1^j \Delta p_{t-1}^i + \gamma_2^j \Delta p_{t-1}^i + B^j F_t(\bullet) + u_t^j \quad (2)$$

where μ^i, α^{ij}, γ_1^i, γ_2^i, and γ_3^i in equation (1) denote parameters to be estimated; and u_t^i denotes an independently and identically distributed error term. Δ represents the first difference operator. Similar definitions apply for equation (2). The term $B^i F_t(\bullet)$ is defined as follows:

$$B^i f_t(\bullet) = \beta_1 sin\left(\frac{2\pi t}{12}\right) + \beta_2 cos\left(\frac{2\pi t}{12}\right) + \beta_3 cos\left(\frac{4\pi t}{12}\right) + \beta_4 cos\left(\frac{4\pi t}{12}\right)$$

β_s denotes parameters to be estimated; $s = 1, 2, 3, 4$ refer to the seasonality parameters (captured by the *sin* and *cos* functions).

The network analysis component uses the adjustment coefficients from equations (1) and (2) as inputs to a network model, specifically computing the PageRank and betweenness measures—the former is discussed in detail while the latter is just reported in the results. The intention behind the PageRank measure can be understood by considering a naïve hypothetical measure of market linkages. Suppose we set the linkage between markets A and B to 1 if market A influences market B and zero otherwise. Then, we can construct a simple measure of systemic influence based on the number of markets that a given market influences. This hypothetical measure, however, suffers from three shortcomings.

First, because this hypothetical measure takes only the value of one (if markets are linked) or zero (if markets are not linked), it does not consider the strength of the linkage.

Second, the hypothetical measure assigns the same weight regardless of whether connections to this market influence other markets. To see this, consider four markets: A, B, C, and D. Then assume that market A influences market C and market B influences market D; market C does not influence any other market, while market D influences other markets. A naïve approach would assign the same importance to markets A and B. However, centrality measures (including the PageRank measure we employ here) account for the importance of the markets in the context of the network and, thus, assign a higher value to market B and a lower value to market A.

Third, the importance of a market should be adjusted downward if a market influences a market that is also influenced by many other markets. In contrast to the naïve hypothetical measure, the contribution to the PageRank will be higher if a market influences a market with fewer other influences. In the context of the above four-market example (with the markets now playing a different role), assume that A influences C and B influences D. Further, C is influenced by many other markets, but D is only influenced by B, while both C and D have the same PageRank. Then, B will be assigned a higher PageRank than A.

The first shortcoming is addressed by allowing the strength of each linkage to vary according to the size of the parameter estimate. The adjustment coefficients of the error-correction model, α^{ij} $(0 < \alpha^{ij} < 1)$, take the value of the corresponding parameter estimate if it is significantly different from zero at a 1 percent level of significance and zero elsewhere.

The second and third shortcomings are addressed by using the PageRank measure. First, we begin with the matrix of all adjustment coefficient estimates of the error-correction model. Then, we construct a matrix,, the elements of which (denoted as α^{ij}) are related to the adjustment coefficient matrix as follows. If α^{ij} is significantly different from zero at the 1 percent level of significance (which implies that market *i* is influenced by market *j*), the corresponding element of *A*, takes the value of α^{ij}. If α^{ij} is not significantly different from zero in the original matrix, then it takes a value of zero in *A*. Then, matrix *A* is adjusted as follows: If a row has at least one non-zero α^{ij}, the elements of that row are normalized to add up to 1. If all α^{ij} s in a row are zeros, then $\alpha^{ij} = 1/n$, where *n* denotes the number of columns (corresponding to number of markets). This new matrix, denoted by *T*, is the stochastic transition matrix.

To ensure convergence, we follow Brin and Page (1998) and add (to the matrix *T*) a matrix in which every row adds up to 1 and every cell in the row has the same value. A dampening factor equal to 0.85 gives the weight (of the convex combination of the two matrices) assigned to the transition matrix *T*. Let *S* be the matrix created by this convex combination. The PageRank vector, denoted as *PR*, is estimated when convergence of the following equation is reached,

$$PR^{(k+1)} = PR^{k}S, \tag{3}$$

where *k* denotes the number of iterations. We begin with an initial *PR* value that is the same for every market. The stochastic transition matrix *T*, and therefore the market link structure estimated using equations (1) and (2), determines convergence to the final *PR* vector.

