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PEA AND LENTIL MARKET ANALYSIS

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PEA AND LENTIL MARKET ANALYSIS

Project Summary:

This report consists of pea and lentil market analysis, specifically focusing on two markets, including the ingredient market and commodity market. The ingredient market analysis consists of analyzing current trends, major market categories in which pea and lentil are used as main ingredients, and identifying the manufacturers and/or distributors of the products. After identifying the trends in the ingredient market, we forecast the major market growth categories in the ingredient market using autoregressive integrated moving average (ARIMA) models. The pea and lentil commodity market analysis consider supply and demand, including the identification of export markets for U.S. peas and lentils. Similarly, after identifying the trends in commodity markets, we use both the ARIMA model and neural network auto regression (NNAR) to forecast production, prices, and utilization in the United States.

The results of the ingredient market analysis indicate that the top market categories for peas include frozen food, cereal bars, savory snacks, and canned food. The top market categories for lentils include soups, savory snacks, dried food/pasta/noodles/pizza, crackers, and sauce dips. We also identified some of the market categories that manufacturers need to avoid because of their diminishing growth. Ingredient market categories that show a decreasing trend include chilled meats, artisanal bread rolls, breakfast cereals, and cookies (sweet biscuits). The results of the commodity market analysis for peas and lentils indicate that production of both peas and lentils is highly volatile, and show a decreasing trend during 2017–2020. The pea price forecast shows an increasing trend during 2017–2020, while the lentil price forecast shows a decreasing trend during the same period. Results of ingredient market analysis coupled with commodity

market analysis help pea and lentil growers, processors of North Dakota, and the Northern Pulse Growers Association with the information about manufacturers and/or distributors of products containing peas and lentils as ingredients as well as the general market structure of peas and lentils.

Introduction:

The food security definition has evolved from aspects of food availability and food price stability in the 1990s, to food accessibility and its utilization in the 2000s (FAO, 2006). The Food and Agricultural Organization (FAO) defines food security as the situation that "exists when all people, at all times, have physical, social and economic access to *sufficient*, *safe* and *nutritious* food which meets their dietary needs and food preferences for an active and healthy life". The key terms in the above definition include "sufficient", "safe" and "nutritious" food. Many economists argue that, at present, sufficiency of food is not a problem, but the distribution of food is the main problem. However, access to safe and nutritious food is the key for food security.

Humans consume protein in different forms, including animal and plant sources. Pulses, specifically, dry/green peas and lentils are a rich source of protein, carbohydrates, fiber, etc. For obtaining protein, one major advantage of pulse consumption over meat consumption is that pulses contain only tiny amounts of fat. On the other hand, meat consumption may lead to excess fat consumption while acquiring protein. The growing global middle class tends to increase their meat consumption as their income grows. Similarly, due to distribution issues, the poor do not receive required nutritious food around the globe. Hence, different global populations suffer from two extreme situations of either obesity or malnutrition than ever before.

In order to celebrate the benefits of pulses, the United Nations, led by its Food and Agriculture Organization (FAO), declared 2016 as the International Year of Pulses. Specifically, FAO Director-General Jose Graziano da Silva stated that (United Nations, 2015),

"Pulses are important food crops for the food security of large proportions of populations, particularly in Latin America, Africa and Asia, where pulses are part of traditional

diets and often grown by small farmers." On declaring 2016 as the year of International Year of Pulses, the UN Secretary-General Ban Ki-moon claimed that (United Nations, 2015),

"The International Year 2016 is a great opportunity to raise awareness of the benefits of pulses as the world embarks on efforts to achieve the newly adopted Sustainable Development Goals."

Sustainability is often mentioned regarding pulses, citing two important points including: 1) the benefits of pulses/legumes, in general, to fix atmospheric nitrogen and enrich soil; and 2) the amount of water it takes to produce a unit quantity of peas and/or lentils is much less than meat (chicken or beef). For example, it takes 4,325 and 13,000 liters of water to produce 1 kg of chicken, and 1 kg of beef, respectively, while it takes only 50 liters of water to produce 1 kg of peas or lentils (Euromonitor International, 2016). Additionally, most pulses have a low glycemic index, low fat, high fiber, and no cholesterol (FAO, 2016).

Major pulses grown in the United States include peas, lentils, chickpeas, etc. Canada is the major exporter of pulses in the world, followed by the United States. Table 1 shows the protein content and other nutrition information of major pulses. As indicated in Table 1, peas and lentils have one of the highest concentrations of the protein and fiber. Additionally, pulses are a major source of micronutrients and vitamin B9, or Folate, which are essential for active and healthy human life. Also, Table 1 shows that lentils contain high protein and carbohydrates compared to peas and chickpeas, while peas contain high fiber when compared to lentils and chickpeas. On the other hand, fat content is highest in chickpeas when compared to peas and lentils.

Table 1: Nutritional Value for every 100 g of pulses

Type of Pulse	Protein (g)	Fat (g)	Fiber (g)	Carbohydrate (g)
Pea	18.4	1.4	26.0	42.4
Lentil	25.4	1.8	10.7	49.3
Chickpea	21.2	5.4	12.4	45.5

Source: FAO, 2016.[1]

Table 2 shows the essential micronutrients and vitamin B9 for each 100 g of peas, lentils, and chickpeas. Lentils contain greater amounts of iron, phosphorus, and copper compared to peas and chickpeas. On the other hand, chickpeas contain more magnesium, potassium, and vitamin-B9 than peas and lentils.

Table 2: Essential Micronutrients and B-9 Vitamin for every 100 g of pulses

Type of Pulse	Iron (mg)	Magnesium (mg)	Phosphorus (mg)	Potassium (mg)	Zinc (mg)	Copper (mg)	B9/Folate (mg)
Pea	3.5	116	295	1010	2.39	NA	138
Lentil	7.0	103	391	855	3.90	0.74	295
Chickpea	5.4	146	342	1116	3.2	0.67	557

Source: FAO, 2016.

Figure 1 shows the harvested acres of dry peas and lentils in the United States between 1980 and 2016. For both dry peas and lentils, the harvested acres have shown an increasing trend. Specifically, harvested acres of peas have increased from 343 thousand acres in 2011 to 1330 thousand acres in 2016. Similarly, harvested acres of lentils have increased from 411 thousand acres in 2011 to 908 thousand acres in 2016.

[1] FAO (2016) report titled "Pulses: Nutritious Seeds For A Sustainable Future" contains the nutritional information of major pulses grown around the world.

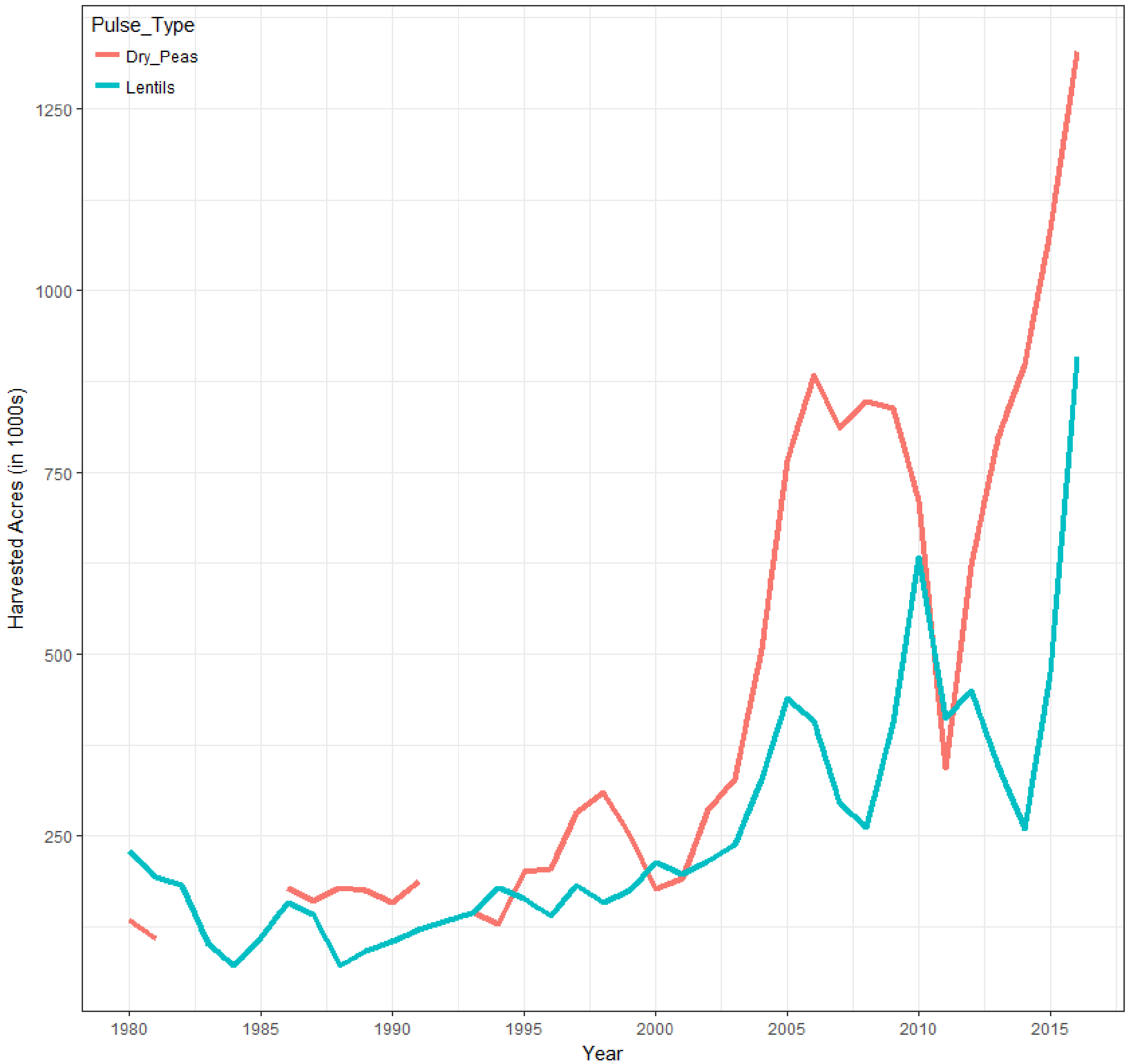

Figure 1. Harvested acres of U.S. dry peas and lentils, 1980-2016.
Notes: Missing data exists for dry peas for years 1982, 1983, 1984, 1985, and 1992.

Figure 2 contains two sub-figures: panel (A), and panel (B). Panel (A) in Figure 2 shows production of U.S. dry peas and lentils. Production of dry peas has been consistently higher than the production of lentils in the United States between 1980 and 2016. Panel (B) of Figure 2 shows the average price of dry peas and lentils between 1980 and 2016. In contrast to production, panel (B) shows that the lentil price is consistently higher than the dry pea price for the entire 1980–2016 period.

