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Beef, lamb, pork and poultry meat commodity prices: Historical fluctuations and synchronisation with a focus on recent global crises

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Abstract: This work addresses short-run fluctuations of nominal global meat commodity prices, that is, beef, lamb, pork, and poultry, from January 1980 to October 2023, thus including the COVID-19 pandemic and the Russo-Ukrainian conflict. It tries to answer the following questions: how do fluctuations in meat commodity prices behave historically? Are meat commodity prices synchronised? Do their co-movements show specific features during recent global crises such as the COVID-19 pandemic and the Russo-Ukrainian war? Using a 'classical' framework of cycle analysis, the work provides a series of turning points upon which statistics on phase and cycle durations and amplitudes are generated. Care is put into highlighting the pros and cons of employing algorithms based on turning points instead of harmonic models. Global nominal meat prices feature cycles lasting between 3.8 and 4.6 years on average. Pork prices, contrary to other meat prices, are characterised by a highly volatile and prevalently contractionary behaviour. From a policy perspective, the article provides results on the synchronisation of couples of meat prices and on the existence of a common meat price cycle both historically and during the COVID-19 pandemic and the Russo-Ukrainian war.

Keywords: classical cycle; COVID-19 pandemic; meat price cycle; meat price synchronisation; Russo-Ukrainian war

Fluctuations in global food prices play a fundamental – though not exclusive (Dewbre et al. 2008; Davidson et al. 2016) – role in determining domestic food prices. This is particularly true for developing economies, where raw food commodities strongly influence retail prices due to relatively low rates of food processing (Dewbre et al. 2008). Since ancient times, meat has represented – and still does – an important source of nutrients in the human diet. Its increasing consumption seems to be strictly connected to rising *per capita* incomes (Sans and Combris 2015; Whitnall and Pitts 2019). Deficiency in meat proteins, on the other hand, is a cause of starvation in economically underdeveloped populations (Baltic and Boskovic 2015). Movements in global meat prices thus become important for both food security and the planning of meat production and consumption processes.

Fluctuations in meat prices are intimately related to movements in the underlying livestock and poultry markets. Extant literature has devoted special attention to hogs and cattle markets (e.g. Fliessbach and Ihle 2020a), whose cyclical features were identified to last

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from 3 to 4 years in the former and 6 to 10 years in the latter case. According to Fliessbach and Ihle (2020b), results usually rely on techniques such as spectral and harmonic analysis. The number of works addressing the cyclical behaviour of meat prices, however, is limited in number, and when this happens (e.g. Cashin et al. 2002), meat prices are confined to play only a marginal role in the whole story.

In light of the foregoing, this work focuses on the short-run cyclical properties of four global meat commodity prices, namely beef, lamb, pork and poultry, trying to address the following questions: what are the updated cyclical facts characterising historical meat commodity prices? Do meat commodity prices move together? Do they present peculiar co-moving features during recent global crises like the COVID-19 pandemic and the Russo-Ukrainian war? Compared to Cashin et al. (2002), who studied, along with many other commodities, beef and lamb prices between January 1959 and August 1998, this work provides a comprehensive and up-to-date account of meat price cycles, adds pork and poultry prices, analyses their fluctuations over the period from January 1980 to October 2023, and therefore includes both the COVID-19 pandemic and the Russo-Ukrainian conflict. Refraining from improper deflators to avoid potentially misleading results, it focuses on nominal, i.e. undeflated, prices. In order to capture the salient turning points of meat prices fluctuations, it employs the modified Bry-Boschan algorithm for quarterly data (MBBQ) (Harding and Pagan 2016), which also works on yearly data, extending the symmetric window from 2 months (Cashin et al. 2002) to 6 months. Following Kulish and Pagan (2021), it critically inspects the use of the MBBQ algorithm compared to the harmonic model (Harvey and Jaeger 1993). Finally, it tests the synchronisation between pairs of meat price cycles and the existence of a common meat price cycle placing special emphasis on co-movements during the COVID-19 pandemic and the Russo-Ukrainian conflict.

MATERIAL AND METHODS

Data. The dataset covers meat prices from January 1980 to October 2023, i.e., 526 observations at monthly frequency. This choice allowed me to use the most updated data, including both the COVID-19 pandemic and the Russo-Ukrainian conflict. Data are available from the IMF's Primary Commodity Price System, which publishes and updates prices and indexes of several commodities on a regular basis. The final dataset was obtained by merging meat prices from January 1980 to December 1989 (IMF 2023a) with meat prices from January 1990 to October 2023 (IMF 2023b). The splicing of different series was carried out, considering that both datasets contain the same information related to different periods. Four typologies of meat were considered: beef (Australian and New Zealand 85% lean fores, CIF US import price, USD cents/pound), lamb (Frozen carcass Smithfield London, USD cents/pound), pork (51–52% lean hogs, US price, USD cents/pound), and poultry (whole bird spot price, ready-to-cook, whole, iced, Georgia docks, USD cents/pound). The series above were assumed to represent the benchmark for global meat markets.

