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Morning-Fresh: Declining Prices and the Right-to-Choose in the Faroe Fish Market

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Abstract

Theory predicts that when homogeneous goods are auctioned sequentially, to prevent intertemporal arbitrage the sale prices should exhibit no trend over time. Ashenfelter (1989) was the first to empirically test this hypothesis, and found that prices in wine auctions tended to decline throughout the day. We use transaction-level data from wholesale fish auctions in the Faroe Islands to test for price trends using two methods: price-ratios and regression analysis. Both methods agree that prices in our data are declining. Furthermore, the pattern persists both on aggregate, and within individual fish species. We attribute the price decline to two main factors: the declining number of bidders, and the possibly declining quality of fish, throughout the day. Though the dataset logs each unit of the same fish-type as identical, early auction winners have the right to choose their preferred box before the rest is re-auctioned. This is likely to contribute to a decline in perceived fish quality in later auctions that is unobservable in the data, but possibly important in motivating bidder behaviour.

JEL Classification: D44, D47, Q22

Keywords: auctions, sequential auctions, afternoon effect, declining price anomaly, fish market, right-to-choose auctions

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1 Introduction

One highly celebrated, yet intuitive, result in the sequential auctions literature states that under standard assumptions, the equilibrium price path should not feature a time-trend (Weber, 1983). Were this not the case, intertemporal arbitrage could occur: if prices increase over time, more bidders should bid earlier (conversely: later, if prices drift down). In an equilibrium, then, expected prices should be the same across rounds. However, Ashenfelter (1989) found that auction prices of identical bottles of wine were twice as likely to fall, as they were to rise over the scope of the day; hence the term the *declining price anomaly* or *'the afternoon effect.'* Thereafter, other studies have found price trends in sequential auctions in numerous settings, including Beggs and Graddy (1997) who observe declining prices in auctions for art, and Raviv (2006), who finds increasing prices in auctions for used cars.

We investigate price trends in wholesale auctions for fish in the Faroe Fish Market using two methods: the price-ratio approach of Ashenfelter (1989), and regression analysis. Our dataset contains transaction-level information from all the auctions held at the market between January and December 2017, allowing us to check for price trends both on aggregate, and at the level of individual fish-types.

Results from both methods agree: declining prices throughout the day occur both on aggregate, and at the fish-type level. We attribute this pattern to two characteristics of the market. Firstly, compared to other fish markets, the Faroese fish market has few bidders; since some bidders satisfy their daily demand early, later auctions have fewer participants, thus less competition and lower prices. Secondly, though nominally all lots of fish of a particular type are logged as homogeneous goods, winners in early auctions have the 'right-to-choose' their preferred lots before the rest is re-auctioned. Having the option to pick first is valuable if there are unobserved quality differences between lots. Winning an earlier auction may also be valuable since it permits the winner to load the fish onto their truck quicker and proceed with distribution. Quantifying this last effect is the subject of future work on this data.

2 The Faroe Fish Market

The Faroe Fish Market is a private company founded in 1992 to coordinate the wholesale of fish in the Faroe Islands. Though auctions had also been used prior to 1992, buyers could only bid via telephone on large bulk amounts. The current design, conversely, allows the bidders to inspect the fish in advance, and choose however much they need. Each fish-type is defined by the fish species and size. Depending on the day's catch, the selection of types on offer varies. The auctions are run daily from 10am, and bidders can participate either in person, or remotely through an online bidding system.

The auctions are run as clock-auctions, which combine both a descending, and an ascending phase. The auctioneer announces the fish-type and initial price, then starts the price-clock. If no bidders enter at the starting price, the price falls until a bidder

enters; the clock is then paused momentarily, giving other bidders the chance to also start bidding. If no other bidders enter, the first-bidder wins and pays the clock price; if other bidders do enter, the price-clock reverses direction, and the price rises until all-but-one bidders drop out again. The winner can decide how much of the remaining supply they wish to purchase, before the residual is re-auctioned in subsequent rounds.

3 Data

Our data covers all auctions run at the Faroe Fish Market from January to December 2017. We observe 5,398 auctions covering 63 fish-types, with 25 bidders participating. The fish in our sample were caught by 314 vessels, and landed at 19 different ports.[1]

Table 1 shows the number of transactions by auction round. Most auctions (58%) end after the first round, when the first winner buys the entire supply; 2,243 transactions occur in the second round or later.