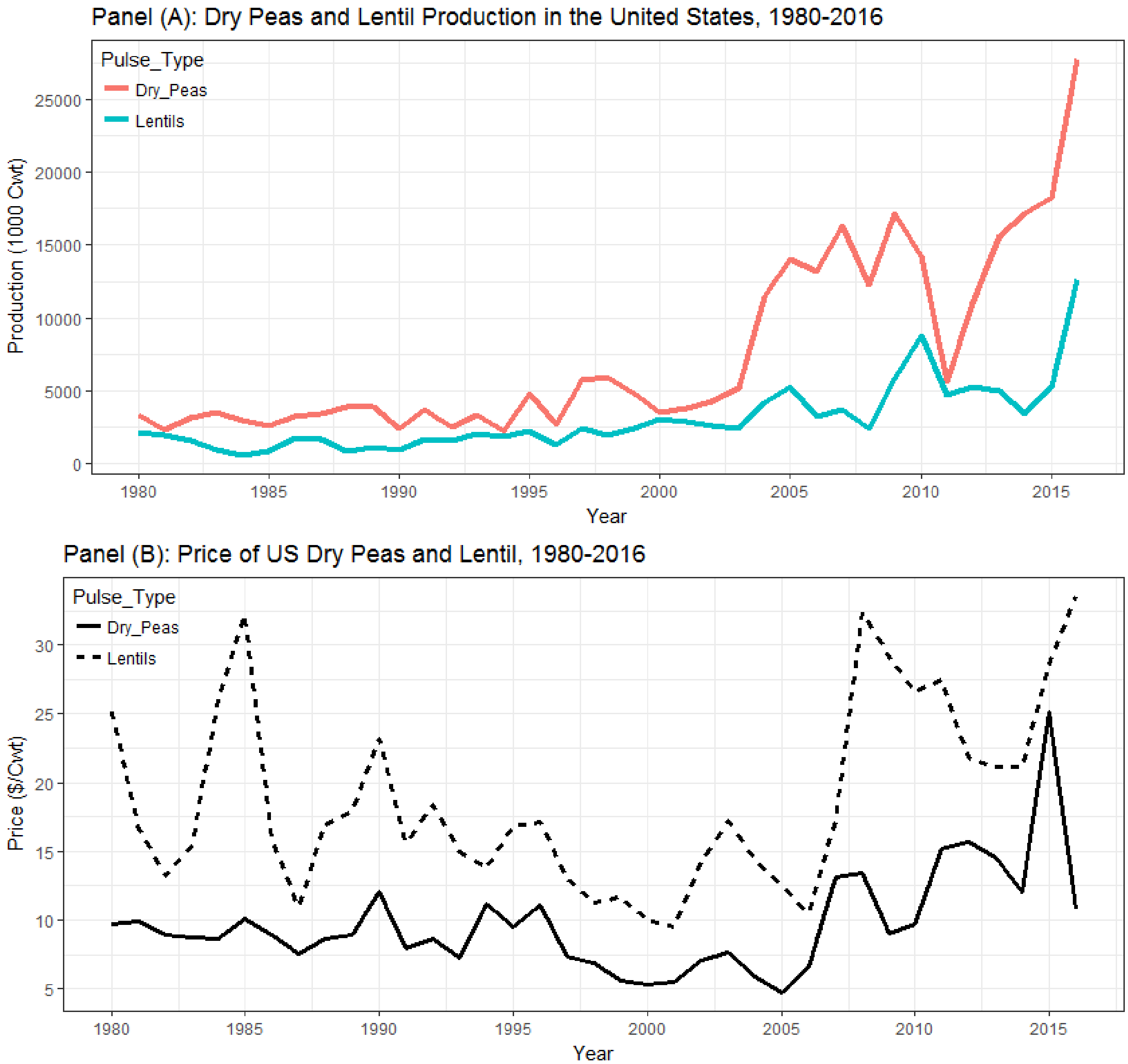

Figure 2. Production and average prices of U.S. dry peas and lentils, 1980-2016.

Figure 3 shows the value of production of U.S. dry peas and lentils during 2000-2016. As shown in the figure, the value of production was dominated by each for about half of the time in the last 16 years. Dry peas and lentils have the highest values of production at $459 million in 2015 and $351 million in 2016, respectively.

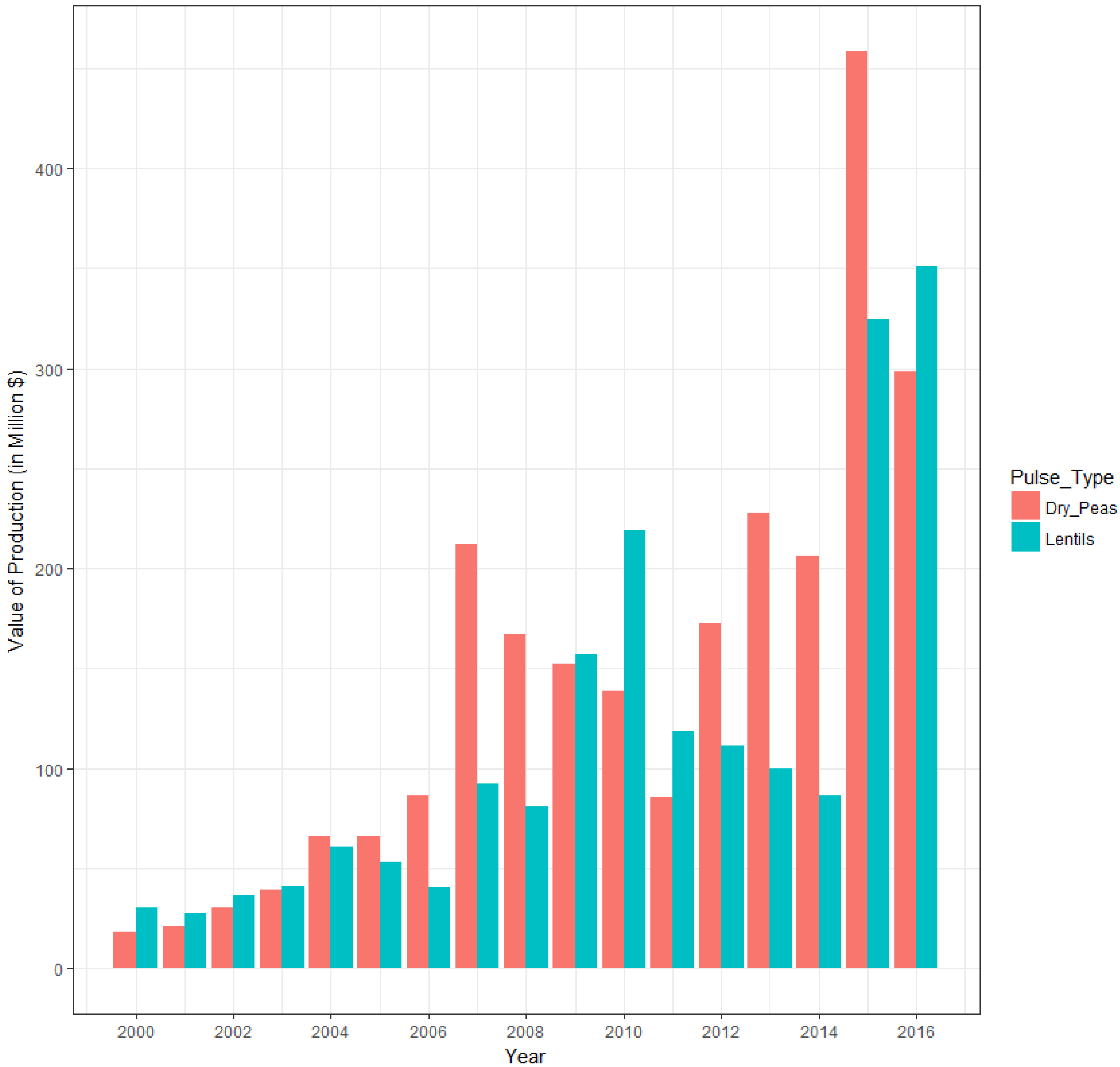

Figure 3. Value of production of U.S. dry peas and lentils, 2000-2016.

From the producers' perspective, growing pulses, especially lentils, achieved greater crop returns than any other major crops that commonly grow in the Northern Great Plains. For example, Table 3 shows a comparison of market income, total costs incurred, and crop returns per acre of major crops in Northwestern North Dakota. Specifically, returns on lentils are greater than any other crop listed in Table 3.

Table 3. A comparison of market income, total costs, and returns per acre of major crops in Northwestern North Dakota.

Entity per acre	Durum	Winter Wheat	Corn	Lentil	Soybean
Market Income	193.12	178.88	306.90	326.40	226.20
Total Costs	205.98	206.06	294.15	235.21	216.84
Returns	12.86	27.18	12.75	91.19	9.36

Source: https://www.ag.ndsu.edu/farmmanagement/documents/17-nw-bud-pdf

The value of pulse cultivation (especially lentils) and the health benefits of consuming pulses provide a win-win situation to both growers and consumers. Additionally, the cultivation of pulses has the benefit of fixing atmospheric nitrogen into the soil. Therefore, pulse crops are recommended for crop rotations with other non-legume crops, such as grains, to improve soil fertility.

This report consists of market analysis of peas and lentils in both ingredient and commodity markets. Specifically, we identify the current trends of major market categories that use peas and lentils as major ingredients and forecast 2-year market volumes of growing market categories. Similarly, commodity market analysis consists of forecasting the production, and price of U.S. peas and lentils between 2017 and 2020. We also analyze and forecast an aggregated domestic food utilization of dry peas and lentils between 2016 and 2019. The rest of the report consists of literature review, ingredient market analysis, commodity market analysis, methodology, and global market (trade) structure for U.S. peas and lentils.

Literature Review:

Literature on pulses show that there are various groups of studies that focus on key research questions including the health and nutritional benefits of consuming pulses, survey results of U.S. populations who consume pulses, and the need for developing improved cultivars of pulses that adapt to changing climatic conditions, particularly in the Northern Great Plains.

Many studies focus on the health and nutritional benefits of consuming pulses. For example, a study by Mudryj, Yu, and Aukema (2014) claims that pulses are a major source of protein and fiber along with phytochemicals, saponins, and tannins, which possess anti-oxidant properties. Another study by Campos-Vega et al. (2010) finds that lentils contain high phenolic, flavonoid, and condensed tannin content, which are responsible for anti-oxidant properties. Duane (1997) conducted a dietary study in which humans are given a diet that consists of beans, lentils, and peas for seven weeks. Duane (1997) finds that the human subjects who were given the specific diet detected very low serum low-density lipoproteins (LDL) cholesterol.

Another dietary study conducted by the Baltimore longitudinal study of aging (BLSA) found that humans consuming fiber-rich containing foods including legumes, non-white bread, whole grains, etc. had the lowest BMI, as well as the lowest waist circumference. Finally, a few studies have also indicated that the saponins present in pulses may contain anti-cancer properties (Ellington et al. 2006; Shi et al., 2004).

Several studies examined the effect of pulse consumption on diabetes and glucose control (Jenkins et al. 2012; Hartman et al., 2010; Shams et al. 2010). Jenkins et al. (2012) using parallel randomized control trials studied a sample size of 121 human subjects where they were given 1 cup of cooked beans, chickpeas, or lentils per day. Jenkins et al. (2012) find that those who consumed the pulse dosage of 1 cup/day showed a reduction in their body weight, waist circumference, glycemic index, and blood pressure.

Additional studies focused on survey results related to consumption of pulses in the United States. For example, Mitchell et al. (2009), using dietary intake data collected from 1999–2002 National Health and Nutrition Examination Survey (NHNES), state that on any given day, approximately 7.9% of U.S. population consumes beans, peas, and lentils. However, since 2002, it was expected that the percentage of the U.S. production that consumed pulses would have been increased.

Other studies focused on the adaptability of pulses to changing climate in the United States and Canada. For example, Cutforth et al. (2007) studied the adaptation of pulses in changing climatic conditions in the Northern Great Plains. Their review focused on the sustainability and yield of pulse crops in response to temperature, water and climate changes in different geographic locations. Specifically, they stated that if the temperature increases $\leq 2.5^0$Celsius, then it encourages agricultural production in temperate regions, but may decrease agricultural production in the tropical regions. Finally, Cutforth et al. (2007) suggests that research and development (R&D) of cultivars are key for adapting to changing climatic conditions in the Northern Great Plains.

Ingredient Market for Peas and Lentils:

Introduction:

There has been an increasing demand for plant protein in the United States. Specifically, manufacturers have been interested in replacing traditional (animal) protein with plant protein due to *IgE* mediated allergies, increasing costs and changing consumer preferences (e.g., vegan preferences). Legumes, including peas, lentils and other pulses, are an important source of protein in addition to carbohydrates and fiber. In light of changing consumer preference, interest in a healthy diet and increasing demand for plant-based protein, it is important to explore and quantify the market potential for pulses, especially peas and lentils, as food ingredients.

Two objectives were addressed in this section:

1. To analyze the market product launches (SKU's, stock keeping units) that contain pea and lentils as the main ingredients (i.e., as the top, or in the top 4 ingredients);
2. To identify and forecast the top market categories in the ingredient market that contain peas and lentils as their main ingredient (ranked in less than five in the ingredient list of the product's nutrition label).