Methodology. The analysis exploited the properties of nominal, i.e. undeflated, meat prices, so as to capture their cyclical characteristics regardless of other influences (Labys et al. 1998) and without introducing spurious or artificial patterns (Tomek 2000). This decision seemed reasonable from two practical perspectives. First, consumers are unlikely to look at real commodity prices, in that retail prices are very different from and much more stable than commodity prices. Meat producers, on the other hand, might be interested in nominal commodity prices deflated by their production costs. Such a deflator, however, is not available. Following Tomek's (2000) suggestion of deflating only when appropriate, this work employed undeflated prices, breaking the practice established in the commodity literature (e.g. Roberts 2009; Rossen 2015) of using *passe-partout* deflators such as the US consumer price index.

Meat price cycles were identified through a 'classical' framework based on the levels of the logarithm of the underlying price series (Harding and Pagan 2002). Data alteration was restricted to two preliminary processes: in order to disentangle the price cycle, all prices were adjusted for seasonality, i.e. stripped of their seasonal pattern, by employing the X-11 procedure (Bell and Monsell 1992); log meat prices were then multiplied by 100 to express phase amplitudes in percentages.

The MBBQ dating algorithm (Harding and Pagan 2016) was used to identify each series' turning points, i.e. peaks and troughs. The latter, in turn, were exploited to define phases, i.e. the period between two consecutive turning points, and cycles, i.e. the period between two consecutive peaks or troughs (each phase/cycle was a left-open interval, in that, from an operational viewpoint, it was conventionally made to start after the first delimiting turning point). To sum up, given the alternance between peaks and troughs, three

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consecutive turning points, i.e. two consecutive phases, were necessary to define one full cycle. The MBBQ algorithm used a few censoring rules for dating the cycle, which were borrowed from Cashin et al. (2002) and slightly modified to fit the problem at hand. Based on a stylised description of agricultural commodity markets for annual crops, they employed a minimum phase length of one year (12 months) and a minimum cycle length of two years (24 months). The former rule captured the fact that any variation in the supply of an annual crop would have consequences on its price, at least until the following harvest. The latter rule accounted for the eventuality of a bad harvest happening before or after a good one, thereby suggesting a minimum productive cycle of two harvests. These approximations have been successfully employed in the analysis of metal commodity markets (Roberts 2009; Rossen 2015) and are, thus, even more appropriate for studying meat commodities. A six-month search window was employed in place of the two-month search window in Cashin et al. (2002). This choice allowed for a better capture of the relevant short-term fluctuations peculiar to meat commodity prices. The MBBQ algorithm was set so as to recognise as a single phase those price slumps larger than 10% in magnitude. Turning points are, thus, used to build a binary state variable S_t, which proxied the meat price cycle, indicating whether a certain meat price found itself in contractionary (S_t = 0) or expansionary (S_t = 1) phase in a certain month (Harding and Pagan 2002, 2016).

State variables – one for each meat price – served multiple tasks. First, they were used to characterise the cycle in terms of average durations, i.e. the average number of months spanned by a certain phase, and amplitudes, i.e. the average percentage variation in meat prices within a certain phase. Second, following Harding and Pagan (2006), they were employed to test the synchronisation of meat prices by estimating the following system:

$$E\begin{bmatrix} S_{1t}-\mu_{S_1} \\ \vdots \\ S_{nt}-\mu_{S_n} \\ \dfrac{(S_{1t}-\mu_{S_1})(S_{2t}-\mu_{S_2})}{\sqrt{\mu_{S_1}\left(1-\mu_{S_1}\right)\mu_{S_2}\left(1-\mu_{S_2}\right)}}-\rho^{12} \\ \vdots \\ \dfrac{(S_{(n-1)t}-\mu_{S_{(n-1)}})(S_{nt}-\mu_{S_n})}{\sqrt{\mu_{S_{(n-1)}}\left(1-\mu_{S_{(n-1)}}\right)\mu_{S_n}\left(1-\mu_{S_n}\right)}}-\rho^{(n-1)n} \end{bmatrix}=0 \tag{1}$$