Table 1: Number of transactions in each round

Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Transactions	3,155	1,051	538	287	151	86	55	34	17	10	7	3	2	1	1

4 Trend analysis using price-ratios

To evaluate price trends in auctions, Ashenfelter (1989) calculates the price ratio for each round relative to its predecessor. In our case, the ratio is defined by $\frac{(k)^{th}\ price}{(k-1)^{st}\ price}$ for all $k \geq 2$ where k indicates the auction round for a particular fish-type on a given day. This calculation only applies to auctions with two or more rounds: if the first winner buys the entire supply there is no trend to calculate. Our sample contains 2,243 eligible auctions.

Table 2: Distribution of price patterns: overall, and for cod and haddock

	All auctions		Cod		Haddock	
Increasing	267	11.9%	206	14.0%	42	8.0%
Decreasing	1,813	80.8%	1,149	78.1%	459	85.9%
Unchanged	163	7.3%	116	7.9%	27	5.1%
Mean of ratios	0.942		0.953		0.937	
Standard deviation	0.107		0.099		0.080	
Number of comparisons	2,243		1,471		528	

Note: Prices compared to the price in the previous round.

[1] Online Appendix A, Section 8, provides further details on fish-types.

Table 2 summarizes the ratio calculations, both for the whole sample, and for the two largest fish species: cod and haddock. We find declining prices: in all three cases most price ratios are below unity, and prices are over five times as likely to fall as they are to rise; they remain unchanged less than 10% of the time. As the mean ratios are also below one, price declines are larger in magnitude than increases.

5 Regression analysis

The most direct regression approach to checking for price trends is to regress the price on the round, while controlling for fish-type and the first price of the day. We include these controls for two reasons: firstly, the prices can vary depending on the day of the week (Salladarré et al., 2017), and secondly, if buyers' valuations are affiliated, the signals sent through an earlier price influence later prices. To account for variability in the trend across clusters, we run a linear mixed regression model with a random intercept and slope, grouped by fish-type.

Table 3 reports a decreasing price trend, with a negative coefficient of -1.365 ($p = 0 < 0.001$). The random effect estimates in Table 3 show that there is considerable variation across fish-types, but the overall effect of round on prices is negative. Checking the individual slope coefficients, all 63 fish-types exhibit a negative time-trend.[2]

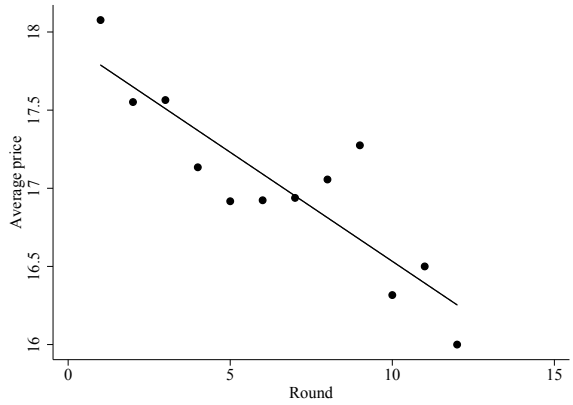
Table 3: Mixed regression model for estimating prices

Fixed effects			
Round	-1.365	(0.302)	***
First price	0.917	(0.034)	***
Constant	2.774	(0.479)	***
Random effects			
Var(Round)	3.144	(1.390)	
Var(Constant)	10.509	(6.287)	
Var(Residual)	2.900	(0.748)	
Number of observations: 5,398. Number of groups: 63			
Robust standard errors in brackets. $***p < 0.001$, $**p < 0.01$, $*p < 0.05$.			

To compare our results to other fish markets, we use the method of Gallegati et al. (2011), who analyse the Ancona fish market in Italy. They calculate the average price of each round in all the auctions in the sample, then compare average prices between rounds. To illustrate this method, we apply it to the auctions of 'cod (size 4)', the most frequently sold fish-type. Like Gallegati et al. (2011), we find that the prices are decreasing: as Figure 1a shows, the average price is highest for the first and lowest for the last auction round of the day, with a decrease of nearly 12%. As Figure 1b shows,

[2]Full list of coefficients is available in Online Appendix B, Section 9.

regressing the average price on auction round confirms a negative trend in the average prices of cod, with a coefficient of -0.1395 ($p < 0.001$).