ARIMA Model:

The Autoregressive Integrated Moving Average model (ARIMA) was used for estimation and forecasting the market volumes of top market categories. The ARIMA model is specified as follows (Box and Jenkins, 1976).

$$\Delta y_t = y_t - y_{t-1} = \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \sum_{i=1}^{q} \beta_i e_{t-i} + \epsilon_t \qquad (1)$$

where y_t represents the actual data, y_{t-1} represents the lagged value of the data, p is the number of autoregressive terms, q is the number of moving average terms, α_i and β_i are the parameters, and ϵ_t is the residual term. Δy_t represents the differenced (first difference) time series to maintain stationarity of the time series variable. The number of differences required to make the series stationary is also referred to as the order of integration (d). Differencing removes the trend component of the time series variable.

Equation (1) is estimated and later used for forecasting market volumes of top market categories, including bakery and cereals, frozen food, savory snacks, soups, crackers, sauce dips, dried food, cereal bars, and canned food. It is important to note that these market volumes of top growth categories are general market/industry categories and they are not specific to peas and lentils. The basic idea is to analyze the increasing and decreasing market volumes of market categories and then identify whether the current ingredient market categories (that use peas and lentils as main ingredients) are part of these top market categories.

Forecast Accuracy Measures:

We use two forecast accuracy measures for selecting the best ARIMA model to forecast the market growth categories. They are

Mean Absolute Error: $MAE \ = \frac{1}{n}\sum_{i=1}^{n} |e_i|$

Root Mean Square Error: $RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n} e_i^2}$

where n, e_i represents number of observations in the sample and residual, respectively. Residual (e_i) is computed using predicted market volume $(\hat{Y}_i)$ minus the actual market volume (Y_i).

The best ARIMA model is selected from a few competing models at two levels: 1) the model yielding the highest forecast accuracy, as mentioned above; and 2) after determining the residual analysis of the selected model. Specifically, we conducted three tests including the Ljung-Box test for serial correlation in the residuals, and the Jarque-Bera test and the Shapiro-Wilk test for testing the normality of the residuals (Ljung and Box, 1978; Jarque and Bera, 1980; Royston, 1982). The best model, after passing the forecast accuracy criteria, serial correlation test, and normality test is finally used for forecasting.

Data:

Market volumes of ingredient data were collected from www.datamonitor.com. We also collected the data from www.euromonitor.com for pulses, especially the total sales of pulses (in '000 tonnes) including beans, peas and other pulse groups. Additionally, the distribution of pulses through retail outlets, food service and institutions were collected from Euromonitor International as a percent of total volume.

Pea and lentil market commodity data are collected from the U.S. Department of Agriculture's (USDA) vegetable and pulses outlook database (USDA/ERS, 2017). Specifically, we collected the harvested acres, production, price and utilization data between 1980 and 2016 from the vegetable and pulses outlook database. Domestic food utilization data of both dry peas and lentils in million pounds are collected from historical vegetable and pulses yearbook tables between 1980 and 2015.

Product Launches Over Time:

Figure 4 and Figure 5 show the number of product launches that contain peas and lentils as one of the major ingredients between 1990 and 2015, respectively. One of the important takeaways from the Figure 4 and Figure 5 is that the number of product launches that contain peas as the major ingredient are consistently higher than the number of product launches that contain lentils as a major ingredient. One of the reasons for a lower number of product launches for lentils could be due to high lentil prices compared to pea prices on per unit basis and perceived current consumer preferences.

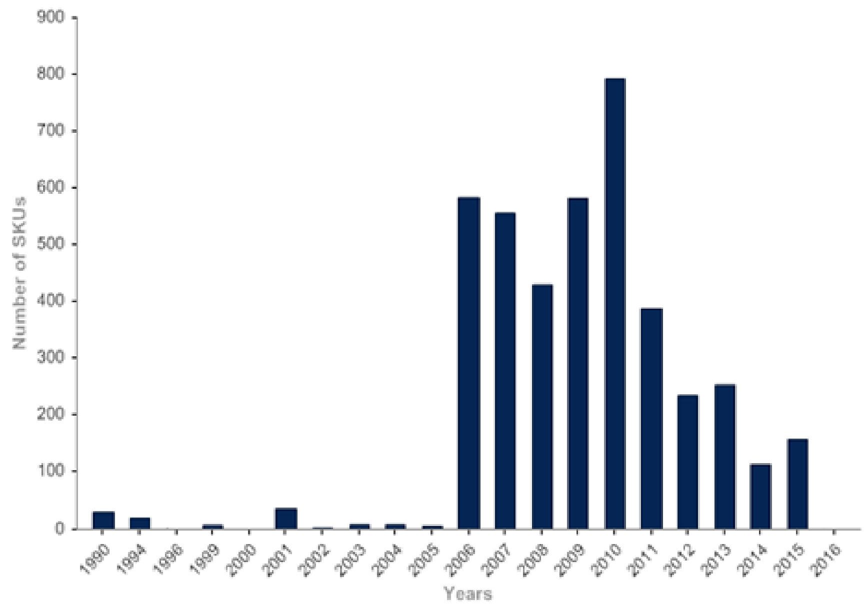

Figure 4. Product launches over time containing peas as the ingredient

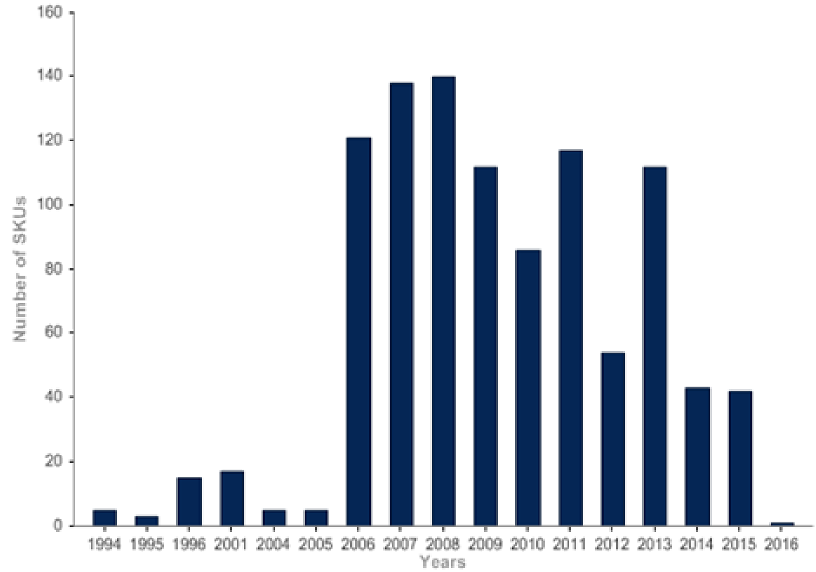

Figure 5. Number of product launches over time containing lentils as an ingredient.

Figure 4 and Figure 5 show that the number of product launches peaked in 2010 for peas and in 2008 for lentils, and decreased thereafter, respectively. In product development, the usual practice of manufacturers is to experiment and launch various products in an attempt to capture new markets due to changes in consumer preferences. During the 2008–2010 period, changes in consumer preferences shifted in favor of pulses and the number of product launches peaked, and stabilized thereafter. It is important to note that the number of product launches shown in Figure 4 and Figure 5 are products that were launched and there is no guarantee that all these products have been successful after their launch.

Table 4. Number of products containing peas and lentils and their rank in the ingredient list, 2010–2015.

Rank in ingredient list	Peas	Lentils
≤ 5	131	34
> 5 & ≤ 10	50	7
> 10	119	16
Total	300	57

Source: Computed from the data collected from www.datamonitor.com.

Table 4 shows the number of product launches containing peas and lentils as the major ingredient in the ingredient list of the product's nutrition label. In general, every product has a list of ingredients mentioned in the nutrition label. Ingredients are ranked in the order of the size of their portion. So, the first listed ingredient has the larger share of the product, with proceeding ingredients comprising smaller portions of the product. For example, in Table 4, there are 131 products that contain peas and 34 products that contain lentils listed in top 5 ingredients of the product.

Results:

The results indicate that the top market categories for peas include frozen food, savory snacks, cereal bars, and canned food. Top market categories for lentils include soups, savory snacks, dried food/pasta/pizza/noodles, crackers, and sauce dips.

As expected, manufacturers are well positioned to develop the majority of the products in markets that are growing. We also identified some of the categories that manufacturers should consider avoiding because of their diminishing growth. Some of the categories/markets that show a decreasing trend include chilled meats, noodles/pasta-based artisanal bread rolls, breakfast cereals, and cookies.

Table 5 shows the results of unit root identification comparing two tests, including the Phillips-Perron (PP) test, and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test (Phillips and Perron, 1988; Kwiatkowski et al., 1992). The results of unit roots for the PP test and the KPSS test are conflicting in some of the categories including dips in levels data and frozen food, dried food, and canned food in the case of 1st differenced data. When the test results of both the PP test and the KPSS test conflict with each other, then we consider the KPSS test to be binding (Pfaff, 2008). Overall, the results of crackers and dips are stationary in levels data, while bakery cereals, frozen food, savory snacks, soup, and cereal bars are stationary after taking the first difference of the series. Finally, the dried food and canned food categories are stationary after taking the second difference of the series.

Table 5. Test results of the order of integration

	Phillips-Perron Test		KPSS Test	
Category	w/drift	w/drift & Trend	w/drift	w/drift & trend
Levels Data				
Bakery Cereals	0.543	-1.526	0.882**	0.192**
Frozen Food	0.373	-2.096	0.853**	0.163**
Savory Snacks	0.846	-3.170	0.884**	0.104
Soup	0.933	-2.128	0.881**	0.188**
Crackers	0.074	-2.143	0.878**	0.123
Dips	-0.454	-3.721**	0.884**	0.074
Dried Food	1.337	-2.888	0.873**	0.190**
Cereal Bars	-3.929	-1.558	0.878**	0.218**
Canned Food	-1.896	0.716	0.876**	0.194**
1st Differenced Data				
Bakery Cereals	-4.148**	-4.599**	0.187	0.112
Frozen Food	-2.196	-2.085	0.233	0.134
Savory Snacks	-3.442**	-3.209*	0.174	0.102
Soup	-3.288**	-3.431*	0.245	0.129
Crackers	-3.106**	-2.973	0.162	0.101
Dips	-6.410**	-6.314**	0.082	0.069
Dried Food	-2.737*	-2.868	0.392	0.152**
Cereal Bars	-1.499	-3.153	0.626	0.136
Canned Food	-1.225	-2.274	0.451	0.186**
2nd Differenced Data				
Dried Food			0.143	0.071
Canned Food			0.233	0.065

Notes: The null hypothesis is non-stationarity of the series in case of the Phillips-Perron's (PP) test, while it is the stationarity of the series in case of the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. In case of PP test, critical values at 5% level with a drift, and with a drift & trend are -2.90, and -3.47, respectively. In case of KPSS test, critical values at 5% level with a drift, and with a drift & trend are 0.463, and 0.146, respectively.

The null hypothesis is non-stationarity in the case of the PP test, while it is stationarity in the case of KPSS test. Hence, if the test statistic in the case of the drift and trend is less than -3.47 at the 5% significance level, then we reject the null hypothesis of non-stationarity in the PP test. On the other hand, if the test statistic in the case of the drift and trend is less than 0.146 at the 5% significance level, then we reject the null hypothesis of stationarity in the KPSS test.

After identifying the order of integration, the best ARIMA model is estimated after analyzing the residuals of various competing ARIMA models as well as the best model regarding the forecast accuracy measures mentioned earlier.

In this study, although the volumes of different market categories are a small sample, the forecast results are reliable given there is not much random variation in the sample. For example, Hyndman and Kostenko (2007) claim that "*to accurately estimate a model where the data contain a lot of random variation, it is necessary to have a lot of data. On the other hand, if the data have little variation, it is possible to estimate a model more or less accurately with only a few observations*".

Forecast results of different market categories considered in the study are presented in Figures 6 and 7. The forecast results of the bakery cereals, frozen food, savory snacks, and soup market categories in Figure 6 suggest that all the categories show an increasing trend. For example, bakery cereals forecast results suggest that the market category would increase from 14,910 million kilograms in 2016 to 15,190 million kilograms in 2018. Similarly, the frozen food market category would increase from 7,266 million kilograms in 2016 to 7332 million kilograms in 2018, while savory snacks increase their ingredient market from 3,248 million kilograms in 2016 to 3380 million kilograms in 2018. Finally, soup forecast results suggest that its market category increases from 1,454 million kilograms in 2016 to 1,538 million kilograms in 2018.