through the generalised method of moments (GMM) – actually a method of moments (MM) in that the number of moment conditions equals the number of parameters – with heteroskedasticity and autocorrelation consistent (HAC) standard errors. In particular, given the number of considered meat prices n, each system consisted of 0.5 × n × (n + 1) moment conditions, that is, n sample means of the corresponding states μ_{S1}, ..., μ_{Sn} and 0.5 × n × (n – 1) correlations between pairs of states ρ^{12}, ..., $\rho^{(n-1)n}$. To test synchronisation between pairs of prices, System 1 reduced to a system of three moment conditions and three parameters (e.g. μ_{Sbeef}, μ_{Slamb}, $\rho^{beef,\ lamb}$), where correlation ρ measured the synchronisation between a couple of meat price cycles. To ascertain the existence of an overall meat price cycle (n = 4), System 1 became a system with ten moment conditions and ten parameters. In both cases, synchronisation was assessed in terms of the W-statistic developed by Harding and Pagan (2006), which was distributed as χ^2 with 0.5 × n × (n – 1) degrees of freedom. The approximation of the inverse of the variance-covariance matrix of the moment conditions was carried out via Moore-Penrose pseudoinverse (Moore 1920; Penrose 1955). The magnitude of each pairwise phase synchronisation was measured using the concordance index $\hat{P}$ (Harding and Pagan 2002) in Equation (2),

$$\hat{P}=\frac{1}{T}\left[\sum_{t=1}^{T}S_{xt}S_{yt}+\sum_{t=1}^{T}\left(1-S_{xt}\right)\left(1-S_{yt}\right)\right] \tag{2}$$

which supplied an estimate of the amount of time the proxies for meat price cycles, S_{xt} and S_{yt}, found themselves in the same phase. While cycle characterisation in terms of durations and amplitudes was restricted to complete phases, synchronisation analysis exploited the information delivered by the full sample, that is, it also accounted for those incomplete phases at the two ends of the sample, which lacked definite starting and ending turning points (i.e. informally: total number of phases = starting incomplete phase + complete phases + ending incomplete phase). This implies that each complete meat price cycle was actually identified on a different number of points, depending on its intrinsic characteristics. Following Kulish and Pagan (2021), a comparison between the results of the MBBQ algorithm and those of the harmonic model (Harvey and Jaeger, 1993) was carried out to provide a critical overview of turning-point-based and oscillation-based cycles. The MBBQ algorithm and the synchronisation analysis were implemented in Julia 1.9.2 (Bezanson et al. 2017), while the harmonic model was implemented in EViews 12.

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RESULTS AND DISCUSSION

Visualising turning points. Analytical peculiarities of meat prices are included in Table 1, which collects some descriptive statistics concerning raw prices and first-differenced log-transformations, i.e. approximate percent changes. On average, beef meat was the most expensive, closely followed by lamb. Pork and poultry shared similar average prices, the latter meat being the cheapest of the sample. Once first-differenced, the series presented two features. First, poultry prices had the largest average percent change from period to period, namely 0.31%. Furthermore, pork showed the largest price variability, with a standard deviation about 2.9× larger than that of poultry, i.e. the price with the lowest variability.

The MBBQ algorithm supplied a sequence of turning points for each series of meat prices. These dates are reported in Table 2 and organised in peaks and troughs for each meat. The turning points were reported for the sake of transparency and were used to build the state vector S_t, that is, the proxy for each meat price fluctuation.

Figure 1 collected log-transformed meat prices and their turning points (Table 2) in a four-subplot layout, one for each meat price series. Triangles pointing upwards stand for peaks, and triangles pointing downwards for troughs. The vertical lines signal the outbreak of two major recent socio-economic shocks, namely the COVID-19 pandemic starting on December 31, 2019 (dashed line) and the Russo-Ukrainian war (dash-dotted line) starting on February 24, 2022 (in what follows, all analyses regarding recent global crises conventionally include the month in which they started).

Table 1. Descriptive statistics of meat prices (raw and first-differenced logs)

Statistic	Beef	Lamb	Pork	Poultry
Raw prices (USD cents/pound)				
Mean	135.20	123.76	77.89	75.65
Median	115.80	120.19	71.03	64.32
Minimum	74.53	78.20	21.56	31.48
Maximum	274.26	187.57	162.91	202.64
SD	48.93	25.02	24.78	35.69
Observations	526	526	526	526
First-differenced log-prices (%)				
Mean	0.10	–0.06	0.02	0.31
Median	0.21	0.05	–0.25	0.21
Minimum	–19.48	–16.89	–41.46	–46.31
Maximum	18.47	12.74	62.35	26.36
SD	3.65	3.86	9.47	3.26
Observations	525	525	525	525

Source: Author's calculations

A graphical inspection suggests that the selected censoring rules were appropriate to capture the most striking turning points of each series. As an example, the algorithm was able to identify the deep collapse in global pork prices happening in 1998 (Luby 1999). It also captured the sustained fall in lamb prices happening between July 1980 and February 1983 without introducing negligible turning points. Following the COVID-19 outbreak, all meat prices showed a deep collapse until March/June 2020 and a subsequent sharp increase, ending between December 2021 and August 2022, i.e. around the start of the Russo-Ukrainian war. This result is in line with those of Monge and Lazcano (2022), who observed a mean-reverting behaviour in commodity prices during the COVID-19 pandemic. A subsequent fall in prices has been following until the present. Each nominal meat price showed its own peculiar behaviour. Beef prices were clearly trending from the mid 2000s onwards. Despite historically being the cheapest meat, the strong and stable increase in poultry prices over time has recently brought them closer to the level of beef. Lamb prices, on the other hand, have recently shown a sharp decline, thus approaching the level of pork. Nowadays, pork is the cheapest meat. Should poultry prices continue to rise, pork meat would likely represent the historically cheapest option despite its relatively high volatile changes from period to period.