(a) Average price of 'cod 4' in each round and regression line

Round	-0.1395	***	(0.022)
Constant	17.928	***	(0.145)
Number of observations: 12			
$F(1, 10) = 39.19^{***}$, $R^2 = 0.772$			
Robust standard errors in brackets.			
$^{***}p < 0.001$.			

(b) Estimation results for average prices of 'cod 4'

Figure 1: Trends in average prices of 'cod 4'

We extend this analysis to other fish-types that have been sold over at least three rounds in our sample; out of the 63 fish-types, 22 fit this criterion. Testing for trends on the average prices of these 22 fish-types at the standard 5 percent significance-level, six show declining prices, two show increasing prices, and the remaining 14 exhibit no significant trend.[3] However, out of the ten most frequently sold fish, four exhibit declining average prices, while the two types that show increasing prices rank outside the top ten.

6 Explaining the declining prices

We focus on two main explanations for declining prices in our sample: the right-to-choose nature of the auctions, and the small bidder pool. The auctions at the Faroe Fish Market are right-to-choose auctions, allowing bidders to pick their preferred goods if they win early. Decreasing prices could be expected in right-to-choose auctions as this would imply that the 'best' goods would be picked first, as noted by Gale and Hausch (1994). As our data does not contain a proxy for quality, we cannot quantify this effect, but it is a plausible explanation.

Furthermore, several papers have suggested that supply uncertainty leads to decreasing prices (Jeitschko, 1999; Neugebauer and Pezanis-Christou, 2007). Our auctions also involve uncertain supply: especially since the first winner may buy the entire supply, the residual supply for subsequent bidders is very uncertain. This option value of winning early could contribute to declining prices, especially if supply is low from the outset. This

[3]These regression results are shown in their entirety in Online Appendix C, Section 10.

would coincide with the results of Salladarré et al. (2017), who found that prices decrease more when supply is low.

To establish a reliable 'low-supply' benchmark, sufficient data is necessary. Hence we restrict our attention to cod and haddock, which are most frequently sold, and together account for almost 70% of the data. As before, we use a mixed regression model grouped by fish-type, and measure random and fixed effects with respect to the round. Model 1 in Table 4 includes an interaction of the low-supply dummy (which takes value 1 for 'below-average supply') and the round. Though the coefficient is more negative when supply is low, the difference is economically negligible.

Engelbrecht-Wiggans and Kahn (1999) attribute declining prices to decreased competition in later rounds because buyers have limited capacity for purchases and thus may purchase the required quantities in earlier rounds. This results in fewer buyers in later rounds, and hence decreased competition. In our data this effect may be important, since the Faroe Fish Market features a much lower buyer-to-seller ratio than fish markets studied by, for example, Gallegati et al. (2011) and Salladarré et al. (2017). To gauge the plausibility of a competition effect, we regress the number of bids on the round, and found a coefficient of -0.0874 ($p < 0.001$): the number of bidders decreases by almost nine percent per round.

Table 4: Expanded mixed regression model estimates for cod and haddock

	Model 1		Model 2		Model 3	
Round*	-0.573	***			-0.516	***
(Low-supply=0)	(0.104)				(0.103)	
Round*	-0.639	***			-0.483	***
(Low-supply=1)	(0.083)				(0.064)	
Round			-0.496	***		
			(0.075)			
Bids			0.517	***	0.523	***
			(0.062)		(0.057)	
First price	0.768	***	0.714	***	0.7120	***
	0.054		(0.051)		(0.048)	
Constant	4.172	***	3.686	***	3.697	***
	(0.872)		(0.760)		(0.753)	
Observations	3,651		3,651		3,651	
Wald χ^2	314.6 (3 d.f)		385.8 (3 d.f.)		413.5 (4 d.f.)	
Wald $p-value$	$p < 0.001$		$p < 0.001$		$p < 0.001$	

Robust standard errors in brackets. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$.
Output of random-effects parameters suppressed for brevity.

Adding the number of bids as a regressor in Model 2 in Table 4, we find that the number of bids is positively correlated with price (coefficient: 0.517, $p < 0.001$). The

round coefficient remains negative, -0.496 ($p < 0.001$), implying that the number of bids alone, is insufficient for explaining declining prices.

Model 3 in Table 4 includes both the number of bids, and the interaction between the round and low supply. The price coefficients remain significantly negative; though the direction of the difference has reversed, it remains economically negligible. Competition, even combined with supply uncertainty, is insufficient to explain the declining-price anomaly in our data.