The *PR* vector provides a synthesis of the full matrix of adjustment coefficients which reflects the underlying network structure of the market system. Market systems with markets that are either not connected or fully connected with each other will have every market receiving the same *PR* value while market systems with a few dominant markets will have a very unequal *PR* distribution.

Appendix 6. Domestic Market Linkages for Table Tomatoes, Green Peppers, and Dry Onions

Regions	Table Tomatoes		Green Peppers		Dry Onions	
	Harvest	Lean	Harvest	Lean	Harvest	Lean
Adana	0.01	0.01	0.03	0.08	0.02	0.02
Agri	0.01	0.06	0.05	0.13	0.12	0.05
Ankara	0.06	0.05	0.04	0.01	0.12	0.07
Antalya	0.06	0.02	0.03	0.08	0.03	0.03
Aydin	0.01	0.01	0.03	0.01	0.02	0.02
Balikesir	0.06	0.01	0.15	0.05	0.02	0.02
Bursa	0.01	0.01	0.16	0.04	0.03	0.02
Erzurum	0.01	0.01	0.04	0.02	0.10	0.14
Gaziantep	0.01	0.01	0.05	0.01	0.02	0.03
Hatay	0.01	0.01	0.04	0.04	0.03	0.02
Istanbul	0.07	0.13	0.05	0.03	0.04	0.03
Izmir	0.01	0.01	0.05	0.06	0.03	0.03
Kastamonu	0.05	0.05	0.03	0.03	0.03	0.02
Kayseri	0.01	0.01	0.03	0.09	0.06	0.04
Kirikkale	0.01	0.01	0.02	0.06	0.03	0.03
Kocaeli	0.06	0.08	0.02	0.02	0.02	0.02
Konya	0.01	0.01	0.02	0.02	0.02	0.02
Malatya	0.01	0.01	0.02	0.06	0.02	0.02
Manisa	0.12	0.01	0.02	0.01	0.03	0.03
Mardin	0.01	0.01	0.02	0.02	0.02	0.02
Samsun	0.01	0.01	0.02	0.01	0.03	0.02
Sanliurfa	0.01	0.01	0.02	0.04	0.02	0.03
Tekirdag	0.32	0.31	0.02	0.01	0.02	0.02
Trabzon	0.01	0.03	0.02	0.02	0.03	0.02
Van	0.01	0.05	0.02	0.02	0.04	0.20
Zonguldak	0.10	0.13	0.02	0.02	0.03	0.02

Note: Numbers in the columns represent market i's centrality in terms of its influence on other markets.

Appendix 7. Domestic Market Linkages for Table Tomatoes, Green Peppers, and Dry Onions – Spatial Analysis

Figure A.7.1. **Table tomatoes, Harvest season**

Figure A.7.2. **Table tomatoes, Lean season**

Figure A.7.3. **Green peppers, Harvest season**

Figure A.7.4. **Green peppers, Lean season**

Figure A.7.5. **Dry onions, Harvest season**

Figure A.7.6. **Dry onions, Lean season**

Appendix 8. Production and Prices for Table Tomatoes, Green Peppers, and Dry Onions Across the Regions

