IMPACT OF FESTIVALS ON GOLD PRICE EXPECTATION AND VOLATILITY

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Abstract

Despite its growing prominence as investment during recent years, gold as jewellery still accounts for about half of global gold consumption, the world's largest consumers being China and India. There are annual festivals, such as Akshaya Tritiya Festival and the end of Ramadan, which can be considered as a source of demand in gold markets because they are linked to traditions of buying or making gifts of gold. More recently, traditional gifts of cash given during the Chinese Spring Festival have often been replaced with gold.

The purpose of our study is to investigate the effects of a selection of festivals on the expectation and volatility of daily gold price changes. Dummy variables indicating the day (or beginning) of the festival are modified to reflect a certain impact pattern within the surrounding time period; a combination of regression and GARCH models can then differentiate between pre- and post-effects of the (first) festival day. For example, we find that volatility tends to increase significantly after Akshaya Tritiya, without a discernible increase in expectation. Around the end of Ramadan, on the other hand, an increase in gold prices can be observed, with volatility tending to increase as well.

Key words: Gold prices; festivals; GARCH with covariates

1 Introduction

"Today, gold is regarded as a sign of prosperity, an ornament, a currency and an integral part of Chinese religion." This statement can be found in the research summary on the outlook for gold demand and supply in China, a publication by the World Gold Council [9], which is a market development association of gold mining companies representing more than 60% of the global annual gold production.[1] The demand for gold around Chinese Spring Festival, the most essential part in Chinese culture, is said to impact the gold price globally, as the traditional gift of red envelopes with cash has, in recent years, increasingly been replaced by jewellery.[2]

Even though China is catching up rapidly, the world's largest consumer of gold is still India. Physical buyers in India are expected to come in "seasonal patterns, dictated by festivals such as Akshaya Tritiya in May and Diwali in September, as well as the wedding season, which runs from September to December."[3] A period of heavy gold buying in the Middle East is usually said to be the end of Ramadan.[4]

According to the World Gold Council website[5], global demand for jewellery responds relatively inelastic to price changes, despite higher price levels. Some weakness, which was recently witnessed

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[1] http://www.gold.org/.

[2] Financial Times, 2012-01-24.

[3] Financial Times, 2011-07-18, 2012-05-12.

[4] Financial Times, 2011-09-02.

[5] http://www.gold.org/.

in India — Indians are considered among the most price-sensitive buyers[6] — and in markets in Europe and the Middle East, has been absorbed by growth generated in China, Russia and Egypt. Though its prominence as investment has been increasing during recent years, gold as jewellery still accounts for about half of world's annual consumption.

The main stream of articles in extant finance literature concerned with gold investigate precious metals (gold, platinum, palladium, silver) as alternative investment class to traditional portfolios, in both cash and derivative markets.

Batten et al. [1] employ a monthly VAR framework to assess macroeconomic determinants of volatility in the precious metal market. Their findings suggest that precious metals are "too distinct to be considered a single asset class" because volatilities do not appear impacted jointly by the same key factors. While both monetary and financial variables variables proved significant for gold, neither of them was found significant for silver. This adds to findings in other studies, e.g. on futures by Erb and Harvey [5].

A special focus has been put on the study of relations between precious metal and FX markets. Capie et al. [3] use a combination of regression and GARCH model for weekly returns on gold prices in USD with the Sterling (Yen) to USD exchange rate as covariate in the regression term. The authors conclude that during the span of thirty years from the early 1970s onward, gold has served as a hedge against USD exchange rate fluctuations, "but that it has done so to a degree that seems highly dependent on somewhat unpredictable political attitudes and events". Pukthuanthong and Roll [6], however, found no empirical evidence for a special relation between the USD price of gold and USD weakness that would allow to imply a positive impact from foreign currencies' appreciation. Using daily data from the past forty years, and applying a conditional correlation GARCH model, they show that a higher price of gold can be associated with depreciation in every currency (USD, Euro, Pound, and Yen) over the same time period. Sari et al. [8] investigate co-movements and information spillovers among the precious metal, oil and FX markets on the basis of a VAR model. They found evidence of close linkage in the short run after shocks.

Our paper contributes to a further field of research on gold prices. The goal of our study is to assess the effects of a selection of festivals on the distribution of daily gold price changes, in particular to examine in which way festivals impact the expectation and volatility of returns.

