Is the technical conversion factor informativeabout the price ratio of processing livestock?

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ABSTRACT

The technical conversion factor (TCF) is a survey-based estimate of the percentage of carcass weight obtained per unit of live weight. Practitioners and researchers have used it to predict the corresponding price ratio. We use both in-sample regressions and out-of-sample forecasting analysis to test the validity of this approach in case of predicting the price effects of processing livestock in Europe. By regressing the price ratio on the inverse value of the corresponding TCF for a large panel of European countries and animal types, we find a significant positive relation between these variables, which also has economic value in terms of improving out-of-sample forecasting precision. This result is shown to be robust to animal type, year and country fixed effects. The technical conversion factor thus has information value about the corresponding price ratio.

Keywords: agriculture, carcass weight, live weight, pass-through, price effect

1. INTRODUCTION

Agricultural production is characterized by a chain of transformations from livestock to consumer products. First, a live animal is slaughtered to get primary carcass parts like meat, offals and skin. Then, these components are processed to obtain different products like sausage or lard (FAO (2011)). A detailed understanding of how the processing of livestock affects agricultural prices is of paramount importance for producers and consumers of agricultural products. To achieve this, economic policy makers like the Food and Agricultural Organization (FAO) use surveys to collect information on the physical efficiency of the processing of livestock and the corresponding price ratios. They use so-called technical conversion factors (hereafter TCF) to quantify the extraction productivity. In case of livestock, the TCF indicates in percent term the dressed carcass weight that can be extracted per unit of the live weight of slaughtered animals. For example, if there is 100 kg of carcass weight obtained from 200 kg of live weight, the TCF is 0.5.

TCFs are published by FAO using the information received from surveys sent to its member nations (FAOSTAT (2009)). Their main scope is ”to arrive at approximate estimates of the total availability of food in each country, expressed in terms of quantity as well as in terms of calories, protein and fat” (FAOSTAT (2009)). In recent years, TCFs have been widely applied in research and calculations in different fields. For instance, Lazarus et al. (2014) use TCFs in calculating carbon footprint for crops and livestocks, while Luan et al. (2014) employ the conversion factor in computing the land requirements for food in South Africa. OECD-FAO (2015) takes them as factors in constructing prices and quantities for a variety of agricultural products, as well as for performing the Aglink-Cosimo economic model which analyses supply and demand of world agriculture. The study of Smith et al. (2016) uses conversion factors to estimate the global dietary supply of nutrients. Chaudhary et al. (2016) use TCFs to obtain the weight of primary crop required for an amount of processed food in their calculations of biodiversity loss due to anthropogenic land. Finally, FAO has been using the TCFs to impute missing observations in agricultural price series (Kirkendall et al. (2015), Dubey et al. (2016)).

In this paper we analyze the TCFs and price ratios of the processing of four common livestock, namely cattle, pig, chicken and sheep, for the European countries between 1969 and 2015. We expect to find a close connection between the TCF and the price ratio of livestock versus carcass meat, since the TCF corresponds to the physical reality behind the price ratio of livestock products. We focus on the EU member states because they share the so-called Common Agriculture Policy (CAP). As such, we focus on one integrated geographic region for the reason of avoiding interregional shocks and differences in policy that can affect our analysis. Clearly, there are also intraregional effects, for which we control in the analysis using country dummies. Another reason is the availability of high quality price data at both Eurostat and FAO for a large number of countries and types of livestock in this area.

Our first contribution is to provide a descriptive analysis of the relationship between the TCF and the producer price ratios over the period 1969 to 2015. We combine various sources to create the longitudinal data-base of both the TCF and producer price ratios. The longitudinal time series is unbalanced, because of the many cases for which data are missing. We analyze the data through summary statistics and scatter plots, giving a first indication of the positive relationship between the TCF and producer price ratio.

