Time Series Forecast Model Selection for Wholesale Chicken Parts Prices

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ABSTRACT

Poultry wholesale parts prices have drastically changed as the industry has evolved over the years. The volatility experienced is due to response of input price volatility and demand and supply shocks. Such shocks include; avian influenza disease, crop droughts, and recession. These changes are often driven by world economic conditions that impact the roughly 20 percent of U.S. production that is exported. Price forecasting of poultry parts is of prime importance within the industry for developing customer prices. Integrators utilize a number of unbiased reporting companies to benchmark internal wholesale prices, then apply their own formulation based on margins to arrive at a final price. One reporting firm is Urner Barry (UB); this has become the "go to" for many in the industry. Econometricians developing economic models are dependent on an understanding of the poultry market shifts and forecasting ability. Accurate forecasting of prices is extremely important; it is from these prices that integrators establish base prices with buyers (foodservice, retail grocer, restaurants, and other outlets) for products. This research project incorporated re-estimation of a model developed and published by McKenzie, Goodwin, and Carreira, "Alternative Model Selection Using Forecast Error Variance Decompositions in Wholesale Chicken Markets" (McKenzie, Goodwin, & Carreira, 2009). The modal conclusion from this model was that VAR models, which incorporate price correlations across chicken parts, outperform AR models used to forecast whole bird (WOG) prices. The updated model extends the out-of-sample forecast horizon, and this, coupled with the fact that the poultry industry has transitioned to more further processed value added products, brings into question if previous model results still holds true.

BACKGROUND

- The United States poultry industry is the largest producer of poultry meat globally producing a projected 40 billion pounds in 2017 (NCC).
- The poultry industry has evolved away from producing the standard 8-piece cut-up and whole bird. Consumer demand has shifted integrators' focus to production of further processed value-added products. In 1990, the percentage of birds marketed as whole, cut-up, and further processed were 18%, 56%, and 26%, respectively. In 2015, the percentages were forecasted to be 11%, 40%, and 49%, respectively, for whole, cut-up and further processed[1].
- The poultry industry is extremely vital to the United States agricultural economy, specifically broiler production. In 2016, the chicken industry provided 1.2 million jobs, $68 billion in wages, $313 billion in economic activity and $24 billion in government revenue.

OBJECTIVES

- Re-estimation of model developed by McKenzie, Goodwin and Carreira to include updated data values
- Determine if results still hold true with industry and consumer changes
- Null hypothesis – H_0: VAR model specification is not different from AR model specification
- Alternate 1 – H_1: VAR forecast are preferred to AR
- Alternate 2 – H_2: AR forecast are preferred to VAR

REFERENCES

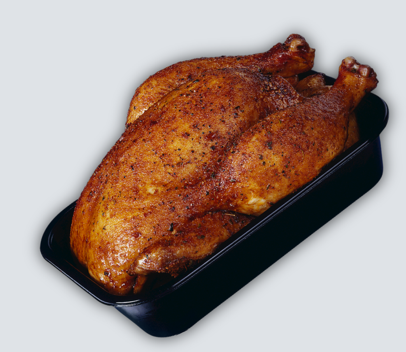
- 1. National Chicken Council (NCC). (2017). *How Broilers are Marketed.*
- 2. Urner Barry Publications, Inc. (2017). *Chicken History.*

METHODS

- Vector Autoregressive (VAR) models and Autoregressive models were specified with 3 month lags and dynamic forecasts were estimated over a 1 to 9 month ahead forecast horizon.
- The in-sample model estimation period used UB monthly aggregated reported prices from January 1998 to July 2007. The out-of-sample forecasts were generated from August 2007 to May 2017.
- UB Parts prices include: Boneless skinless breast tender out (BSBTO), leg quarter (LQ), wings (WING), whole bird with out giblets (WOG).
- Utilized Diebold-Mariano (DM) test to compare price forecasting models

Statistics of Monthly Average Prices (Cents/Pound) Selected Broiler Parts for the Northeast U.S. Market (January 1989 - May 2017) [2]

Part	Mean	Variance	Minimum	Maximum
BSBTO	145.31	665.60	105.00	255.55
LQ	33.44	122.94	13.76	54.00
SMWING	110.37	1623.52	41.00	196.27
JMWING	107.65	1376.25	42.63	188.78
WOG	79.31	360.22	46.59	126.33
THIGH	43.09	283.35	14.67	236.00
TENDER	149.99	995.71	91.40	236.00
DRUM	41.12	156.86	20.42	65.29