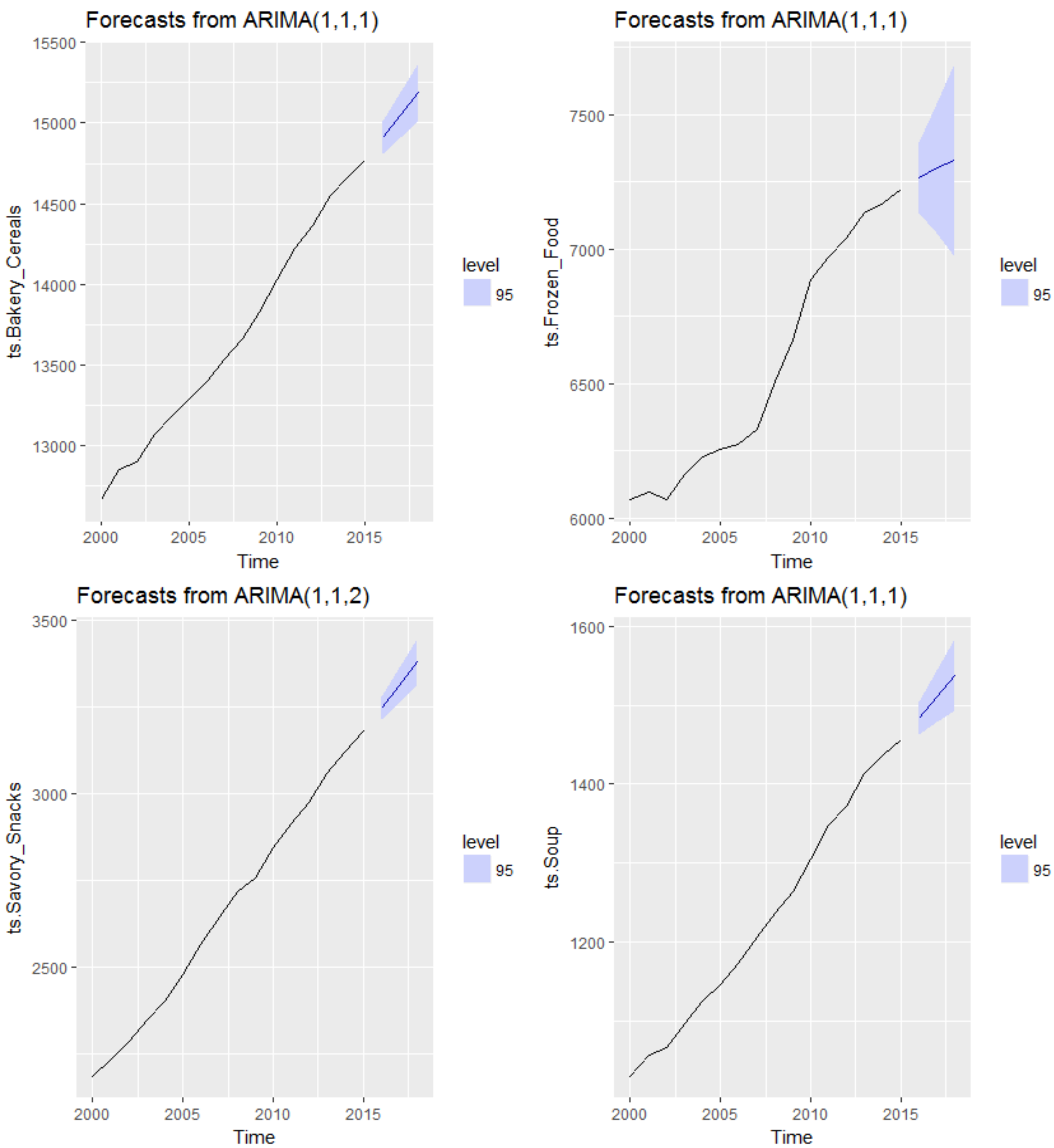

Figure 6. Forecast results of the best ARIMA model for bakery cereals, frozen food, savory snacks, and soup market categories (Units: Million Kilograms [Kg m])

Figure 7 shows the results of market categories including crackers, dips, dried food, and cereal bars. Forecast results of all market categories considered show an increasing trend. For instance, forecast results suggest that the crackers market would grow from 594 million kilograms in 2016 to 596 million kilograms in 2018, which is a nominal increase compared to other categories. The dips market shows an increase from 372 million kilograms in 2016 to 382 million kilograms in 2018. The dried food market shows an increase from 3,605 million kilograms in 2016 to 3726 million kilograms in 2018. Finally, the cereal bars market shows an increase from 306 million kilograms in 2016 to 324 million kilograms in 2018.

It is important to note that all the market categories and their volumes used in ingredient markets are for the entire market and they are not specific only to the use of peas and lentils. However, after analyzing the stock keeping units containing peas and lentils as their main ingredient, results suggest that they are being used in the markets that are growing.

Manufacturers that use peas and lentils as their main ingredients for making final products should consider developing their products in the growing markets indicated in the forecast results.

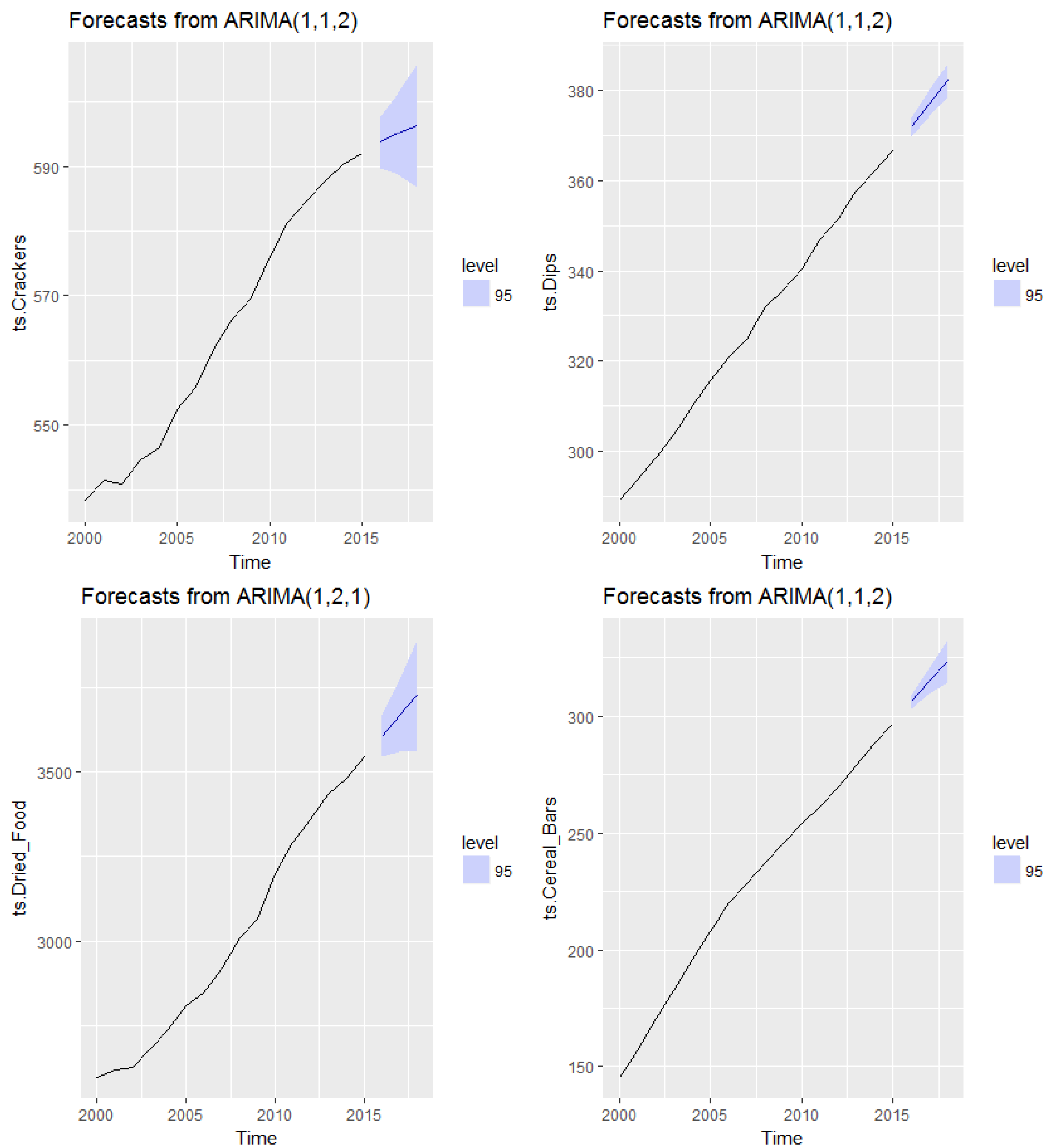

Figure 7. ARIMA forecast results of different market categories in the United States (Units: Million Kilograms [Kg m]).

Euromonitor keeps track of the sales of pulses by category as a proxy for consumption or use of pulses in the ingredient market. Table 6 shows the sales (in volumes) of different pulse categories between 2010 and 2015. As shown in Table 6, the sales of peas in the ingredient market have grown from 60 tonnes in 2010 to 104 tonnes in 2015. In Table 6, lentils are part of the aggregated "other pulses" group.

Table 6. Sales of Pulses by Category: Total Volume, 2010–2015.

'000 tonnes	2010	2011	2012	2013	2014	2015
Beans	741	677	744	704	769	818
Peas	60	62	47	81	97	104
Other Pulses	169	173	187	223	173	203
TOTAL	970	913	978	1009	1040	1126

Source: Euromonitor International, 2016.

Table 7 shows the distribution of pulses as a percent of total volume at retail, food service, and institutional outlets between 2010 and 2015. Table 7 indicates that most of the distribution of pulses occurs at retail outlets compared to food service and institutional outlets. As shown in Table 7, the distribution of pulses through retail outlets has been consistently greater than 85% of the total volume distributed through various outlets.

Table 7. Distribution of Pulses by Format: % Total Volume, 2010–2015.

% Total Volume	2010	2011	2012	2013	2014	2015
Retail	86.4	85.7	85.8	86.4	88	87.9
Food Service	12.5	13.2	13.2	12.5	10.9	11.0
Institutional	1.1	1.1	1.0	1.1	1.1	1.1
TOTAL	100	100	100	100	100	100

Source: Euromonitor International, 2016.