Our second contribution is to formally quantify and test the relationship between TCFs and price ratios of livestock processing by regressing the price ratio (dependent variable) on the inverse of TCF (abbreviated as ITCF) and three other variables, namely trend (time effect), animal type and country. As predicted, we find that the TCF is informative about the value of the price ratio. The ITCF has an estimated regression coefficient of around one, indicating an unitary positive relationship with the dependent variable. We also find that the ITCF is useful for the out-of-sample prediction of price ratio.

The remainder of this paper is organized as follows. In Section 2, we discuss the characteristics of TCFs and price ratios of processing livestock. Section 3 describes our data, while Section 4 explains the methodology. The results are discussed in Section 5. Section 6 summarizes our main conclusions.

2. THE CHARACTERISTICS OF TCFS AND PRICE RATIOS OF PROCESSING

2.1. Technical conversion factor

The technical conversion factor of livestock is a measure which indicates in percent term the amount of a product extracted per unit of the originating one. These extraction rates differ across countries and time because of differences in technology, costs, and margins. It is a key statistic determining food prices. For this reason, the Food and Agricultural Organization of United Nation (FAO) monitors the evolution of the technical conversion factor. Their analysis starts with collecting the TCF data by sending out questionnaires to the member nations (FAOSTAT (2009)).

Since 1960, FAO has published three publications about the TCF. The first book issued in 1960 presents conversion rates of products in countries around the world. It is the foundation for the second and third publications, in 1972 and in 2009, with adjusted, extended, and refined contents to increase comprehensiveness and comparability. Although these publications include several transformation levels of different products, here we only focus on first level conversion factors of livestock processing.

Table 1 presents the TCFs of cattle, chicken, pig and sheep processing in 28 European countries (members of CAP) over time. As can be clearly seen, the coverage of the TCFs for chicken processing was low (two to three cases) in the first two publications. It was only included for a large number of countries (all 28 members) in the 2009 publication. Besides, the average extraction productivity differs among animal groups. The first-stage processing of chicken and pig is characterized by higher average TCFs (around 75-77%) compared to the ones of cattle and sheep which are approximately 48 - 54%.

To perceive how the TCFs evolved over 53 years, we compare their statistics in 2009 with the ones in 1957. Where the TCF in year 1957 is missing, data of the year 1968 is used instead. As can be seen, except for the TCFs of chicken processing which have too few observations in the first two publications to make any reliable conclusions, we find that in general the conversion rates for the three other animal types are stable over time.

Table 1: **Technical conversion factors of first stage processing of cattle, chicken, pig and sheep.** This table summarizes the technical conversion factors at the first-stage processing of 4 animals - cattle, chicken, pig and sheep - in 28 European countries (CAP members). Sources: FAOSTAT (1960, 1972, 2009)