A critical perspective on the characterisation of cyclical fluctuations. Kulish and Pagan (2021) argue that models such as the harmonic one (Harvey and Jaeger 1993) impose oscillations as they imply complex roots. These structural models have been widely employed in the study of beef and hog price cycles (e.g. Fliessbach and Ihle 2020a). For this reason, a harmonic model was estimated to understand whether it is able to capture the cyclical behaviour of meat prices. Poultry prices were chosen as an example, as their cyclical features are still relatively underexplored.

$$\ln P_t^{poul} = \mu_t + \psi_t + \varepsilon_t \quad (3)$$

$$\mu_t = \mu_{t-1} + \beta \quad (4)$$

$$\psi_t = \phi \cos(\lambda)\, \psi_{t-1} + \phi \sin(\lambda)\, \psi^*_{t-1} + \xi_t \quad (5)$$

$$\psi^*_t = \phi \cos(\lambda)\, \psi^*_{t-1} + \phi \sin(\lambda)\, \psi_{t-1} + \xi^*_t \quad (6)$$

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Table 2. Dates of turning points - nominal meat prices

Beef		Lamb		Pork		Poultry	
peaks	troughs	peaks	troughs	peaks	troughs	peaks	troughs
–	Aug, 1982	July, 1980	Feb, 1983	Sept, 1982	Oct, 1983	Oct, 1980	Apr, 1983
July, 1983	July, 1986	June, 1984	Mar, 1985	Mar, 1985	Apr, 1986	Apr, 1984	Aug, 1985
Dec, 1989	July, 1992	Mar, 1988	June, 1989	Aug, 1987	Apr, 1989	Aug, 1986	July, 1987
July, 1993	Mar, 1996	Oct, 1990	July, 1991	Oct, 1990	Apr, 1992	May, 1989	Aug, 1991
Mar, 1997	Nov, 1998	Sept, 1993	Sept, 1995	Oct, 1993	May, 1995	May, 1994	Nov, 1994
Mar, 2002	June, 2003	Jan, 1997	Aug, 1998	July, 1996	Dec, 1998	Aug, 1998	Oct, 1999
Aug, 2008	Feb, 2009	Dec, 2004	Mar, 2006	Aug, 2001	Sept, 2002	July, 2004	May, 2006
Sept, 2014	Jan, 2016	May, 2008	Mar, 2009	Nov, 2004	Aug, 2009	Dec, 2008	May, 2011
June, 2017	Oct, 2018	Mar, 2011	Aug, 2012	Oct, 2011	Sept, 2012	June, 2018	Apr, 2020
Nov, 2019	Mar, 2020	July, 2014	Apr, 2016	Apr, 2014	July, 2020	May, 2022	–
Feb, 2022	–	Dec, 2019	June, 2020	Aug, 2022	Apr, 2023	–	–
–	–	Dec, 2021	–	–	–	–	–

Source: Author's calculations

The model consisted of four equations. Equation (3) decomposed the observed log poultry prices $\ln P_t^{poul}$ into a trend component μ_t, a cyclical component ψ_t, and an irregular component $\varepsilon_t \sim \text{IIN}\ (0, \sigma_\varepsilon^2)$. Equation (4) modelled the trend component, introducing the deterministic slope β. Finally, Equations (5) and (6) captured the stochastic cycle, where $\phi \in [0,1)$ was the damping factor to impose stationarity on $\ln P_t^{poul}$, $\lambda \in (0, \pi)$ was the frequency expressed in radians, while ξ_t and ξ_t^* were disturbances sharing the same variance, that is, $\xi_t, \xi_t^* \sim \text{IIN}\ (0, \sigma_\xi^2)$.