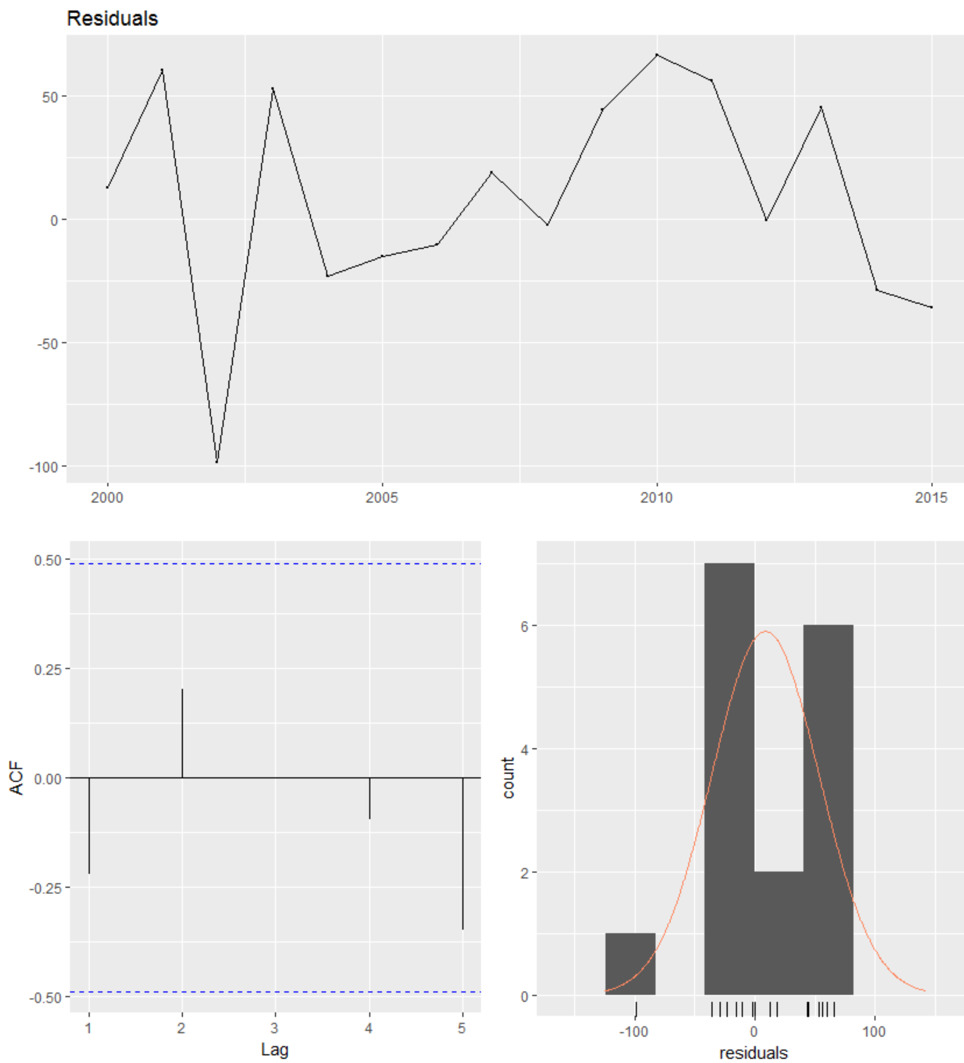

Figure 8. Example of residual analysis of the fitted ARIMA (1,1,1) model of Bakery Cereals.

Figure 8 shows an example of the results of residual analysis where the normality of the results is shown along with the autocorrelation function (ACF). The pictorial results in Figure 8 shows that the residuals of the fitted ARIMA model satisfy the normality assumption and the residuals are stationary, which indicates that no major information is left in the residuals.

List of Manufacturers or Distributors that used peas and lentils as ingredients in their product development (Source: DataMonitor.com)

1. Cofresh Snack Food Ltd.
2. Blount Fine Foods, Inc
3. Calbee North America, LLC
4. Pacific Foods of Oregon, Inc.
5. Sprout Food, Inc.
6. Mediterranean Snack Food Co.
7. Eat Well Enjoy Life
8. Fig Food Co., LLC
9. Boulder Canyon Natural Foods
10. MSFC
11. Kohinoor Foods USA Inc.
12. Nature's Earthly Choice
13. Nature's Marketing
14. Target Corp.
15. Imagine Foods, Inc.
16. Amy's Kitchen, Inc.
17. Honest Co.
18. Wolfgang Puck Food Co.
19. Café Spice
20. Campbell Soup Co.
21. LesserEvil Brand Snack Co.

22. Hope Hummus LLC
23. Purely American Foods
24. Solazyme, Inc.
25. Jaali Bean, Inc.
26. Cook! SF
27. Murad, Inc.
28. La Tera Fina
29. Cedarlane Natural Foods, Inc.
30. Baby Gourmet Foods Inc.
31. One Degree Organic Foods
32. Sukhi's Gourmet Indian Foods
33. Dr. McDougall's Right Foods, Inc.
34. Enray Inc.
35. Flores Farm GmbH
36. Scooter Food LLC
37. Big Y Foods, Inc.
38. Simply 7 Snacks, LLC
39. Topco Associates, LLC
40. Loblaws Inc.
41. Enjoy Life Natural Brands, LLC
42. Jerry's Enterprises
43. Whole Foods Market
44. Harris Teeter

45. Williams-Sonoma, Inc.

46. Trader Joe's

47. Schnuck Markets, Inc.

48. Original SoupMan Inc.

49. General Mills Sales, Inc.

50. MXO Global Inc.

51. Fig Food Co., LLC

52. Modern Table, Inc.

53. Dare Foods, Inc.

54. Bandar Foods, LLC

55. Boulder Canyon Natural Foods

56. Horizon Organic Dairy, LLC

57. Chattem, Inc.

58. Natural Intentions, Inc.

59. Quinoa Corp.

60. Love Grown Foods, LLC

61. Foodhold USA LLC

62. Candle Family Foods, LLC

63. Mediterra Inc.

64. R. W. Garcia Co. Inc.

65. Kind, LLC

66. Pinnacle Foods Group LLC

67. Orgain, Inc.

68. Wild Pea LLC

69. Toufayan Bakeries, Inc.

70. Sunshine Mills, Inc.

71. Gruma Corp.

72. Raw Indulgence, Ltd.

73. Beech-Nut Nutrition Corp.

74. Suja Life, LLC

75. Coty

76. Revlon, Inc.

77. Inter Parfums, Inc.

78. Hampton Creek Foods Inc.

79. West Thomas Partners, LLC

80. ProTings

81. American Flatbread

82. BFree Foods Ltd.

Commodity Market for Peas and Lentils:

Methodology:

The ARIMA model was described in the ingredient market analysis section. Here, we describe the Neural Network Auto Regression (NNAR) model (Athanasopoulos, and Hyndman, 2012). Before describing the NNAR model, we need to discuss the basic architecture of the feed-forward neural network. A typical feed-forward neural network architecture consists of three layers, including the input layer, hidden layer, and output layer (Figure 9). The input layer consists of input nodes as covariates ($Y_{t-1}, Y_{t-2}, \ldots., Y_{t-p}$), while the output layer consists of the response variable (Y_t). The output from input layer (Z_j) is passed on to the hidden layer, which consists of hidden nodes. In the hidden layer, the output from the input layer is transformed into a non-linear function such as the sigmoid function ($C(Z)$) (Athanasopoulos, and Hyndman, 2012). The output generated from the hidden or intermediate layer is finally passed onto the output layer as the prediction of Y_t (Athanasopoulos, and Hyndman, 2012).

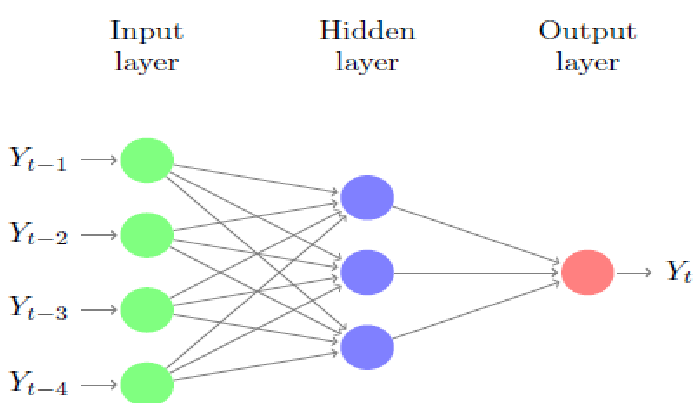

Figure 9. Neural Network Auto Regression, NNAR (4, 3).

An example of a feed-forward neural network is represented in Figure 9, showing four autoregressive terms as inputs in the input layer connecting the three hidden nodes in the hidden/intermediate layer. Weights, which are represented by W_{ij}, connect each input node *i* to hidden node *j*. Weights connecting the input nodes and hidden nodes are referred to as parameters. The output from the input node is passed onto the hidden node Z_j, which is represented by the following equation (Athanasopoulos, and Hyndman, 2012)

$$Z_j = a_j + \sum_{i=1}^{4} W_{ij} Y_{t-i}$$

where a_1, a_2, a_3 and $W_{1,1}, \cdots, W_{4,3}$ are parameters, which are learned from the data. In the hidden node, the value is transformed into a non-linear function such as the sigmoid ($C(Z)$).

$$C(Z) = \frac{1}{1 - e^{-Z}}$$

The value of $C(Z)$ serves as an input to the output layer.

Initially, the weights are assigned random values using a standard normal distribution and are later updated by learning from the data. The customary practice is to train the model several times using different starting values due to randomness, after which the results are averaged. In this study, we train the model 20 times with different starting values taken from the standard normal distribution and the results are averaged before forecasting the best NNAR model.

In this study, we used $NNAR(p,k)$, which represents the neural networks auto regression model, with p—representing the number of autoregressive lags of the time series, and k—representing the number of hidden nodes of the neural network. After training the model, it is important to test the presence of serial correlation in the residuals of the fitted model. After satisfying the residual tests, the estimated NNAR model is used to forecast the time series.

Results and Discussion:

We estimate two models including the ARIMA model and the NNAR model for each of the time series variables. Before estimating the models, we need to test for stationarity of the time series as a precondition. Table 8 shows the test results of unit roots (order of integration) for both dry peas and lentils. Specifically, we tested for production and price time series data at levels, and after taking first difference. Production and price time series data collected between 1980 and 2016 are used for forecasting production and prices for the 2017–2020 period. In Table 8, order of integration results show that the levels data is not stationarity for production and price data of both dry peas and lentils. Testing for order of integration after taking the first difference indicates that the series is stationary.

Table 8. Test results of the order of integration for commodity data

	KPSS Test	
Category	w/drift	w/drift & trend
Levels Data		
Dry Peas		
Production	1.465**	0.255**
Price	0.550**	0.287**
Lentils		
Production	1.406**	0.177**
Price	0.407**	0.265**
Dry Peas & Lentils		
Domestic Food Use	0.928**	0.147*
1st Difference Data		
Dry Peas		
Production	0.274	0.058
Price	0.043	0.039
Lentils		
Production	0.222	0.056
Price	0.126	0.025
Dry Peas & Lentils		
Domestic Food Use	0.170	0.100

Notes: The null hypothesis is the stationarity of the series in case of the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. In case of KPSS test, critical values at 5% level with a drift, and with a drift & trend are 0.463, and 0.146, respectively. ** Indicates significance at 5% level.

After estimating the order of integration, the next step is to estimate the number of autoregressive terms (p), and the number of moving average terms in the case of the ARIMA model and the number of hidden nodes in the case of the NNAR model.

In the case of the ARIMA model, we estimated different models including ARIMA (3,1,1), ARIMA (2,1,1), ARIMA (2,1,2), ARIMA (1,1,0), ARIMA (0,1,1), ARIMA (3,1,0), and ARIMA (1,1,1). We compared the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) for all the ARIMA models mentioned above. The best model is the model that contains the lowest AIC and BIC criteria. The best ARIMA model is then tested for any serial correlation (Ljung and Box, 1978) and normality (Jarque and Bera, 1980; Royston, 1982) to satisfy the assumptions of the residuals of the fitted ARIMA model. After satisfying results for both the tests, the best model is used to forecast the time series of both production and prices of dry peas and lentils for the 2017–2020 period.

Figure 10 shows the forecast results of U.S. dry pea production from both the ARIMA (2,1,2) model and NNAR (3,1) model. Overall, the results show that there will be a slight decreasing, or static, trend in U.S. dry pea production. Specifically, ARIMA (2,1,2) estimates that the U.S. dry pea production would barely increase from 26,974 thousand CWT in 2017 to 27,004 thousand CWT in 2020. The NNAR (3,1) model predicts that U.S. dry pea production will decrease from 25,393 thousand CWT in 2017 to 25,155 thousand CWT in 2020.

Figure 11 shows the forecast results of U.S. dry pea prices from both the ARIMA (1,1,0) and NNAR (2,1) models. ARIMA (1,1,0) results predict a decrease in price from $19.88 per CWT in 2017 to $15.41 per CWT in 2020 while NNAR (2,1) shows decreases in the price of dry peas from $14.12 per CWT in 2017 to $13.90 per CWT in 2020.

Figure 12 shows the forecast results of U.S. lentil production from both the ARIMA (3,1,0) and NNAR (4,2) models. Overall, the results show that there will be a decreasing trend in U.S. lentil production. Specifically, ARIMA (3,1,0) estimates that the U.S. lentil production will decrease from 10,744 thousand CWT in 2017 to 9,807 thousand CWT in 2020. The NNAR (3,1) model predicts a much higher decrease in U.S. lentil production from11,347 thousand CWT in 2017 to 7,403 thousand CWT in 2020.