No	Country	Cattle			Chicken			Pig			Sheep		
		1957	1968	2009	1957	1968	2009	1957	1968	2009	1957	1968	2009
1	Austria	na	0.52	0.53	na	0.8	0.75	0.79	0.8	0.81	0.5	0.54	0.53
2	Belgium	0.54	0.55	0.54	na	na	0.72	0.78	0.79	0.79	0.5	0.5	0.5
3	Bulgaria	0.46	0.47	0.51	na	na	0.72	0.71	0.7	0.66	0.41	0.42	0.42
4	Croatia	na	na	0.53	na	na	0.74	na	na	0.77	na	na	0.5
5	Cyprus	0.55	na	0.53	na	na	0.76	0.8	na	0.74	0.5	na	0.49
6	Czech Republic	na	na	0.53	na	na	0.75	na	0.82	0.71	na	0.48	0.45
7	Denmark	0.5	0.48	0.49	0.8	na	0.76	0.72	0.72	0.7	0.5	na	0.49
8	Estonia	na	na	0.57	na	na	0.76	na	na	0.76	na	na	0.44
9	Finland	na	na	0.52	na	na	0.75	na	na	0.75	na	na	0.45
10	France	na	0.5	0.52	na	na	0.75	na	0.78	0.74	na	0.45	0.5
11	Germany	na	0.52	0.53	na	na	0.73	0.83	0.67	0.77	0.49	0.48	0.48
12	Greece	na	0.5	0.52	na	na	0.73	na	0.77	0.76	na	0.5	0.49
13	Hungary	na	0.55	0.57	na	na	0.75	na	0.45	0.82	na	na	0.48
14	Ireland	na	0.53	0.52	na	0.8	0.75	na	0.75	0.75	na	0.49	0.5
15	Italy	0.53	0.54	0.55	0.89	na	0.75	0.81	0.83	0.79	0.55	0.49	0.49
16	Latvia	na	na	0.63	na	na	0.72	na	na	0.82	na	na	0.59
17	Lithuania	na	na	0.57	na	na	0.76	na	na	0.76	na	na	0.44
18	Luxembourg	0.56	0.54	0.54	na	na	0.72	0.87	0.79	0.79	na	na	0.5
19	Malta	na	na	0.57	na	na	0.75	na	na	0.79	na	na	0.5
20	Netherlands	0.52	0.52	0.54	na	na	0.78	0.77	0.77	0.75	0.5	0.49	0.49
21	Poland	0.47	0.51	0.52	na	na	0.69	0.81	0.79	0.77	0.48	0.5	0.45
22	Portugal	na	0.54	0.55	na	0.7	0.75	na	0.84	0.76	na	0.37	0.5
23	Romania	na	na	0.49	na	na	0.75	na	na	0.71	na	na	0.43
24	Slovakia	na	na	0.54	na	na	0.7	na	na	0.85	na	na	0.47
25	Slovenia	na	na	0.54	na	na	0.75	na	na	0.87	na	na	0.47
26	Spain	na	0.5	0.52	na	na	0.75	na	0.8	0.79	na	0.45	0.49
27	Sweden	0.55	na	0.54	na	na	0.73	0.78	na	0.77	0.5	0.41	0.46
28	United Kingdom	na	0.54	0.54	na	na	0.68	na	0.74	0.76	na	0.47	0.51
# Observations		9	16	28	2	3	28	11	17	28	10	15	28
Average		0.52	0.52	0.54	0.85	0.8	0.74	0.79	0.75	0.77	0.49	0.47	0.48

2.2. Price ratio of processing livestock

The price ratio of livestock processing refers to the relation between prices of products received by the producers when selling live meat and carcass meat. Investigating this price ratio for several countries and animal types jointly is complementary to previous studies, who have either examined the consumer price ratios of agricultural commodities, or focused on a single animal type. For example, Tveteras and Asche (2008) and Asche et al. (2013) analyze the fishery industry, while Chavas and Holt (1991), Parker and Shonkwiler (2013) and Holt and Craig (2006) investigate the dynamics in hog-to-feed price ratios.

In this paper we research the price ratios of livestock in the first transformation level, which turns the live animal into primary components like meat, offals, fat and skin (FAO (2011)). Particularly, we focus on the price ratio of meat. This choice is due to three reasons. First, among all products derived from the carcass like meat, skin, bone, and offals, meat has the most important use in human daily consumption. Second, it accounts for a major part of the carcass. As can be seen in Table 1, between 50 and 75 percent of the body is meat, depending on the animal type. Other components like skin, bone, offals and fat only have a negligible economic value compared to it.

The price ratio of meat (abbreviated as PR) is obtained by dividing the carcass meat price to the live weight meat price, of which they are measured at the same mass (of 100kg normally). Economically, the price of carcass meat should cover all transformation costs, namely the purchasing cost of the livestock (i.e. the liveweight price), the labor and infrastructure costs needed to slaughter the animal, and the profit margin.

2.3. Relationship between price ratio and TCF

The extraction rate (or TCF) is expected to have an inverse relationship with the meat price ratio. When the TCF increases, the price ratio decreases. To clarify this argument, we consider a stylized numeric example. Assume that, for processing livestock, we have a TCF of 0.5, meaning that with 100 kilogram of live weight we can obtain 50 kilogram of carcass meat. Assume further that the price of 100kg live weight is 100 euro. Then the price of 50kg carcass meat should at least cover its material costs, which is the price of 100kg live weight. As such, 50 kg carcass meat has the minimum price of 100 euro, and, when expressed for the same units of weight, the price ratio equals at least two. In the same manner, increases in the TCF (e.g. due to higher efficiency in the processing) can be expected to lead to decreases in the price ratio, and vice versa in case of a decrease. In conclusion, on average we expect the TCF to be inversely proportional with the price ratio, and that the minimum value of the price ratio is the inverse of TCF. Henceforth, we call 1/TCF the Inverse Technical Conversion Factor (abbreviated as ITCF), and investigate its relation with the producer price ratio of processing livestock.