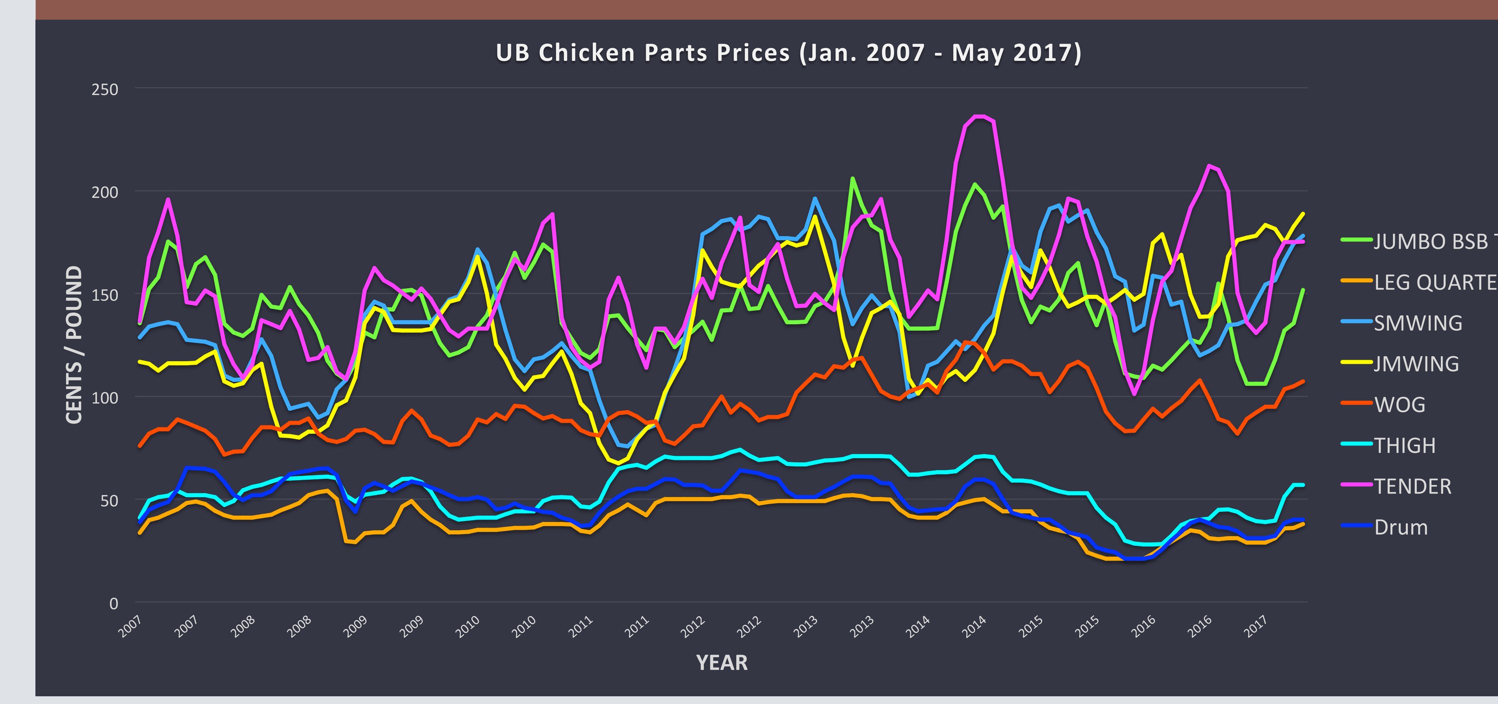


- Individually tray packed parts
- Further processed value added chicken patties on processing line
- Ready-to-eat rotisserie chicken

RESULTS / CONCLUSION

- Results for each poultry part are evaluated with the DM test based upon Mean Square Error (MSE) and Mean Absolute Error (MAE) criteria. The Mean Error (ME), MAE, Root Mean Square Error (RMSE) and Theil's U Statistic are also recorded. We observe relatively large forecast errors compared with the McKenzie, Goodwin and Carreira model, which may be attributed to the higher volatility that the market has experienced in more recent years.
- There were some differences with the updated model. The most notable difference is the change in model preference for forecasting the WOG. Previously the VAR model was preferred overall; however, now the AR model is preferred except for four instances. This is indicative of the industry's shift to further processed value-added products whereby prices of parts are no longer as closely tied to the cost and price of the whole bird. AR models are overwhelmingly preferred when forecasting individual parts prices. Again, this may be attributed to the fact that further processed, value-added products using parts now have more inputs and are impacted by other exogenous factors. Further processing reduces the correlation between the parts and, accordingly, reduces the forecasting power of VAR models.