Table A.8.1. **Table tomatoes**

Region	Population, 2018	Production, tons, 2005–2018 average	Surplus or deficit region[54]	Price, TL/kg, 2005–2019[55] average	Volatility[56]
Adana	4,045,211	991,193	Surplus	1.62	0.98
Ağrı	1,110,464	40,284	Deficit	2.17	1.13
Ankara	5,546,531	146,044	Deficit	2.00	1.13
Antalya	3,111,486	2,299,369	Surplus	1.95	1.05
Aydın	3,082,078	715,168	Surplus	1.89	1.02
Balıkesir	1,749,095	397,691	Surplus	2.05	1.15
Bursa	4,090,182	436,484	Surplus	2.02	1.09
Erzurum	1,073,727	77,852	Deficit	1.98	1.10
Gaziantep	2,806,058	45,976	Deficit	1.68	1.06
Hatay	3,271,927	239,961	Deficit	1.60	0.93
Istanbul	15,254,231	19,913	Deficit	2.23	1.12
Izmir	4,330,317	239,009	Deficit	1.95	1.17
Kastamonu	768,033	64,222	Deficit	2.09	1.16
Kayseri	2,429,092	43,328	Deficit	1.80	1.05
Kırıkkale	1,576,159	124,578	Surplus	1.77	1.01
Kocaeli	3,900,884	78,689	Deficit	2.06	1.10
Konya	2,454,474	182,279	Deficit	1.73	1.02
Malatya	1,739,325	68,751	Deficit	1.83	1.13
Manisa	3,088,210	272,534	Deficit	1.74	0.94
Mardin	2,254,061	39,473	Deficit	1.80	1.06
Samsun	2,785,880	819,801	Surplus	1.86	1.06
Şanlıurfa	3,763,301	215,857	Deficit	1.71	1.07
Tekirdağ	1,804,880	34,354	Deficit	2.13	1.19
Trabzon	2,648,868	14,136	Deficit	2.18	1.16
Van	2,143,427	75,936	Deficit	1.99	1.10
Zonguldak	1,039,320	20,407	Deficit	2.17	1.12

[54] Estimated based on assumptions of national average consumption levels of 109.9 kg/person per year (2018 est.).

[55] January 2005-May 2019.

[56] Std. deviation.

Table A.8.2. **Green peppers**

Region	Population, 2018	Production, tons, 2005–2018 average	Surplus or deficit region[57]	Price, TL/kg, 2005–2019[58] average, sivri variety	Volatility[59]
Adana	4,045,211	270,598	Surplus	2.91	1.79
Ağrı	1,110,464	1,169	Deficit	3.19	1.91
Ankara	5,546,531	8,764	Deficit	3.15	1.92
Antalya	3,111,486	319,844	Surplus	2.87	1.74
Aydın	3,082,078	59,560	Deficit	3.08	1.88
Balıkesir	1,749,095	206,415	Surplus	3.37	1.93
Bursa	4,090,182	182,539	Surplus	3.37	1.96
Erzurum	1,073,727	5,030	Deficit	3.02	1.89
Gaziantep	2,806,058	91,833	Surplus	2.88	2.20
Hatay	3,271,927	113,644	Surplus	2.89	1.77
Istanbul	15,254,231	2,270	Deficit	3.50	2.02
Izmir	4,330,317	116,752	Surplus	3.29	2.06
Kastamonu	768,033	12,454	Deficit	3.00	1.84
Kayseri	2,429,092	1,442	Deficit	2.81	1.79
Kırıkkale	1,576,159	6,922	Deficit	2.73	1.85
Kocaeli	3,900,884	21,698	Deficit	2.89	1.89
Konya	2,454,474	26,830	Deficit	2.72	1.87
Malatya	1,739,325	28,484	Deficit	2.54	1.81
Manisa	3,088,210	195,232	Surplus	2.73	1.79
Mardin	2,254,061	10,183	Deficit	2.64	1.89
Samsun	2,785,880	264,453	Surplus	2.93	1.89
Şanlıurfa	3,763,301	131,514	Surplus	2.69	1.86
Tekirdağ	1,804,880	13,116	Deficit	3.06	1.97
Trabzon	2,648,868	3,620	Deficit	3.05	1.93
Van	2,143,427	7,720	Deficit	2.65	1.72
Zonguldak	1,039,320	5,074	Deficit	3.11	1.88