The idea that festivals influence expectation of price changes as well as volatility leads us to a combination of regression and GARCH specification with covariates entering both equations. The covariates are dummy variables which indicate the day (or beginning) of a festival and are extended to reflect anticipation and/or aftereffects.

All computations were carried out in R [7]. — This paper is organized as follows. Section 2 introduces the data which we use in our study. The model, and how we proceed to capture possible effects of festivals are provided in Section 3. Empirical results are presented in Section 4. A discussion of aspects of robustness is provided in Section 5. Finally, Section 6 gives a summary and some conclusions.

2 Data

Daily gold fixings in USD per troy ounce[7] were used for this study, beginning 1991-01-02 and ending 2012-03-30 (5330 observations). The dates of floating holidays/festivals were taken from miscellaneous websites.[8] The daily gold price series, together with the dates of festivals (represented by the height of

[6] Financial Times, 2012-05-12.

[7] Daily gold price fixings are available at the website of The London Bullion Market Association; http://www.lbma.org.uk/pages/?page_id=53&title=gold_fixings.

[8] Sources of floating festival dates:

- Akshaya Tritiya: http://www.drikpanchang.com/calendars/hindu/hinducalendar.html
- Chinese New Year: http://www.hko.gov.hk/gts/time/conversion.htm
- Dussehra: http://www.drikpanchang.com/calendars/hindu/hinducalendar.html