3. DATA

This section includes three main parts. The first one introduces our data source: EUROSTAT and FAO, and how we collect the data. The second one is about the way price ratios are filtered and paired with ITCFs. Lastly, we provide some explorative analysis about the price ratios and ITCF.

We collect the data and calculate the price ratio for four livestocks - cattle, chicken, pig, and sheep-of the CAP countries. In order to get the longest possible time series, the prices of meat live weight and carcass meat are gathered and combined from EUROSTAT (2017) and FAOSTAT (2017). The furthest data point we can get back in time is the year 1969, while the most recent one is the year 2015. After matching the meat live weight prices and carcass meat prices and restricting the sample to the country-years that the country is effectively a member from the EU and for which there are more than 10 continuous observations, we end up with sample of 21 usable cases with 612 price ratio observations. Table 2 provides the summary statistics for this sample.

Table 2: Price ratios and ITCFs

No	Livestock	Country	Price ratio						ITCF	
			period	# obs	Min	Average	Max	sd	Before 2009	From 2009
1	Cattle	Belgium	1971-2001	31	1.62	1.77	2.04	0.11	1.61	X
2	Cattle	Denmark	1991-2015	25	1.55	1.74	1.92	0.11	2.07	2.04
3	Cattle	France	1969-2002	34	1.35	1.46	1.9	0.11	1.82	X
4	Cattle	Greece	1995-2014	20	1.37	1.65	1.82	0.15	2	1.92
5	Cattle	Italy	1969-1999	31	1.56	1.69	2.03	0.11	1.64	X
6	Cattle	Luxembourg	1969-2015	47	1.63	1.71	1.79	0.03	1.67	1.67
7	Cattle	Netherlands	1969-1990	22	1.57	1.67	1.75	0.04	1.79	1.64
8	Chicken	Austria	1995-2015	21	1.96	2.28	2.41	0.12	1.25	1.33
9	Chicken	Denmark	1991-2015	25	1.06	1.35	1.49	0.11	1.25	1.32
10	Chicken	Italy	1969-1999	31	1.18	1.42	1.63	0.11	1.12	X
11	Pig	Austria	1995-2015	21	1.22	1.23	1.26	0.01	1.25	1.23
12	Pig	Belgium	1970-2007	38	1.09	1.16	1.21	0.03	1.27	X
13	Pig	Czech Republic	2004-2015	12	1.27	1.3	1.33	0.02	1.22	1.41
14	Pig	Denmark	1973-2015	43	1.23	1.36	1.41	0.04	1.39	1.43
15	Pig	Greece	1981-2015	35	0.75	0.98	1.18	0.1	1.3	1.32
16	Pig	Italy	1969-1999	31	1.02	1.17	1.32	0.08	1.2	X
17	Pig	Luxembourg	1969-2005	37	1.16	1.22	1.31	0.04	1.27	X
18	Pig	Spain	1986-2015	30	1.42	1.45	1.52	0.02	1.25	1.27
19	Pig	UK	1973-2005	33	0.97	1.18	1.34	0.09	1.35	X
20	Sheep	Austria	1995-2015	21	1.91	2.07	2.09	0.05	1.85	1.89
21	Sheep	Greece	1991-2014	24	1.941	3.3	4.02	0.65	2	2.04

For this sample, we apply the panel unit root test (Kleiber and Lupi (2011)) to test whether the PR is stationary or not. We apply the test on the balanced panel of 21 selected cases. As can be seen in Table 2, each PR series has a different length. To account for this, we subdivide 21 cases into smaller groups which includes cases with similar data ranges, and perform tests on these subgroups. At a 10% significance level, all tests reject the null hypothesis of a unit root and thus conclude at stationarity over the panel.