57 Estimated based on assumptions of national average consumption levels of 25.3 kg/person per year (2018 est.)

58 January 2005-May 2019.

59 Std. deviation.

Table A.8.3. **Dry onions**

Region	Population, 2018	Production, tons, 2005–2018 average	Surplus or deficit region[60]	Price, TL/kg, 2005–2019[61] average	Volatility[62]
Adana	4,045,211	178,273	Surplus	1.05	0.77
Ağrı	1,110,464	0	Deficit	1.33	0.85
Ankara	5,546,531	523,295	Surplus	1.13	0.76
Antalya	3,111,486	21,410	Deficit	1.32	0.95
Aydın	3,082,078	19,788	Deficit	1.24	0.93
Balıkesir	1,749,095	13,795	Deficit	1.46	1.02
Bursa	4,090,182	284,468	Surplus	1.38	0.95
Erzurum	1,073,727	289	Deficit	1.24	0.86
Gaziantep	2,806,058	41,059	Deficit	1.12	0.84
Hatay	3,271,927	217,583	Surplus	1.13	0.77
Istanbul	15,254,231	716	Deficit	1.34	0.89
Izmir	4,330,317	4,496	Deficit	1.29	0.96
Kastamonu	768,033	497	Deficit	1.22	0.88
Kayseri	2,429,092	28,409	Deficit	1.20	0.87
Kırıkkale	1,576,159	24,366	Deficit	1.13	0.80
Kocaeli	3,900,884	13,924	Deficit	1.30	0.87
Konya	2,454,474	97,732	Surplus	1.12	0.80
Malatya	1,739,325	6,304	Deficit	1.19	0.88
Manisa	3,088,210	58,542	Deficit	1.21	0.88
Mardin	2,254,061	946	Deficit	1.28	0.87
Samsun	2,785,880	572,915	Surplus	1.12	0.83
Şanlıurfa	3,763,301	20,422	Deficit	1.15	0.83
Tekirdağ	1,804,880	23,498	Deficit	1.38	0.91
Trabzon	2,648,868	270	Deficit	1.23	0.92
Van	2,143,427	22,446	Deficit	1.39	0.88
Zonguldak	1,039,320	468	Deficit	1.31	0.94

60 Estimated based on assumptions of national average consumption levels of 21.75 kg/person per year (2018 est.).

61 January 2005-May 2019.

62 Std. deviation.

Appendix 9. Price Transmission Methodology

Johansen's Maximum Likelihood (ML) test (Johansen 1988) is commonly used to test for the presence of co-integrating vectors. To obtain the test results, we first specify the general VAR(k) model, where k is the number of lags:

$$P_t = A_0 + A_1 P_{t-1} + \dots + A_k P_{t-k} + u_t \qquad t = 1, \dots, T, \tag{1}$$

where Pt is an n x 1 vector of prices, and A is the matrix of the coefficients to be estimated. This equation is further converted into the following vector error correction model:

$$\Delta P_t = \Pi_0 + \Pi P_{t-1} + \Sigma_{i=1}^{k-1} \Gamma_i \Delta P_{t-1} + \theta_t \tag{2}$$

where Δ denotes first difference, $\Pi_0 = A_0$, Γ_i represents the dynamic effects, and Π captures the long-run effects of the analyzed series. The goal of the Johansen ML test is to estimate the rank of the Π matrix, which represents the number of co-integrating relationships.

The residual-based test for cointegration, Engle-Granger (1987) procedure, consists of two steps. First, the long run relationship between the pairs of export log-prices is estimated as seen in the example of the relationship between Russian and US wheat prices:

$$P_t^{M1} = \beta_0 + \beta_1 P_t^{M2} + \varepsilon_t \tag{3}$$

where P_t^{M1}, P_t^{M2} are prices in two selected markets. β_0 is a constant, β_1 stands for the price transmission elasticity, and εt is the error term. Second, unit-root tests (ADF, PP, and KPSS) are used to check if the residuals are stationary. Their stationarity would imply that analyzed series are cointegrated, i.e. they move together in the long-run. If two series are cointegrated, then the OLS estimators in (3) are super-consistent and can be used to characterize the series' behavior.

The major difference between the Johansen ML and Engle-Granger methods is that they require different model assumptions. The first one requires a normality assumption, while the latter one is insensitive to the distribution assumption. Therefore, one of the benefits of using the Engle-Granger method is in its relative efficiency over the Johansen ML test if normality does not hold. As to the benefits of using the Johansen ML method, it allows for obtaining more than one co-integrating relationship. The tests were used jointly to assess the robustness of the results.