Figure 13 shows the forecast results of U.S. lentil prices from the ARIMA (3,1,0) and NNAR (3,1) models. ARIMA (3,1,0) results predict a decrease in price from $30.52 per CWT in 2017 to $28.70 per CWT in 2020, while NNAR (3,1) shows a decrease in price from $26.16 per CWT in 2017 to $25.08 per CWT in 2020.

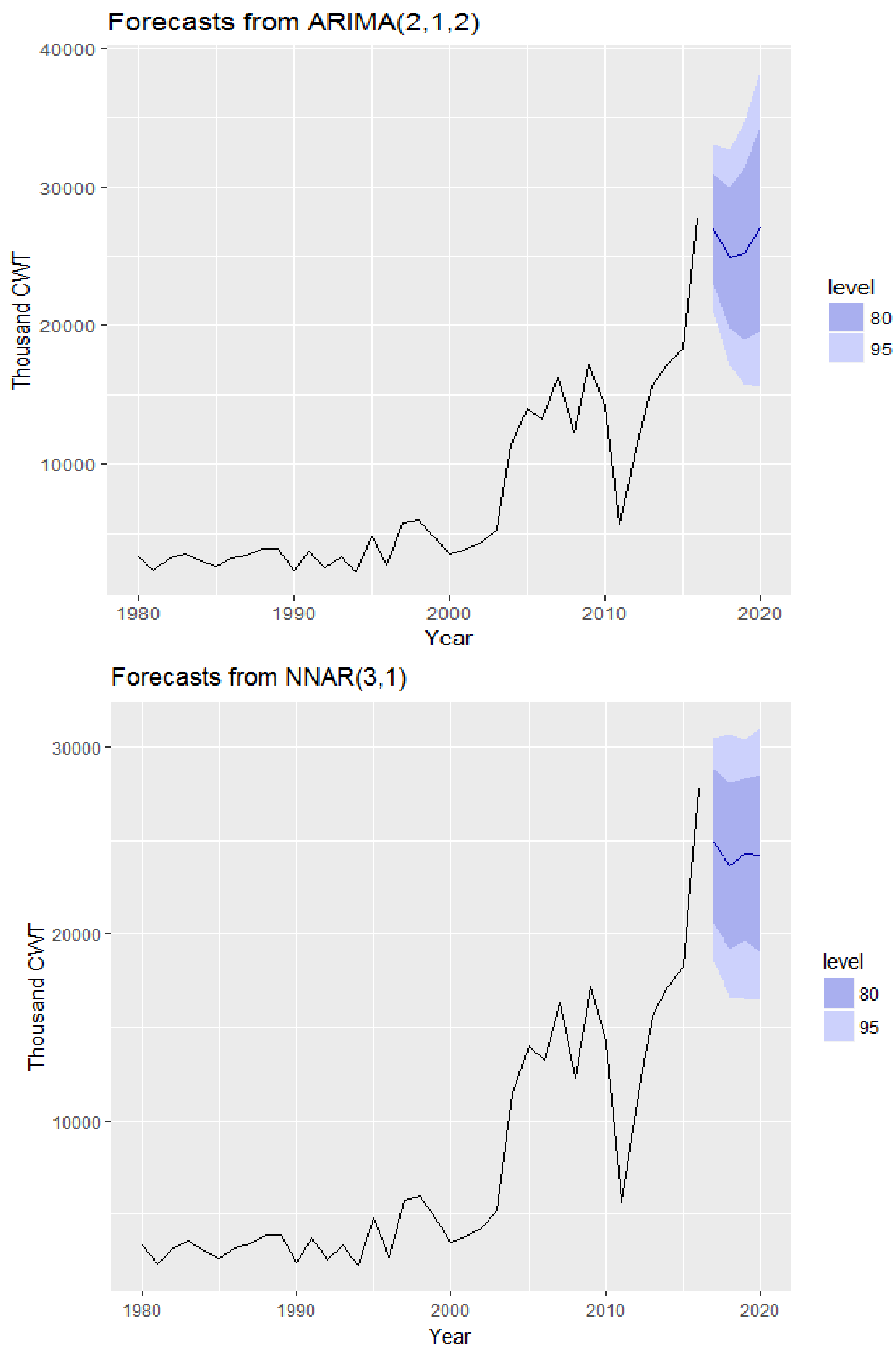

Figure 10. Forecasts of U.S. Pea production from both the best ARIMA and Neural Network Models

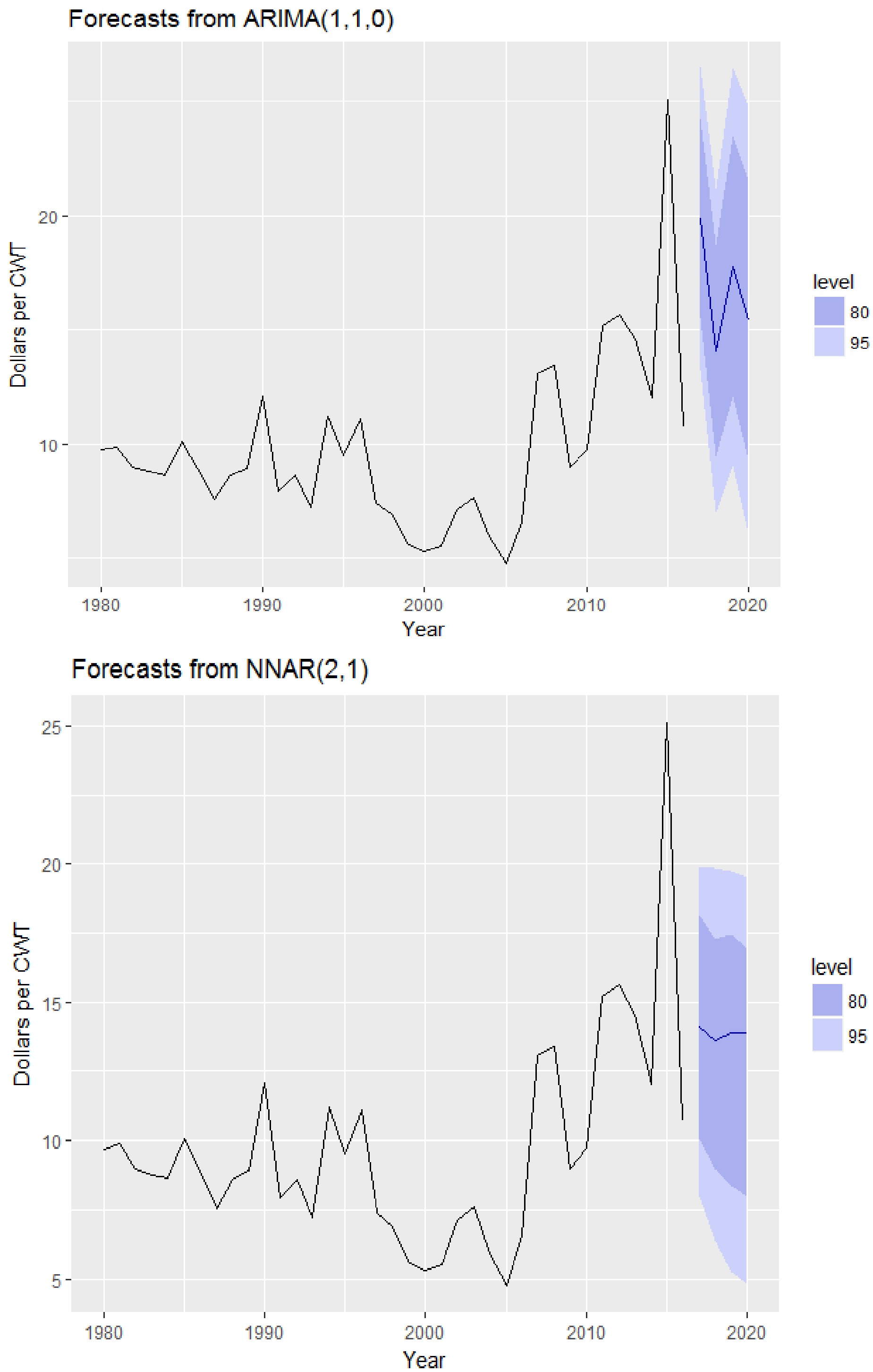

Figure 11. Forecasts of Dry Pea Price from both the ARIMA and Neural Network Models:

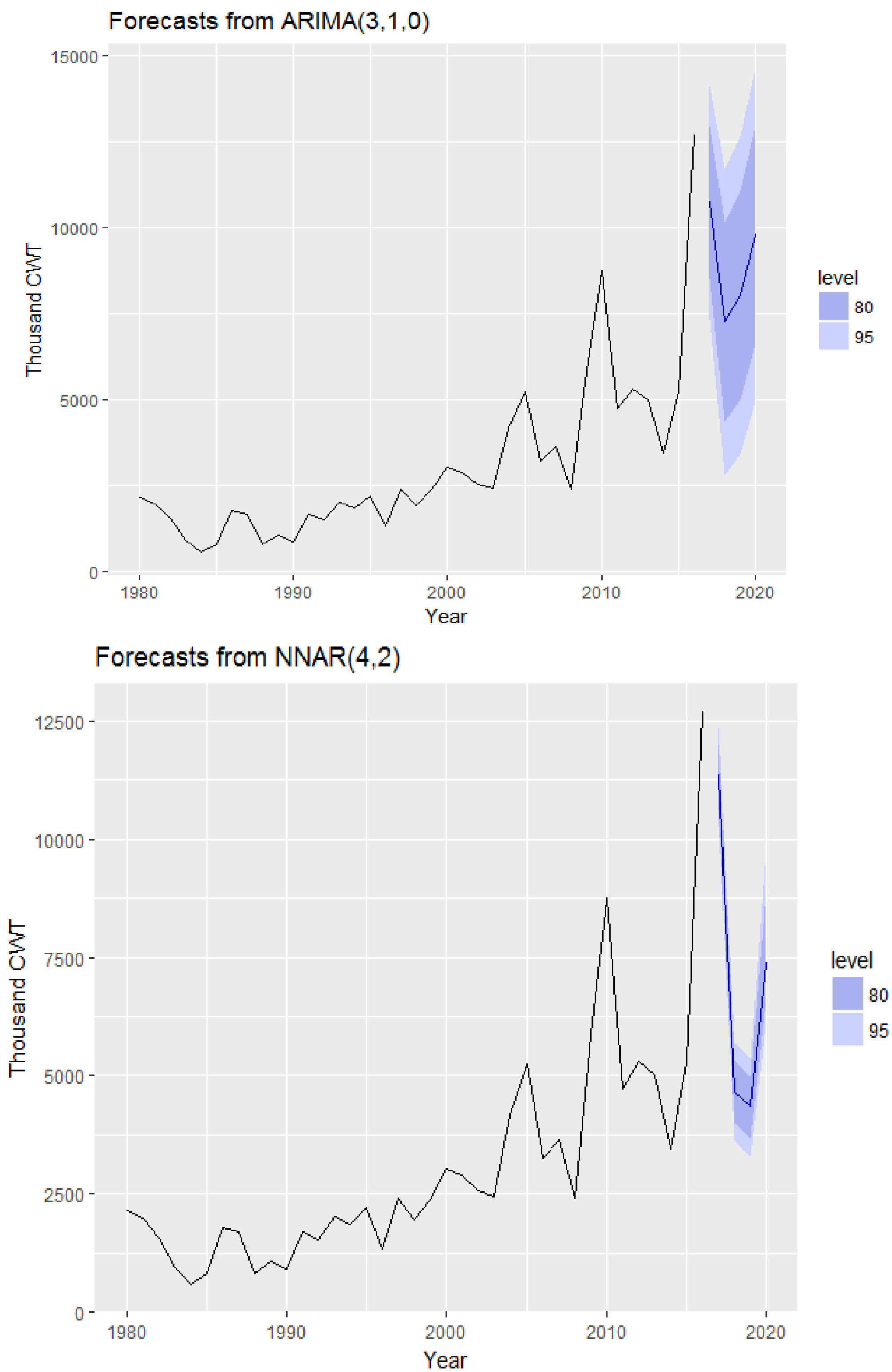

Figure 12. Lentil Production forecast from both ARIMA and Neural Network Models

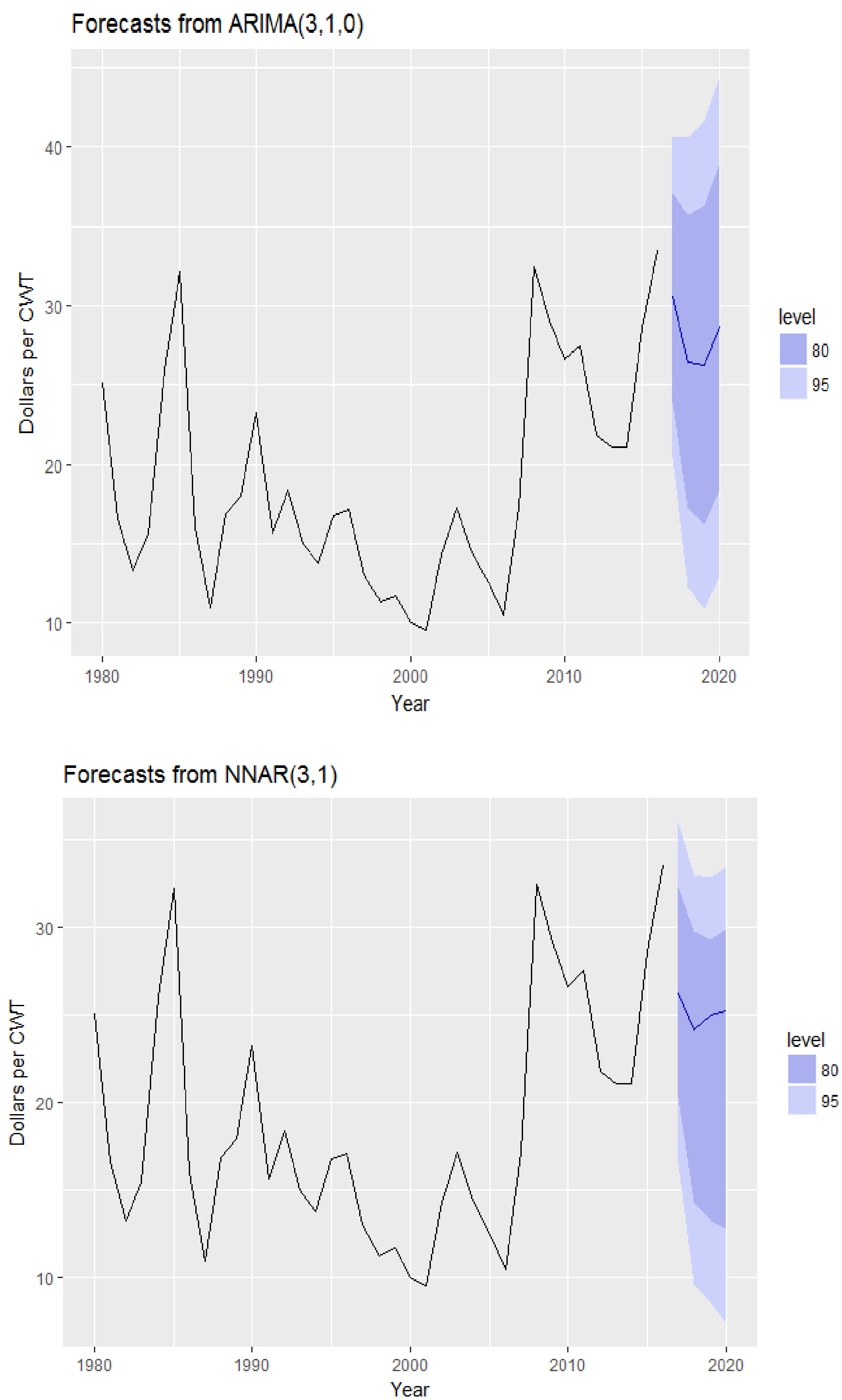

Figure 13. Lentil price forecast from both ARIMA and Neural Network Models

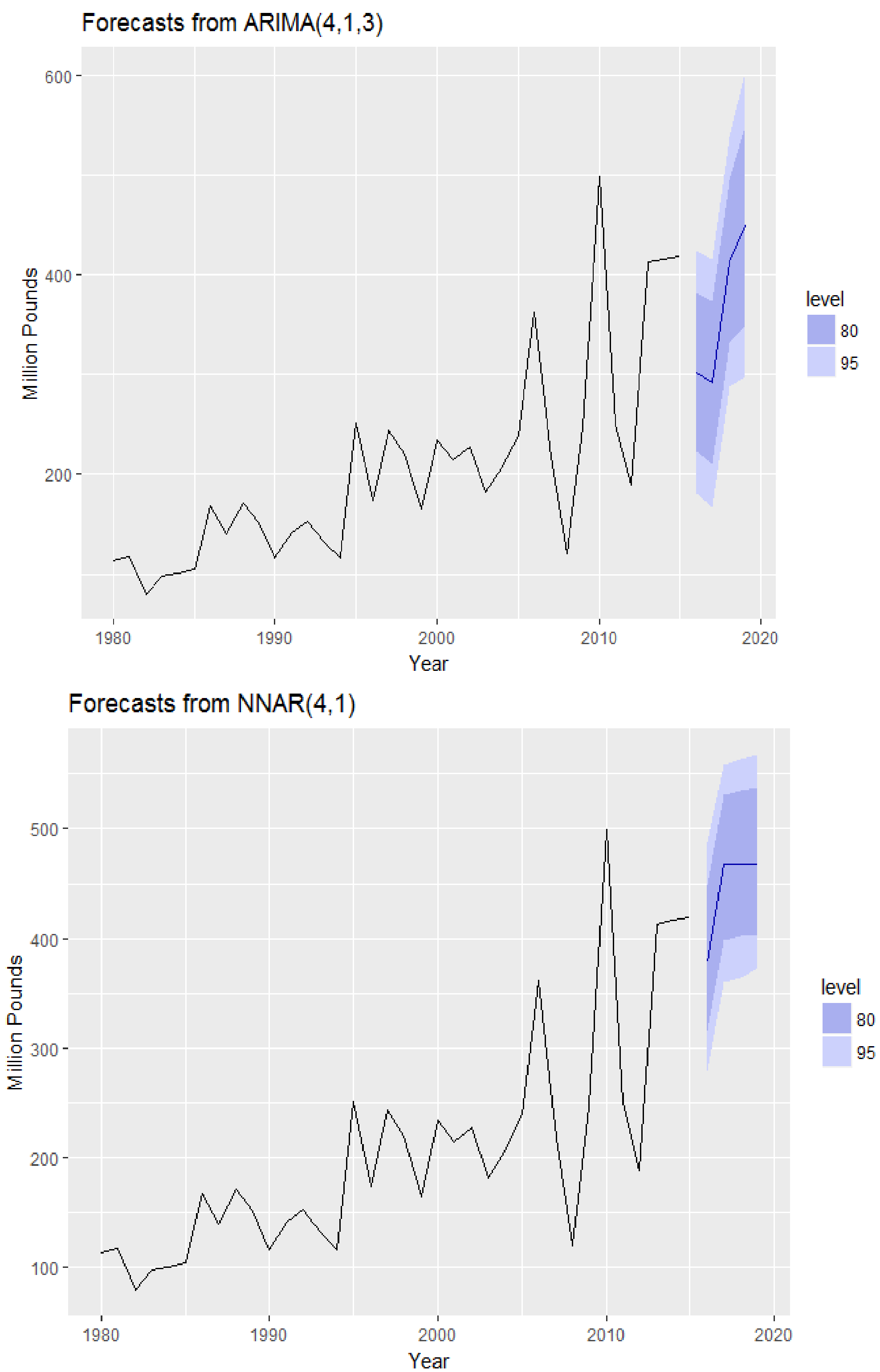

Figure 14. Arima, and NNAR Forecast results of domestic food utilization of both dry peas and lentils.

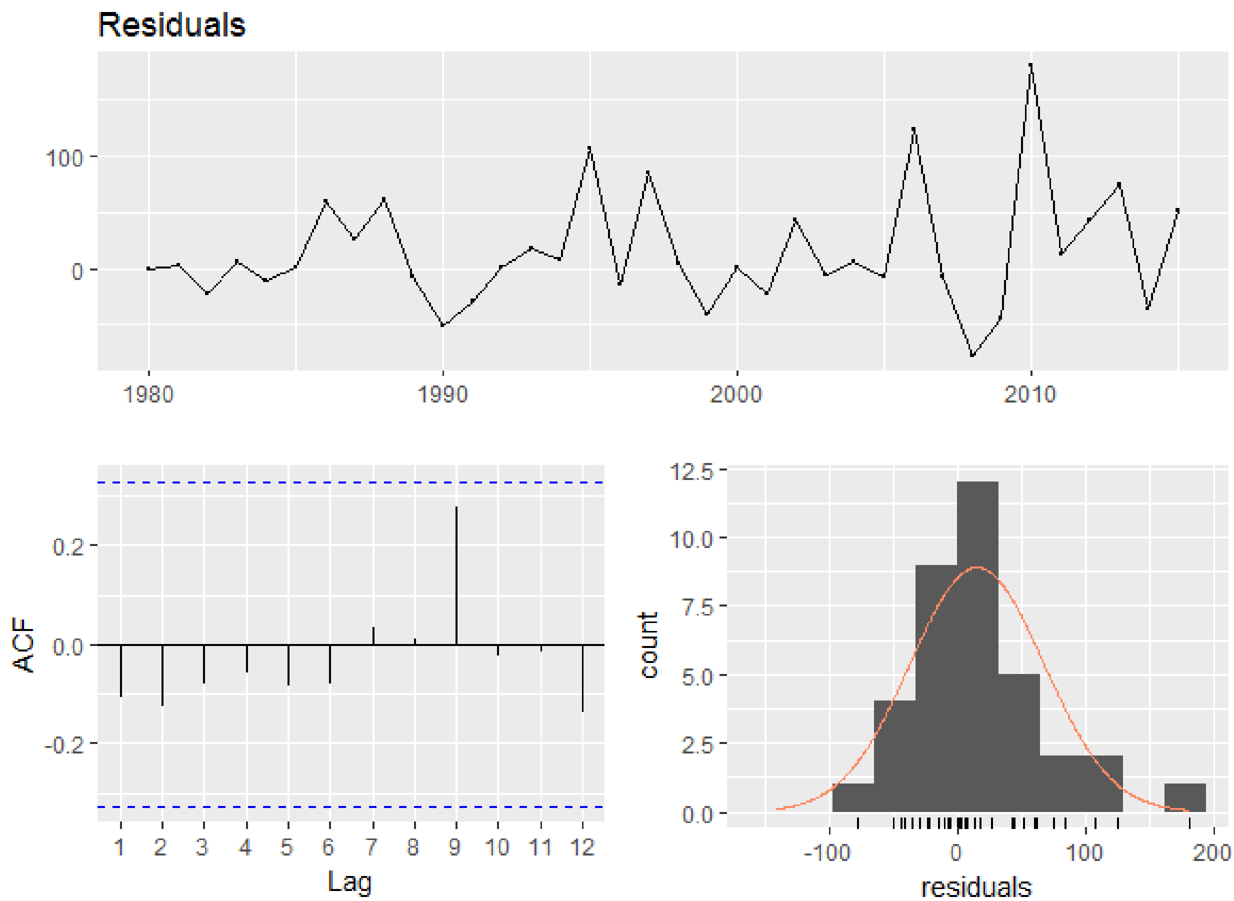

Figure 15. Residual analysis of domestic food utilization of dry peas and lentils' ARIMA (4,1,3) model.