RESULTS



		VAR (3) Estimation August 07 - May 2017				AR (3) August 07 - 17				D-M p-Value of Test of H0: VAR (3) = AR(3)				
										VAR > AR		VAR < AR		Concl.: Data
Step	N	ME.	MAE.	RMSE.	Theil U	ME	MAE	RMSE	Theil U	MSE	MAE	MSE	MAE	Supports
		Forecast Statistics for Series WING												
1	120	1.148	6.128	7.571	0.883	1.072	6.052	7.491	0.873	0.464	0.763	0.536	0.237	FTR H_0
2	120	2.687	10.524	12.942	0.922	2.444	10.291	12.660	0.902	0.923	0.959	0.077	0.041	VAR < AR
3	120	4.319	13.315	16.181	0.933	3.865	13.023	15.657	0.903	0.622	0.856	0.378	0.144	FTR H_0
4	120	5.668	14.973	18.255	0.924	5.021	14.544	17.634	0.892	0.595	0.883	0.405	0.117	FTR H_0
5	120	6.824	16.543	20.127	0.909	6.011	15.907	19.423	0.877	0.582	0.754	0.418	0.246	FTR H_0
6	120	7.841	17.983	21.921	0.901	6.890	17.223	21.083	0.867	0.611	0.437	0.389	0.563	FTR H_0
7	120	8.742	19.397	23.418	0.895	7.678	18.687	22.485	0.860	0.637	0.218	0.363	0.782	FTR H_0
8	120	9.563	20.642	24.624	0.891	8.410	19.776	23.606	0.854	0.719	0.230	0.281	0.770	FTR H_0
9	120	10.289	21.321	25.587	0.885	9.068	20.287	24.512	0.847	0.790	0.387	0.210	0.613	FTR H_0
		Forecast Statistics for Series WOG												
1	120	0.400	2.452	3.205	0.902	0.497	2.543	3.308	0.931	0.390	0.291	0.610	0.709	FTR H_0
2	120	0.981	4.326	5.352	0.897	1.204	4.516	5.766	0.966	0.937	0.919	0.063	0.081	VAR < AR
3	120	1.551	5.363	6.626	0.874	1.840	5.588	7.120	0.939	0.453	0.550	0.547	0.450	FTR H_0
4	120	2.137	6.007	7.491	0.871	2.427	6.119	7.964	0.926	0.572	0.807	0.428	0.193	FTR H_0
5	120	2.678	6.355	8.131	0.878	2.944	6.332	8.435	0.911	0.751	0.921	0.249	0.079	VAR < AR
6	120	3.266	6.467	8.545	0.875	3.505	6.430	8.710	0.892	0.874	0.969	0.126	0.031	VAR < AR
7	120	3.794	6.570	8.823	0.859	4.002	6.612	9.015	0.878	0.863	0.964	0.137	0.036	VAR < AR
8	120	4.282	6.656	8.878	0.844	4.456	6.802	9.177	0.873	0.831	0.894	0.169	0.106	VAR < AR
9	120	4.728	6.701	8.894	0.839	4.872	6.922	9.261	0.874	0.823	0.832	0.177	0.168	FTR H_0
		Forecast Statistics for Series BSBTO												
1	120	0.891	8.905	11.429	0.935	0.492	8.561	10.974	0.898	0.993	0.965	0.007	0.035	VAR < AR
2	120	2.108	13.067	17.728	0.871	1.043	12.392	17.101	0.840	1.000	0.989	0.000	0.011	VAR < AR
3	120	3.374	16.344	22.403	0.862	1.640	15.351	21.544	0.829	1.000	0.999	0.000	0.001	VAR < AR
4	120	4.532	19.158	25.558	0.847	2.284	17.740	24.504	0.812	1.000	1.000	0.000	0.000	VAR < AR
5	120	5.624	20.030	27.185	0.831	3.013	19.141	26.232	0.802	1.000	0.995	0.000	0.005	VAR < AR
6	120	6.677	20.347	27.677	0.816	3.801	19.759	26.965	0.795	0.999	0.979	0.001	0.021	VAR < AR
7	120	7.569	20.490	27.440	0.811	4.521	20.145	27.013	0.799	0.996	0.987	0.004	0.013	VAR < AR
8	120	8.520	19.813	26.853	0.816	5.382	19.871	26.755	0.813	0.990	0.966	0.010	0.034	VAR < AR
9	120	9.256	19.948	27.103	0.848	6.097	19.970	27.188	0.850	0.976	0.969	0.024	0.031	VAR < AR
		Forecast Statistics for Series LQ												
1	120	0.432	2.269	3.254	0.915	0.371	2.081	3.096	0.870	0.990	0.999	0.010	0.002	VAR < AR
2	120	0.995	4.187	5.554	0.941	0.871	3.970	5.302	0.899	0.999	0.999	0.001	0.001	VAR < AR
3	120	1.483	5.497	6.918	0.925	1.310	5.334	6.630	0.886	0.992	0.992	0.008	0.008	VAR < AR
4	120	1.928	6.442	7.917	0.912	1.699	6.200	7.621	0.878	0.995	0.997	0.005	0.003	VAR < AR
5	120	2.355	6.981	8.604	0.901	2.054	6.727	8.265	0.865	0.998	0.997	0.002	0.003	VAR < AR
6	120	2.765	7.334	9.063	0.899	2.382	7.046	8.676	0.861	0.999	0.996	0.001	0.004	VAR < AR
7	120	3.145	7.558	9.274	0.911	2.679	7.232	8.887	0.873	0.999	0.993	0.001	0.007	VAR < AR
8	120	3.499	7.617	9.319	0.932	2.955	7.204	8.907	0.891	0.999	0.995	0.001	0.005	VAR < AR
9	120	3.835	7.636	9.394	0.961	3.222	7.156	8.864	0.907	1.000	0.998	0.000	0.002	VAR < AR