In future research, we will investigate three further explanations for declining prices: risk-aversion (as in Mezzetti (2011)), possible unobserved heterogeneity in fish quality, and the value-of-time. For many buyers in our sample, purchases through the fish market are the only means of accessing fresh fish. The combination of uncertain supply and risk averse buyers would likely contribute to decreasing prices. Since our current dataset doesn't include data on bidders' risk attitudes, testing this hypothesis is beyond the scope of this paper.

Though all fish of the same type are listed as homogeneous products, if unobserved heterogeneity in quality exists, the 'right-to-choose' nature of the auctions may allow earlier winners to pick better fish. Higher early-round prices could then be explained away as a quality-premium. While our current data does not contain quality information, a rough magnitude of the quality-premium could perhaps be elicited from bidders via surveys in future research.

The value-of-time explanation follows from some comments of market participants, who said that for highly perishable goods, the speed of the sale is important. Therefore winning an auction earlier makes the fish more valuable, since it can be loaded onto the trucks faster, and be processed sooner. We are currently working on econometric techniques to incorporate this effect into a model of equilibrium bidding.

7 Conclusions

In our data the ratio method of Ashenfelter (1989), and regression techniques agree: declining prices feature strongly in the Faroe Fish Market both overall and for major species. Our findings align with the theoretical predictions on auctions with the right-to-choose, and the results on auctions with a buyers option. We also found that both competition and supply conditions have an impact on price patterns. Nonetheless, even controlling for these explanations, the declining price-trends persist, highlighting that the declining-price anomaly remains an open topic for further research.

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8 Online Appendix A: Fish-types, prices, and amounts

Table 5: Fish-types, number of transactions, quantities and average prices in 2017

ID	Fish Name	Times sold	Amount (kg)	Avg. price (kr./kg)	ID	Fish Name	Times sold	Amount (kg)	Avg. price (kr./kg)
1	Cod 1	369	258,254	22.29	38	Greenland halibut	9	24,770	30.58
2	Cod 2	457	435,105	20.87					
3	Cod 3	565	1,044,138	18.93	39	Norwegian haddock 1	1	128	8.00
4	Cod 4	649	802,592	17.54					
5	Cod 5	399	57,550	11.93	40	Norwegian haddock 2	2	44	7.10
6	Cod	29	7,702	13.48					
7	Cod 1-2	2	75	19.55	41	Norwegian haddock	94	14,833	8.00
8	Haddock 1	299	52,781	18.00					
9	Haddock 2	366	325,695	17.47	42	Blue ling	85	78,557	12.78
10	Haddock 3	337	237,454	14.89	43	Wolf fish	129	14,993	6.77
11	Haddock 4	82	8,960	2.87	44	Spotted	64	29,029	10.88
12	Haddock	79	10,578	11.19	45	Monkfish 1	1	18	24.00
13	Haddock 1-2	18	957	15.91	46	Monkfish	194	36,683	23.20
14	Whiting	105	20,204	7.55	47	Halibut 1	36	5,251	54.49
15	Whiting 1	2	239	9.25	48	Halibut 2	42	2,358	81.80
16	Coalfish 1	39	6,469	7.78	49	Halibut 3	29	685	94.72
17	Coalfish 2	10	1,947	8.41	50	Halibut 4	6	28	104.00
18	Coalfish 3	12	741	7.53	51	Halibut	1	391	55.00
19	Coalfish 4	6	213	5.52	52	Plaice	46	3,630	5.99
20	Coalfish 5	4	791	4.18	53	Pollack	95	5,377	7.45
21	Coalfish	33	7,189	7.16	54	Smear dab	29	4,438	24.21
22	Coalfish 1-2	8	968	7.73	55	Ray (Skate)	53	17,569	7.67
23	Cusk 1	49	17,303	7.36	56	Skate wings	42	9,681	20.44
24	Cusk 2	37	32,139	7.31	57	Dab	14	428	3.99
25	Cusk 3	25	25,604	7.18	58	Cod roe	4	67	9.58
26	Cusk 4	16	6,330	5.68	59	Turbot	3	10	41.00
27	Cusk	43	9,168	4.32	60	Porbeagle	1	25	7.80
28	Cusk 1-2	5	3,295	7.80	61	Opak	1	40	11.50
29	Cusk 2-3	3	229	6.13	62	Mackerel	1	7	4.80
30	Ling 1	94	75,012	14.95	63	Greenland halibut (sek)	75	131,401	19.05
31	Ling 2	62	156,005	15.60					
32	Ling 3	49	51,508	14.71					
33	Ling 4	36	13,512	11.75					
34	Ling 5	13	417	3.92					
35	Ling	35	10,768	10.50					
36	Ling 1-2	3	408	14.30					
37	Ling roe	1	120	12.00					