Figure 14 shows the forecast results of two models: ARIMA (4,1,3), and NNAR (4,1) using the aggregated domestic food utilization of dry peas and lentils in the United States. ARIMA (4,1,3) forecast results suggest a decrease in total domestic food utilization of dry peas and lentils to 292 million pounds after which there is an increasing trend in utilization. According to ARIMA (4,1,3) results, the domestic food utilization of both dry peas and lentils would increase from 419 million pounds in 2015 to 450 million pounds in 2019. On the other hand, NNAR (4,1) forecast results suggest an increasing trend after a decrease in utilization in 2016. NNAR (4,1) forecast results suggest that the domestic food utilization of dry peas and lentils would increase to 468 million pounds in 2019. Figure 15 show an example of residual analysis showing autocorrelation function of residuals of the fitted ARIMA (4,1,3) model. The residual analysis suggests that the normality assumption of the ARIMA model is satisfied and there is no more significant information that is left in the residuals to be used for improving the accuracy of the forecasts.

Discussion of the Results:

One of the important caveats in time series forecasting models is that the model considers only the lagged values of that particular series. However, it is important to discuss the results of the study in the present context of acreage planted in 2017, and drought conditions in North Dakota and Montana.

Overall, the forecast results of production in the case of peas and lentils suggest that production is going to decrease in 2017. It is important to note that the overall production of a commodity depends on the planted acreage, harvested acreage and yield. Sometimes, there will be a considerable gap between planted acreage and harvested acreage, as well as yield gaps when compared with the previous year due to unforeseen climatic conditions.

Most of the pea and lentil acreage is concentrated in a few states including North Dakota, Montana, Idaho, and Washington. Currently, North Dakota and Montana are facing serious drought conditions in 2017. Specifically, the prevalent pockets of pea and lentil crop cultivation, including north-west and south-west parts of North Dakota, and eastern part of Montana, face severe drought in 2017 (Figure 16).

The recent *Vegetables and Pulses Outlook* by Minor and Bond (2017), released on April 28, 2017, indicates that the planted acreage for dry peas has decreased while the planted acreage for lentils has increased in 2017, compared to the previous year. As mentioned earlier, the harvested acres and yield matters the most in determining the total production of a commodity. Given a drought situation in key areas of pea and lentil cultivation, it is expected that 2017 production will be decreased. The forecast results of dry pea and lentil production also indicate production decreases in 2017 compared to 2016, in line with the expectation due to drought condition in North Dakota and Montana.

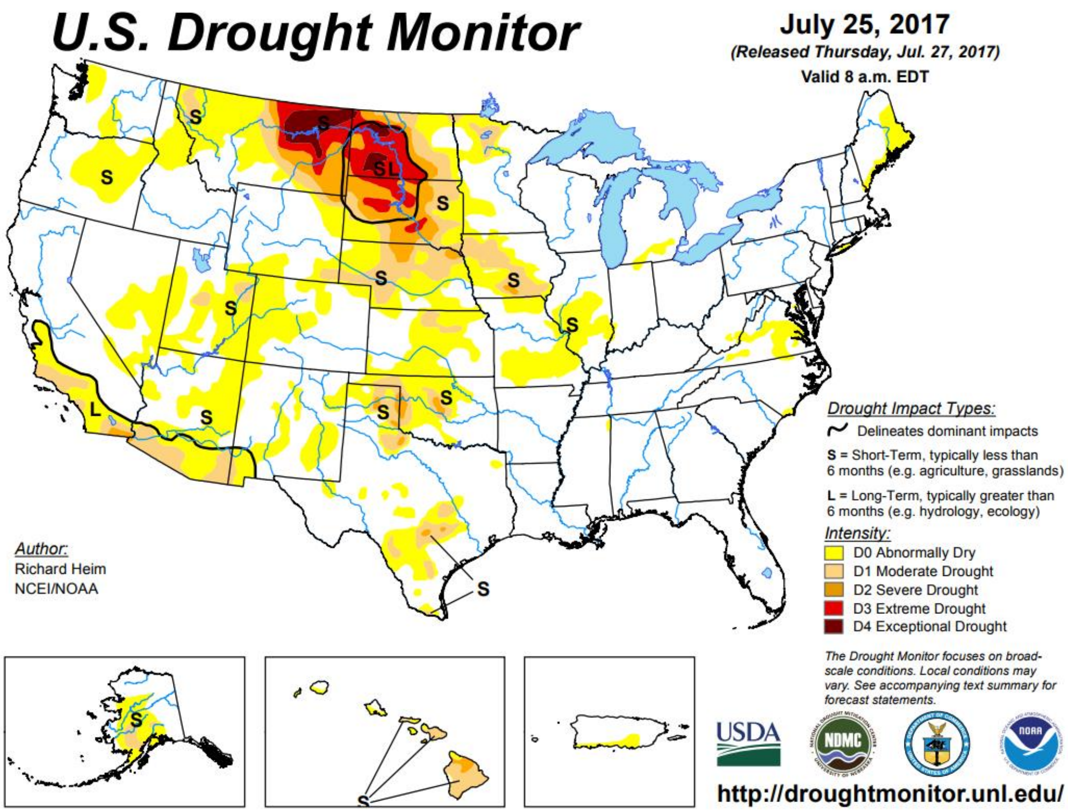

Figure 16. U.S. drought monitor map in 2017.

Source: http://droughtmonitor.unl.edu/

Global Market for U.S. Peas and Lentils

The United States has been a net exporter of both dry peas and lentils. On an average, approximately 50% of total U.S. dry peas and lentil supply is exported during 1980–2010 period (authors' computations using the data from USDA vegetable/pulse yearbook tables). In 2010, 64% of total U.S. dry peas and lentil supply is exported. Therefore, export market of dry peas and lentils is important in determination of their price fluctuations in the United States.

Major export destinations for dry peas (whole green) include India, China, Philippines, Canada, and Colombia. Of total dry pea exports from the United States, India's share is about 42%, followed by China at about 20% (Figure 17) (USDA/ERS, 2017). The value of dry pea exports from the United States has increased from US$ 68 million in MY 2012/13 to US$78 million in 2016/17 (USDA/ERS, 2017). It is important to note that the above figures are only for dried whole green peas. Apart from dried whole green peas, the United States also exports dried split peas, dried whole yellow peas, and dried Austrian winter peas. If we account for all kinds of pea exports, then the value of exports has increased from US$165 million in MY2012/13 to US$185 million in MY2015/2016 (USDA/ERS, 2017).[2]

Similarly, major export destinations for U.S. lentils by volume include India (34%), Spain (13%), Canada (9%), Mexico (6%), Peru (5%), and others (32%) (Figure 18) (USDA/ERS, 2017). The value of U.S. lentil exports has increased from US$21 million in MY2012/13 to US$34 million in 2014/15, and later decreased to US$28 million in MY2015/16 (USDA/ERS, 2017).[3]

[2] The value of dry peas exports in MY2016/17 (until March 2017) were approximately US$152 million.
[3] The value of lentil exports in MY2016/17 (until March 2017) were approximately US$25 million.

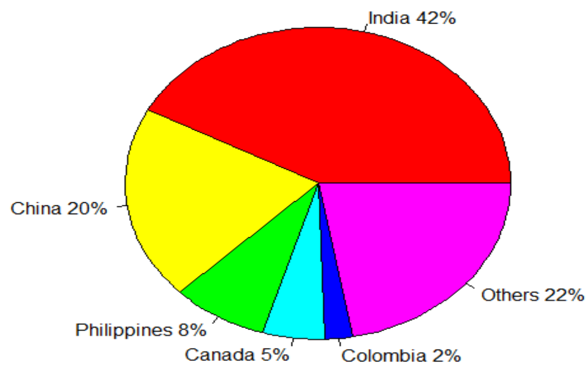

Figure 17. U.S. Export destinations for dry peas (whole green) by volume

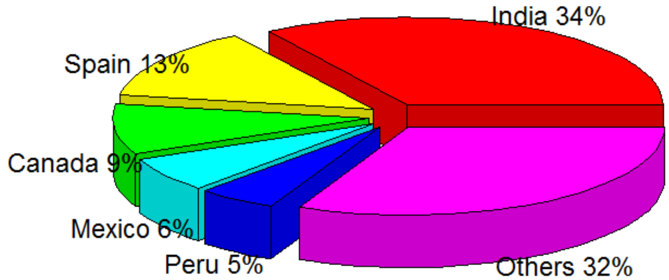

Figure 18. U.S. export destinations for lentils by volume

There are a few important takeaways from recent changes in U.S. exports of dry peas and lentils by volume and by value. India is the major export destination for U.S. peas and lentils, competing with Canadian exports. Canada is the top exporter of peas and lentils in the world. For example, in 2011, Canada accounted for about 35% of total global pulse trade, while the United States accounted for about 12% of total global pulse trade after Canada (Curran, 2011). Traditional export markets for peas and lentils (along with other pulses) include South Asia, the Middle-East, and Latin America, while there is possibility of expanding to new markets such as the European Union and China (especially for lentils) (Curran, 2011).

Part of U.S. pea and lentil exports to Canada could be due to specific type or the high quality of U.S. peas and lentils, which are mixed with Canadian peas and lentils before exporting to a third country. Alliance Grain Traders (AGT) Inc. is one of the largest buyers of pulses from growers and supplier of value-added pulses, and food ingredients in the world. Since major U.S. exports of peas and lentils are directed to few countries, government policies on pulses and climate conditions in countries like India are crucial for continued exports from the United States.

India is the major export destination of U.S. peas and lentils. Pulses are the major source of protein intake in India, particularly for the significant portion of the population that consume a vegetarian, or mostly vegetarian, diet. On September 16, 2016, the chief economic advisor to the current Indian government, and economist, Arvind Subramanian composed a report on incentivizing pulses production through different policy instruments. The report highlights that the primary motivation for incentivizing pulses production is to minimize volatility in domestic pulse markets and safeguard the interests of both farmers and consumers (Subramanian, 2016). A few major recommendations from the report are related to minimum support price, procurement, and other price management policies. Major recommendations of the report include the following (Subramanian, 2016):

1. To build up the pulses stock with targets for individual pulse group.
2. To increase the minimum support price to Rs. 70 per kilogram in 2018.
3. To give a production subsidy for farmers who grow pulses in irrigated areas of about Rs. 10–15 per kilogram of pulses via direct benefit transfer (DBT).
4. To eliminate export ban on pulses and stock limits.

If the Indian government and individual state governments decide to fulfill these above recommendations, then it is expected that domestic pulse production in India would increase. In India, increased pulse production would occur if major pulse growing regions receive sufficient rainfall. If domestic pulse production in India increases, then U.S. pea and lentil prices are expected to decrease along with their exports. In India, most of the pulses cultivation comes under the rain-fed regions, which are highly erratic. Therefore, it is important to consider the new policies enacted, and climatic conditions in major U.S. export markets such as India.

Conclusions and Recommendations:

Results from the ingredient market analysis indicate that manufacturers are using peas and lentils as ingredients in growing markets. However, there are some markets/categories that manufacturers should be aware of due to decreasing market growth. The results of the study provide manufacturers insight into pulse-based (peas and lentils) product performance and guide them in replacing traditional protein concentrates/isolates with cost-effective pulse proteins. As indicated earlier, chilled meats are one of the diminishing markets that lack opportunities for manufacturers. Hence, it is a great opportunity to develop pulse-based products as meat alternatives.

The commodity market analysis of peas and lentils suggest that the production of both dry peas and lentils decrease in 2017 due to drought in key pulses production states including North Dakota and Montana. Production of the dry peas and lentils depend on harvested acres, and yield. In general, both dry pea and lentil prices are volatile. Dry pea prices show an increasing trend, while lentil prices show a decreasing trend. Domestic food utilization of both dry peas and lentil together show a decrease in 2017 compared to 2016 and then showed an increased trend till 2019. Export market of peas and lentils is a critical component in determining their prices as the U.S. exports of peas and lentils together accounted for about 64% in 2010 and increasing thereafter. Hence, dry pea and lentil prices, to some extent depend on the policies enacted and climatic conditions in major U.S. export markets such as India.

Finally, public awareness programs about health benefits of peas and lentils (or pulses in general) should be continued. Although, the FAO declaration of 2016 as the International Year of Pulses benefited consumer's awareness, the efforts of public awareness programs are continued in innovative ways. For example, the results of sales and distribution of pulses are dominant in retail outlets. Increasing the use of peas and lentils as ingredients through workshops and other awareness programs in institutional, and food service centers is important for increasing the market for peas and lentils.

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