Figure 1 visualizes the time series average of the price ratio per country and animal type, in relation with their ITCFs (or the average of ITCFs if two of them are used) of the 21 selected cases. Here the 45 line indicates the reference in which the PR equals with the ITCF. Note that the observations tend to cluster for each animal type, creating disparities among groups. In particular, most chicken and pig indicators stay in lower areas compared to the cattle and sheep ones. We thus find a difference in both extraction productivity and price ratio between animal groups. In fact, the higher TCFs of processing pigs and chickens compared to cattle explain their lower PRs (the detail of how the TCFs link with the PRs has been explained in section 2.3). We also note that most of the observations lie along the 45 line (meaning the average PR has a close value to the ITCF). One exception is the Sheep price ratios of Greece, with an average value of 3.30, while its ITCF is 2.02. Another exception is the Chicken price ratio for Austria which have an average of 2.08, which is substantially higher than than its ITCF, which equals 1.29.

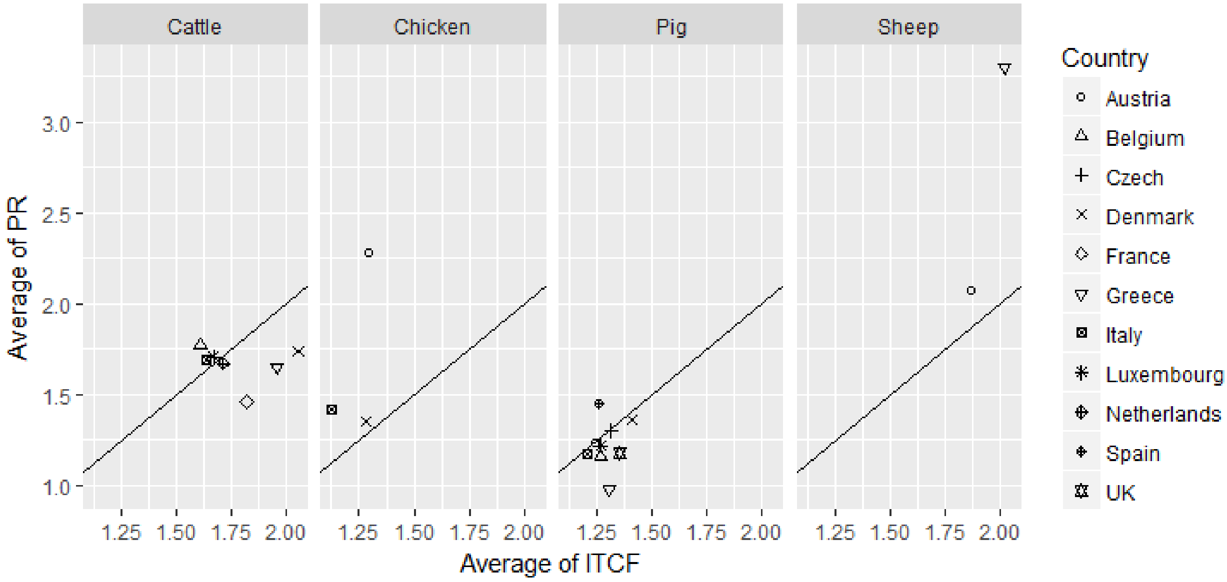

Figure 1: Scatter plots of average price ratio (over time) versus the average of ITCF
This figure visualizes the average of price ratio in relation with the corresponding average ITCFs of 21 sample cases. The black lines are 45 lines, indicating the reference in which the PR equals with the ITCF.

4. METHODOLOGY

The main purpose of our research is to test whether the TCF is informative about the expected value of the corresponding price ratio. We investigate this question using a panel data regression model that explains the price ratio using the ITCFs, the animal type, the country, and the year fixed effects. Among these variables, the ITCF is our main variable of interest.

The empirical analysis is performed using in-sample and out-of-sample evaluation methods.