Appendix 10. Price Transmission Analysis Results

Pairwise (Satellite to Istanbul) Cointegration Regression and Tests for Daily Wholesale Prices

Satellite	Intercept		Slope		R	Johansen
Market	Estimate	Std. Err.	Estimate	Std. Err.	Square	Trace[63]
			Dry Onions			
Adana	-0.1762	0.0161	0.8104***	0.0195	0.70	10.19**
Antalya	0.7543	0.0227	0.6496***	0.0275	0.43	14.03**
Manisa	0.5671	0.0164	0.7184***	0.0198	0.64	15.11**
Mersin	0.1037	0.0209	0.8357***	0.0253	0.60	14.91**
Aydin	0.9324	0.0165	0.6679***	0.0200	0.61	13.50**
Samsun	0.4398	0.0190	0.6044***	0.0230	0.49	13.81**
			Green Peppers			
Adana	-0.8659	0.0223	1.1243***	0.0194	0.82	4.29
Antalya	0.4817	0.0191	0.6945***	0.0166	0.71	7.44
Mersin	-0.6098	0.0193	1.0870***	0.0167	0.85	4.59
Aydin	0.2934	0.0394	0.7762***	0.0342	0.41	13.35**
Samsun	0.1188	0.0274	0.7948***	0.0237	0.61	10.54**
			Table Tomatoes			
Adana	-0.5265	0.0145	1.0349***	0.0196	0.79	6.63
Amasya	-0.1890	0.0156	1.0098***	0.0212	0.76	6.90
Antalya	0.2951	0.0146	0.8197***	0.0198	0.70	7.14
Manisa	-0.4365	0.0142	1.0306***	0.0193	0.80	6.47
Mersin	0.1970	0.0210	0.5991***	0.0285	0.38	13.50**
Aydin	0.1504	0.0208	0.7023***	0.0282	0.46	10.79**
Samsun	0.4372	0.0196	0.6348***	0.0266	0.44	13.64**

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[63] The 0.05 critical value for the Johansen trace test is 7.50.

Pairwise (Satellite to Ankara) Cointegration Regression and Tests for Monthly Consumer Prices

Satellite	Intercept		Slope		R	Johansen
Market	Estimate	Std. Err.	Estimate	Std. Err.	Square	Trace[64]
			Table Tomatoes			
Istanbul	0.2163	0.0070	0.8582***	0.0092	0.98	9.30**
Izmir	-0.0297	0.0100	0.9928***	0.0130	0.97	10.74**
Bursa	0.0838	0.0087	0.8976***	0.0113	0.97	11.14**
Konya	-0.1507	0.0086	0.9980***	0.0111	0.98	9.81**
Antalya	0.0409	0.0097	0.9094***	0.0126	0.97	9.24**
Samsun	-0.0438	0.0094	0.9572***	0.0123	0.97	12.00**
Trabzon	0.1744	0.0079	0.8842***	0.0103	0.98	11.71**
Van	0.0456	0.0100	0.9272***	0.0131	0.97	10.75**
			Green Peppers			
Istanbul	0.2476	0.0149	0.8839***	0.0125	0.97	18.49**
Izmir	0.1344	0.0176	0.9192***	0.0148	0.96	19.72**
Bursa	0.2317	0.0139	0.8704***	0.0117	0.97	13.57**
Konya	-0.1502	0.0354	0.9770***	0.0296	0.88	15.45**
Antalya	0.0000	0.0176	0.9239***	0.0147	0.96	26.52**
Samsun	-0.0518	0.0290	0.9708***	0.0242	0.92	18.91**
Trabzon	0.0449	0.0270	0.9295***	0.0226	0.92	17.50**
Van	-0.1013	0.0338	0.9253***	0.0283	0.88	17.67**
			Dry Onions			
Istanbul	0.1800	0.0060	0.9504***	0.0113	0.98	6.25
Izmir	0.1255	0.0073	0.9603***	0.0137	0.97	8.10**
Bursa	0.2072	0.0074	0.9505***	0.0139	0.96	5.91
Konya	-0.0061	0.0061	0.9864***	0.0114	0.98	8.60**
Antalya	0.1547	0.0085	0.9666***	0.0160	0.96	6.40
Samsun	-0.0267	0.0075	1.0268***	0.0140	0.97	7.07
Trabzon	0.0677	0.0072	1.0220***	0.0135	0.97	6.23
Van	0.2224	0.0107	0.9244***	0.0200	0.93	4.81

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[64] The 0.05 critical value for the Johansen trace test is 7.50.