9 Online Appendix B: Mixed-model estimates

Table 6, below, reports the slope parameters on the round variable, for each fish-type, resulting from the estimation of the mixed regression model of Section 5. All 63 fish-types exhibit a negative coefficient.

Table 6: Slope coefficients on individual fish-types

Fish name	Slope	Fish name	Slope	Fish name	Slope
Cod 1	-0.668	Cusk 1	-0.331	Spotted wolf fish	-1.548
Cod 2	-0.473	Cusk 2	-0.434	Monkfish 1	-1.631
Cod 3	-0.330	Cusk 3	-0.285	Monkfish	-1.722
Cod 4	-0.463	Cusk 4	-0.512	Halibut 1	-5.891
Cod 5	-1.132	Cusk	-0.387	Halibut 2	-5.930
Cod	-1.117	Cusk 1-2	-0.763	Halibut 3	-7.447
Cod 1-2	-1.500	Cusk 2-3	-0.733	Halibut 4	-7.295
Haddock 1	-0.822	Ling 1	-0.186	Halibut	-2.796
Haddock 2	-0.530	Ling 2	-0.403	Plaice	-0.712
Haddock 3	-0.545	Ling 3	-0.386	Pollack	-0.927
Haddock 4	-0.598	Ling 4	-1.073	Smear dab	-4.227
Haddock	-2.228	Ling 5	-0.395	Ray (Skate)	-0.543
Haddock 1-2	-0.760	Ling	-1.123	Skate wings	-1.267
Whiting	-1.846	Ling 1-2	-1.211	Dab	-0.416
Whiting 1	-0.970	Ling roe	-1.180	Cod roe	-0.902
Coalfish 1	-0.550	Greenland halibut	-2.348	Turbot	-2.775
Coalfish 2	-0.745	Norwegian haddock 1	-1.029	Porbeagle	-1.022
Coalfish 3	-0.668	Norwegian haddock 2	-0.860	Opak	-1.161
Coalfish 4	-0.588	Norwegian haddock	-1.163	Mackerel	-0.909
Coalfish 5	-0.562	Blue ling	-1.009	Greenland halibut (sek)	-1.572
Coalfish	-0.481	Wolf fish	-1.196		
Coalfish 1-2	-0.712				

10 Online Appendix C: Trends in average prices

Below are the results from using the average price method of Gallegati et al. (2011), on each of the 22 eligible fish-types in our data-set. Testing at the standard 95% confidence level shows that six fish-types have significantly negative coefficients, while only two are positive; the remaining 14 are not significantly different from zero. The negative coefficients occur, however, on more frequently traded and economically more significant fish-types; the positive coefficients appear on fish that rank outside the top-40 by weight, and thus have limited impact on aggregate price trends.

Table 7: Average increases and decreases in price

Fish-type	Coefficient	p-value	Rank by transactions
Cod 4	-0.14 *	0.0001	1
Cod 3	-0.36 *	0.0097	2
Cod 2	-0.44	0.1018	3
Cod 5	-0.52 *	0.0104	4
Cod 1	-0.52	0.0562	5
Haddock 2	-0.22	0.3634	6
Haddock 3	-0.52 *	0.0110	7
Haddock 1	1.07	0.2190	8
Wolf fish	0.33	0.7558	10
Whiting	-1.05	0.2328	11
Ling 1	0.49 *	0.0182	13
Blue ling	0.34 *	0.0087	15
Spotted wolf fish	-0.41	0.2912	19
Ling 2	0.39	0.0574	20
Ling 3	0.54	0.0891	22
Cusk 1	-0.72 *	0.0316	23
Skate wings	1.05	0.2459	26
Halibut 1	-0.04	0.9130	31
Halibut 3	-11.52 *	0.0038	36
Cusk 3	-0.37	0.2468	37
Dab	3.00	0.0758	40
Monkfish 1	1.93	0.4070	62

*$p < 0.05$; robust standard errors used for calculation.