4.1 In-sample evaluation

We use nested version of the following regression model to analyze the determinants of the price ratios across observations for various animal groups (indexed by a), countries (indexed by c) and years (indexed by t):

$$PR_{a;c;t} = \alpha + \alpha_a + \alpha_c + \gamma Trend_t + \beta ITCF_{a,c,t} + \varepsilon_{a,c,t} \qquad 1$$

In equation (1), corresponds to the intercept of the reference category corresponding to the PR of pigs in Denmark. The terms $a_a$and a_c, respectively denote the animal type and country group, while $\varepsilon_{a;c;t}$ represents the error term. The value of $ITCF_{a;c;t}$ is taken from the Table 1. The deterministic trend variable Trendt takes values from 1 to 47, corresponding to the maximum length of the PR (from 1969 to 2015). IIn terms of animal groups, we thus include dummies for cattle, chicken and sheep, while there are fourteen country dummies: Austria, Belgium, Czech Republic, Estonia, France, Germany, Greece, Italy, Luxembourg, Netherlands, Romania, Slovakia, Spain and UK. There is thus no dummy for pigs and Denmark in order to avoid multicollinearity with the intercept. We present our results using robust standard errors, computed using the HAC robust Arellano (Arellano (1987)) for heteroskedasticity and correlation clustering.

4.2. Out of sample evaluation

In order to evaluate the accuracy of four models in forecasting the price ratio, we conduct out-ofsample forecasts using Mean Absolute Forecast Error (MAFE) as the criterion. The out-of-sample period is from the year 2004 to the year 2015. We estimate the four regression models nested in equation (1) using an expanding estimation window. The MAFE is defined as follows:

$$MAFE = \frac{1}{T-S}\sum_{t=S+1}^{T} |e_t|, \qquad 2$$

where T is the total length of the series (612 observations), S is the burn-in period corresponding to the period 1969 till 2003 (463 observations) and et is the one-step ahead forecast error. The lower the $MAFE$, the better is the forecasting performance of the model. We test the significance of the difference in MAFE between models using the Diebold-Mariano test (Diebold and Mariano, 2002).

5. RESULTS

Our main result is that, for all four models considered, we cannot reject that the coefficient of the $ITCF$ is one at a 95% confidence interval. This indicates an unitary relation between the $ITCFs$ and the price ratios, meaning that when the ITCF increases by one unit, the PR is expected to do the same, ceteris paribus. Plus, as the $ITCF$ is the reverse of TCF, we can also conclude about the reversed relation between the TCF and the PR: When the TCF decrease by one unit, the PR is expected to increase by one, ceteris paribus.

The in-sample and out-of sample regression results of the four models are reported in Table 3. Next, we first discuss the in-sample parameter estimates and the goodness of fit statistics. Then, we evaluate the out-of-sample forecasting accuracy in terms of low values for the $MAFE$.

5.1 In-sample results

Let us first study the estimation results for the single-variate regression model in column (1) of Panel A in Table 3. We find that the least squares estimate of the slope coefficient is 1.019 with a robust standard error of 0.037. The ITCF is thus statistically significant at the 95% confidence interval. It is noteworthy that this simple model can already explain 34.9% of the variation in the price-ratios. The near one value of the ITCF means that, when ITCF increases by one unit, the PR is expected to do the same, ceteris paribus. Importantly, the estimated coefficient remains around one, when controlling in (2)-(4) for the effects of animal type, country and trend. In all specifications considered, the the ITCF has an estimated coefficient of around one, and it is statistically significant at confidence level of 95%.

Table 3: Determinants of the price ratio of processing livestocks

This table presents in-sample and out-of-sample results of 4 regression models nested from equation 1. Our main explaining factor for the independent variable PR is ITCF. Between parenthesis, the HAC robust Arellano (Arellano (1987)) corrections are presented. To avoid multicollinearity, we include dummy variables for all animal types and countries, except for the animal type pig and country Denmark. The p-values reported for the MAFE correspond to the Diebold-Mariano test that Model (j) has equal forecasting performance as model (3), for j = 1; 2; 4.