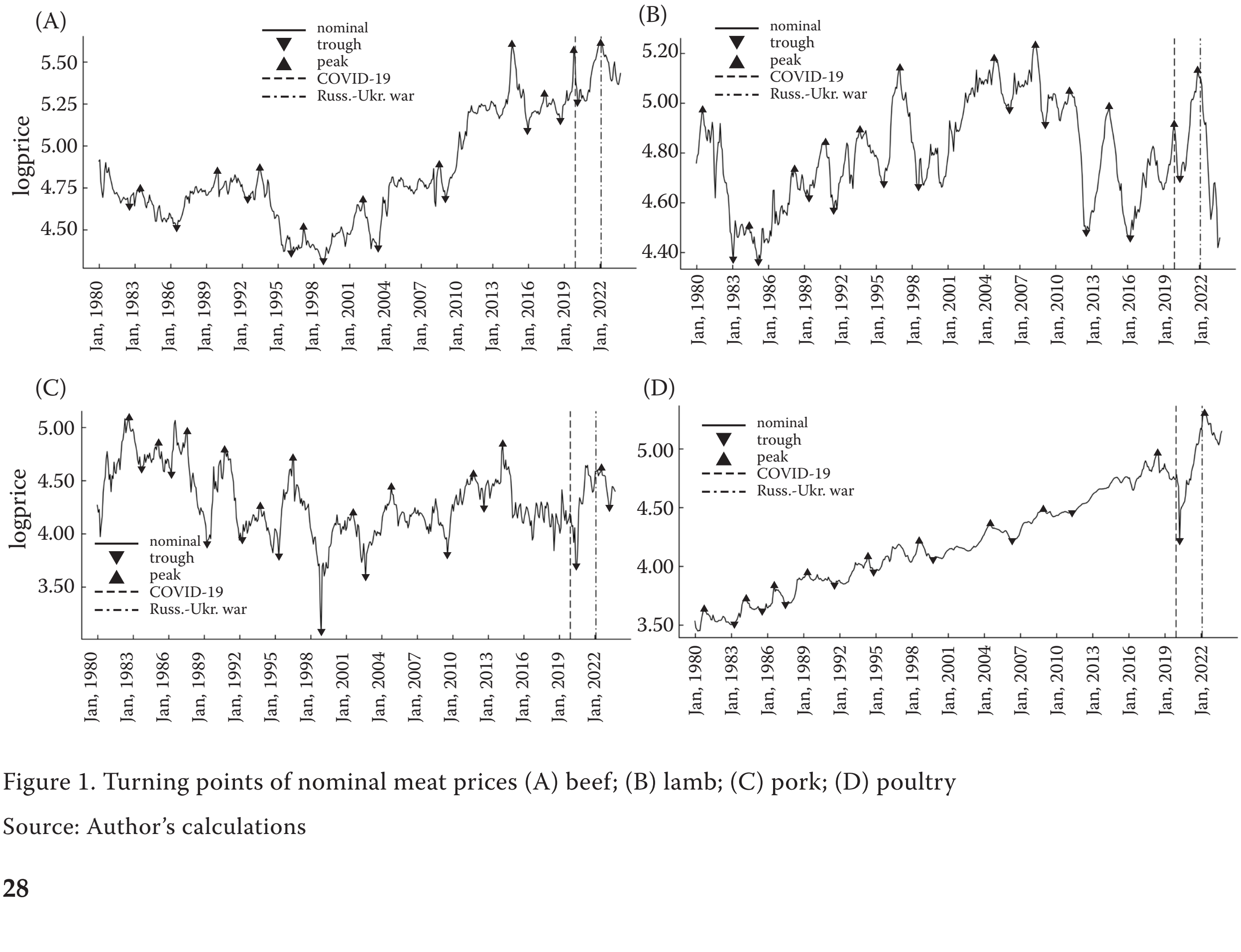

Figure 1. Turning points of nominal meat prices (A) beef; (B) lamb; (C) pork; (D) poultry

Source: Author's calculations

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Table 3 shows the estimates of the harmonic model. Log poultry prices were characterised by a frequency λ equal to 0.09, thereby implying a period equal to 70.63 months (≈ 5.9 years).

Log poultry prices were, thus, filtered using the Christiano-Fitzgerald filter (Christiano and Fitzgerald 2003) over the 70/71 bandpass. Figure 2 presents the results of this operation comparing the original series (solid line), whose peaks and troughs were identified, respectively, by upwards-pointing and downwards-pointing triangles, and the extracted 70/71 cyclical oscillation (dashed line).

As in Kulish and Pagan (2021), the extracted cyclical component failed to capture most of the information contained in the data. This result, graphically rooted in the lower number of turning points characterising the oscillating component, was corroborated by Table 4, which compares the standard deviations of the first-differenced log series of poultry prices and the standard deviation of the 70/71 oscillation.

Clearly, the standard deviation of the 71/72 oscillation explained only 3.48% of the standard deviation of changes in poultry prices. In other words, more than 96% of this change must come from other oscillations. This result corroborates the findings of Kulish and Pagan (2021), thereby pointing to the higher robustness of turning-point-based methods such as the MBBQ algorithm in characterising cyclical features.

Cyclical features. Table 5 presents some basic facts about the cyclical characteristics of nominal meat price cycles. Following Cashin et al. (2002), these were the number of complete cycles (counted as the maximum number of peak-peak or trough-trough cycles) and the fraction of time (%) each meat price cycle spent in the contractionary phase.