Panel A: In-sample regression estimates				
	(1)	(2)	(3)	(4)
ITCF	1:019***	0:996***	1:064***	1:099***
	(0:037)	(0:034)	(0:096)	(0:097)
Trend		0:005***		-0:002***
		(0:001)		(0:001)
Cattle			0:009	-0.002
			(0:058)	(0:059)
Chicken			0:564***	0:573***
			(0:046)	(0:047)
Sheep			0:842***	0:826***
			(0:072)	(0:071)
Austria			0:170***	0:185***
			(0:030)	(0:028)
Belgium			0:250***	0:239***
			(0:043)	(0:042)
Czech Republic			0:219***	0:244***
			(0:036)	(0:034)
France			-0.154***	-0.175***
			(0:048)	(0:046)
Greece			0:134***	0:139***
			(0:038)	(0:038)
Italy			0:165***	0:148***
			(0:040)	(0:040)
Luxembourg			0:233***	0:225***
			(0:042)	(0:041)
Netherlands			0:087*	0:056
			(0:043)	(0:039)
Spain			0:451***	0:463***
			(0:035)	(0:034)
UK			0:075***	0:064***
			(0:021)	(0:019)
Constant	0:015	-0.073	-0:334	-0:335
	(0:044)	(0:054)	(0:154)	(0:147)
R2	0.349	0.364	0.707	0.708
Adjusted R2	0.348	0.362	0.7	0.7
Panel B: Out-of-sample forecast precision results				
	(1)	(2)	(3)	(4)
MAFE	0.354***	0.388***	0.275	0.275

*p<0.1; **p<0.05; ***p<0.01

The most parsimonious model seems to be (3) which, compared to model (4), omits the trend variable, but has a similar goodness of fit. Note also that in (4) the trend variable is insignificant. Animal type and country type are big contributors to the R2. The single-variate model explains 34.9% of the variation in the price-ratios, while model (3) can describe 70.7% of the PR movement. This confirms the joint predictive power of animal type and country in explaining the producer price ratio of livestock, in addition to the ITCF.

5.2. Forecasting precision results

The out-of-sample forecasting performance of the four regression models is evaluated using the Mean Absolute Forecast Error (MAFE) evaluation criterion. The statistical significance of difference of these MAFEs is evaluated using the Diebold- Mariano test (Diebold and Mariano (2002)).The results can be found in Panel B of Table 3. In general, the lower the MAFE, the better the forecast precision provided by the model. We can see that the single-variate model in column (1) of Table 3 returns the MAFE of 0.354. Adding the trend variable deteriorates the out-of-sample forecast precision. This increase in MAFE is consistent with the in-sample result that the trend variable has an insignificant contribution in predicting the price ratios. In contrast, model (3) which forecasts the price ratios using the ITCF in combination with animal type and country dummies has a significantly lower MAFE of 0.275 compared to the two previous models. Comparing columns (3) and (4) of Table 3 we see that including the trend variable does not improve the MAFE. We therefore recommend model (3) for predicting the price ratio using the ITCF variable.

6. DISCUSSION AND CONCLUSION

In this paper we study the technical conversion factor and its relation with the price ratio of processing livestock from live weight meat to carcass meat. We concentrate on four major animal types (cattle, chicken, pig and sheep) and the countries belonging to the European Common Agricultural Policy. We find evidence confirming the close relation between the TCFs and the priceeffect of processing livestock, and this effect is robust to controlling for animal type, country, and trend.

This result has several important implications. Firstly, understanding the close relationship between the TCF and the price ratios is important to understand the pass-through between the physical efficiency of the processing of livestock and the corresponding price ratios. We therefore recommend to FAO to continue the effort of sending out questionnaires to collect the information from the TCFs. Secondly, in order to reduce price volatility and allow access to food, it is important to keep the TCF stable at high values. In fact, the higher the TCF, the more efficient is the livestock processing. Third, from a statistical perspective, the ITCF can be used for imputation when prices are missing.

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