All meat prices completed approximately the same number of cycles in the period from January 1980 to October 2023. While beef and poultry prices fea-

Table 3. Results of the harmonic model applied to poultry prices

Parameter	Explanation	Value
ϕ	dampening factor	0.95***
λ	frequency	0.09***
2π/λ	period (months)	70.63***

*,**,*** $P < 0.1$, $P < 0.05$, $P < 0.01$, respectively; period length may slightly differ from that reported due to rounding
Source: Author's calculations

Table 4. Comparison between the standard deviations of poultry prices

Parameter	Explanation	Value
σ_{dlp}	SD of delta log-prices	3.26×10^{-2}
$\sigma_{70/71}$	SD of 61/62 oscillations	1.13×10^{-3}
$\sigma_{70/71}/\sigma_{dlp}$	ratio of SDs	3.48×10^{-2}

SD – standard deviaton
Source: Author's calculations

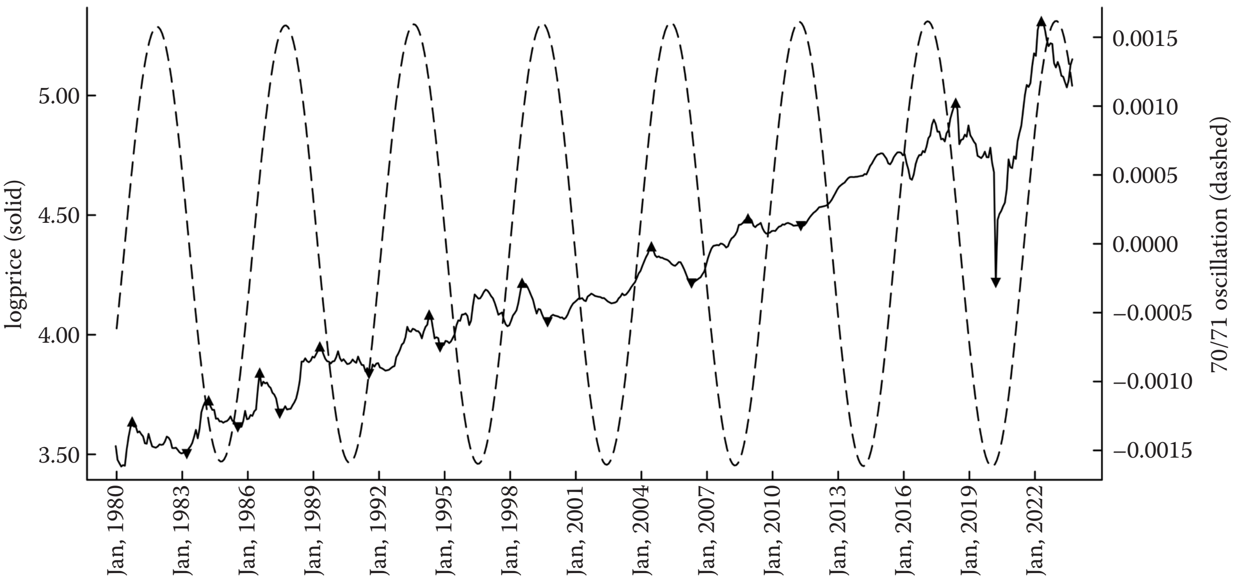

Figure 2. Poultry prices (log) *vs.* extracted 70/71 oscillation

Source: Author's calculations

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Table 5. Cyclical facts – nominal meat prices

Meat	Full cycles	Time in contraction (%)
Beef	9	37.1
Lamb	11	35.4
Pork	10	56.7
Poultry	9	35.5

Source: Author's calculations

tured exactly nine cycles each, pork and lamb displayed ten and eleven full cycles, respectively. Nominal beef, poultry and lamb prices spent low time in contraction, thereby representing a predominantly expansionary phenomenon. Pork prices, on the other hand, spent 56.7% of the time in contraction.

Maximum amplitudes of single phases. Maximum amplitudes of expansionary and contractionary phases were used to identify periods with exceptional phase behaviours. Table 6 shows maximum amplitudes expressed in percent.

Pork prices displayed the largest phase amplitudes of the sample. The expansionary phase amplitude amounted to 112.77% from January 1991 to August 2001. The contractionary amplitude was exceptionally large, –164.49%, from August 1996 to December 1998. The latter result is particularly emblematic in that it reflects the critical state of pork and hog markets during one of their most remarkable historical falls (Luby 1999). Poultry prices, on the other hand, registered their largest expansionary amplitude over a period of 25 months during the COVID-19 period. This behaviour can be interpreted in light of the reopening of the United States' export of poultry to China on November 14, 2019 (USDA 2019) after a ban of 5 years, translating into an increase in exports to China of 7 277% between 2019 and 2020 (USDA 2020) and 16% between 2020 and 2021 (USDA 2021).

Table 6. Maximum amplitudes (%) – nominal meat prices

Meat	Max amplitude (%)	
	expansion	contraction
Beef	92.83 (Mar, 2009 : Sept, 2014)	–52.18 (Oct, 2014 : Jan, 2016)
Lamb	52.00 (Sept, 1998 : Dec, 2004)	–61.08 (Aug, 1980 : Feb, 1983)
Pork	112.77 (Jan, 1999 : Aug, 2001)	–164.49 (Aug, 1996 : Dec, 1998)
Poultry	109.52 (May, 2020 : May, 2022)	–75.38 (July, 2018 : Apr, 2020)

Source: Author's calculations

Average durations and amplitudes. Nominal meat price cycles were characterised in terms of Table 7, which presents average durations expressed in the number of months, and Table 8, which displays average amplitudes measured in percent. Table 7 shows that average expansionary phases lasted longer than average contractionary phases in all cases but pork prices. Expansionary phases of nominal price cycles varied between 21.1 months (≈1.8 years) for pork and 35.8 months (≈ 3.0 years) for poultry prices. Contractionary phases, on the other hand, ranged from 16.0 months (≈ 1.3 years) for lamb to 25.1 months (≈ 2.1 years) for pork prices. The results suggest that the nominal average meat price cycle was between 45.2 months (≈ 3.8 years) for lamb meat and 55.4 months (≈ 4.6 years) for poultry meat.

Examining Table 8, it is also possible to compare average amplitudes. The majority of nominal meat prices featured, in absolute terms, larger average expansionary amplitudes. Pork prices deviated from this behaviour in that they displayed larger absolute average amplitudes for contractions. Average amplitudes of contractionary phases varied in magnitude from –19.9% for poultry prices to –72.2% for pork prices. Expansionary phases, on the other hand, were bound between the average amplitude of lamb, namely 35.2%, and that of pork prices, that is, 70.9%.

The cyclical features of nominal beef and lamb prices appeared to differ slightly from those of Cashin et al. (2002), which were expressed in real terms and measured over a different period. Booms in real beef prices lasted about 25.2 months (29.8 months in this work) with an average amplitude of 30.6% (36.1% in this work). Real slumps lasted an average of 24 months (19.6 months in this work) with an average amplitude of –33.9% (–29.2% in this work). Despite sharing simi-

Table 7. Average durations (months) – nominal meat prices

Meat	Average duration (months)		
	expansion	contraction	cycle
Beef	29.8	19.6	49.4
Lamb	29.2	16.0	45.2
Pork	21.1	25.1	46.2
Poultry	35.8	19.7	55.4

Cycle length may differ from the sum of average durations due to rounding
Source: Author's calculations

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Table 8. Average amplitudes (%) – nominal meat prices

Meat	Average amplitude (%)	
	expansion	contraction
Beef	36.1	–29.2
Lamb	35.2	–33.8
Pork	70.9	–72.2
Poultry	38.5	–19.9

Source: Author's calculations

lar expansionary (33.0% *vs.* 35.2% in this work) and contractionary (–33.1% *vs.* –33.8% in this work) amplitudes, real booms and slumps in lamb meat prices were longer than their nominal counterparts. More specifically, Cashin et al. (2002) found an average expansionary amplitude of 38.9 months (29.2 months in this work) and an average contractionary duration of 23.9 months (16.0 months in this work).

Synchronisation. Table 9 and Table 10 present the results regarding the synchronisation between meat price cycles. The former considers the whole period of analysis, while the latter focuses exclusively on the period covering the COVID-19 pandemic and the Russo-Ukrainian conflict until nowadays (47 observations for each meat price from the end of December 2019 to October 2023). The freshness of these events, together with an adequate number of observations resulting from treating two proximate events as a single crisis lasting 47 months, have led to the neglect of other relevant single crises, mostly wars and financial crises, of the past. Both tables show correlations and corresponding *W*-statistics (in round brackets) below the diagonals, and concordance indexes above the diagonals. At their bottom, they also include the *W*-statistic to test for the existence of the overall meat price cycle.

According to Table 9, half of all potential links present a certain degree of synchronisation. The lamb price cycle, in particular, was characterised by the highest number of synchronised relationships. In descending order of statistical significance, it featured three positive links, with beef (ρ = 0.34***), pork (ρ = 0.24**), and poultry (ρ = 0.17*). Interestingly, pork displayed a mild negative correlation with poultry (ρ = –0.11), suggesting that the producers should diversify between the two products. However, it was not statistically significant. The results changed significantly when they focused exclusively on the period characterised by the COVID-19 pandemic and the Russo-Ukrainian war. Table 10 shows that all pairs of meat price cycles were synchronised. Five out of six links, in particular,

Table 9. Historical synchronization (1980–2023) – nominal meat prices

Meat	Beef	Lamb	Pork	Poultry
Beef	–	68.06	53.23	55.51
Lamb	0.34*** (13.71)	–	61.22	61.22
Pork	0.07 (0.52)	0.24** (6.51)	–	44.11
Poultry	0.08 (0.59)	0.17* (2.78)	–0.11 (1.22)	–
Meat price cycle	*W*-statistic: (40.30)***			

*,**,*** $P < 0.1$, $P < 0.05$, $P < 0.01$
Source: Author's calculations

were characterised by large and strongly significant correlations. In other words, the COVID-19 pandemic and the Russo-Ukrainian war have reinforced the degree of co-movement between couples of meat prices.

The concordance index among pairs of meat price cycles was considered only in the presence of significant relationships, in that large values might be driven by the persistence of expansionary phases, thereby supplying misleading results (Harding and Pagan 2016). According to Table 9, the phases of lamb and beef price cycles historically showed the largest level of phase concordance, namely 68.06%. The latter result reflects their relatively large pairwise correlation. On the other hand, Table 10 provides evidence of large degrees of phase concordance during emblematic health and war crises. As an example, the historical concordance index of 55.51% between beef and poultry prices skyrockets to 91.49% when focusing on the period follow-

Table 10. Synchronization during COVID-19 pandemic and Russo-Ukrainian war (2019–2023) – nominal meat prices

Meat	Beef	Lamb	Pork	Poultry
Beef	–	87.23	65.96	91.49
Lamb	0.75*** (93.34)	–	65.96	82.98
Pork	0.34* (2.82)	0.41*** (14.81)	–	74.47
Poultry	0.83*** (130.32)	0.69*** (73.31)	0.50*** (8.16)	–
Meat price cycle	*W*-statistic: (206.18)***			

*,**,*** $P < 0.1$, $P < 0.05$, $P < 0.01$
Source: Author's calculations

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ing the COVID-19 outbreak. Overall, COVID-19 triggered a generalised V-shaped behaviour in commodity prices (Monge and Lazcano 2022), which also characterised food commodities such as meat. Not investigating causality, this work was unable to address the cause of this phenomenon for meat commodity prices. Figiel et al. (2023), however, suggest that COVID-19 triggered a sharp fall in energy commodity prices followed, in turn, by a milder fall in food commodity prices. The interconnectedness between energy and food commodity prices was witnessed by their consequent recovery. This hypothesis was supported by Vatsa and Baek (2023), whose general findings suggest the relevance of oil demand and supply shocks in affecting meat commodity prices. Of extreme relevance, the significance of the *W*-statistic at the 0.01 level both historically and during the COVID-19 pandemic and Russo-Ukrainian war supports the existence of an overall meat price cycle.

CONCLUSION

This work sheds light on short-term cyclical features of global meat commodity prices, namely beef, lamb, pork and poultry. The mix of censoring rules chosen for the MBBQ algorithm captured the most relevant peaks and throughs, such as the slump in the pork market in 1998 and the sustained fall in lamb prices in the early 1980s. Booms and slumps during the COVID-19 pandemic and the Russo-Ukrainian war were successfully captured. The robustness of the MBBQ algorithm in characterising the meat price cycles was emphasised through a critical comparison with the harmonic model applied to poultry prices.

The analysis provided the following results. First, global nominal meat prices feature cycles lasted on average between 3.8 and 4.6 years. Pork prices distinguished themselves from other meat prices due to their highly volatile and mostly contractionary behaviour. Average durations and amplitudes of beef and lamb price cycles were relatively different from those of Cashin et al. (2002) due to the different periods of analysis and the economic natures of the series, i.e. real in Cashin et al. (2002) and nominal in this work. Second, correlation and concordance analysis showed that lamb meat prices historically co-moved to different degrees with all other meat prices. The synchronisation analysis suggested the existence of an overall historical meat price cycle. Third, during the recent global crises, pairwise links have become tighter and highly positively correlated for all meat prices, thus substantiating the evidence for overall co-movement in meat commodity prices.

Knowing the recurring behaviour of meat commodity prices helps the supply side better plan meat production processes. Policy makers, on the other hand, can use this information to predict upcoming booms and slumps and, thus, design policies are able to modify the duration and amplitude of meat price fluctuations (Fliessbach and Ihle 2020a). Policymakers can also exploit the evidence of an overall meat price cycle to guess how a shock targeting of specific meat affects other meats, historically and during crises, thus enabling the design of appropriate specific or broad-spectrum policies. Depending on the rate and speed of price pass-through from imported meat to retail markets, these results may also have relevant consequences for consumption processes. Unlike developed countries, the developing ones may have very low domestic rates of food processing. For this reason, price changes occurring in international markets are transmitted almost unfiltered to consumers, leaving them more exposed to market uncertainty (Dewbre et al. 2008).

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