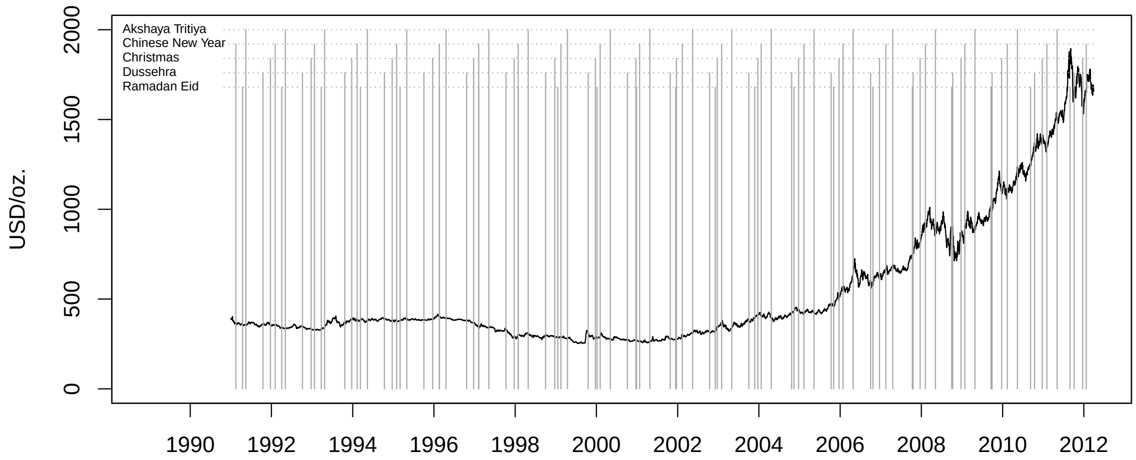


Figure 1: The gold price series and festival dates

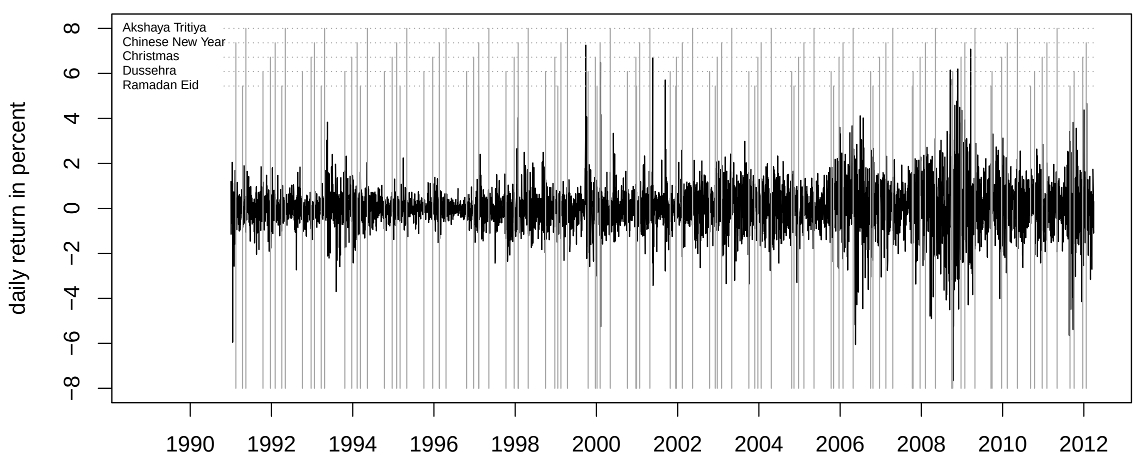


Figure 2: The gold return series and festival dates

the vertical lines) is shown in Figure 1. No effort was made to adjust gold prices for inflation, because the present analysis is based on daily price changes (returns) in percent, which would only be marginally affected by inflation adjustment. The daily return series is displayed in Figure 2.

- Easter: http://www.greencourtsoftware.com/links/easter.cgi
- Eid al-Adha: http://www.takvim.com/ramazan_bayram.php
- Ramadan Eid: http://www.takvim.com/ramazan_bayram.php

3 The Model

3.1 Model structure

The following model is used to analyze the impact of festivals on the expectation and volatility of gold price returns:

$$r_t = c + \nu_t \sqrt{h_t} = c + \epsilon_t \quad (1)$$

$$\nu_t = \eta_t + \sum_i b_i \, d_{it} \quad (2)$$

$$h_t = \alpha_0 + \alpha_1 \, \epsilon_{t-1}^2 + \beta \, h_{t-1} + \sum_i \gamma_i \, d_{it} \quad (3)$$

Here, (r_t) is the series of daily returns on the gold price, (d_{it}) is the (extended, see below) dummy variable for festival i, (η_t) is Gaussian white noise with $\mathrm{var}(\eta_t) = 1$ (hence, $\mathrm{var}(\nu_t) = 1$ for all t), b_i and γ_i are parameters quantifying the impact of festival i, and summation is over all festivals included.

Equation (1) states that gold price returns can be decomposed into a constant c and a heteroskedastic series (ϵ_t) with expectation zero, so that ϵ_t can be seen as the mean-corrected return on day t. (No significant autocorrelation was found in the series of returns.) In equation (2), white noise (η_t) is augmented by a term quantifying the impact of festivals via modified dummy variables on the conditional expectation of r_t. The process (η_t) is the "news" series driving the return process; "news" in this sense excluding information about festivals.

Equation (3) is a GARCH model of order (1,1) (cf. Engle [4], Bollerslev [2]), again augmented by a term accounting for possible festival impact on conditional volatility. Considering this definition of h_t, equation (2) together with equation (1) implies that the magnitude of the impact of festivals on r_t, conditional on η_t and ϵ_{t-1}, is measured in units of the current standard deviation, $\sqrt{h_t}$: The return r_t will be increased by $b_i\sqrt{h_t}$ percent due to the impact of festival i, given all other news. In other words, the term $b_i\sqrt{h_t}$ is the shift in location of the return due to festival impact.

Fitting the model to data proceeds in reverse order: a GARCH model is fitted according to equation (3), yielding the (ν_t) series which still contains information about the impact of festivals on expectation. The series (η_t) is then obtained by regressing (ν_t) on dummy variables (equation (2)). This procedure is illustrated in Figures 4, 5 and 6 below.

3.2 Dummy variables

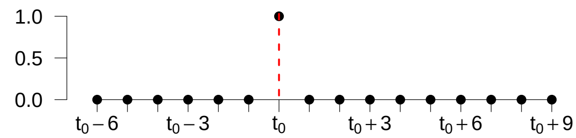
Dummy variables indicate the first day of a festival. For each festival i, we define

$$d_{it} = \begin{cases} 1 & \text{if festival } i \text{ is celebrated} \\ & \text{on days } t \text{ (the first day)}, \ldots, t+n \text{ (the last day)} \\ 0 & \text{otherwise} \end{cases}$$

In case the gold price is not available for the first day of a festival (because this day is a Saturday or Sunday; another example is Christmas), d_{it} is set at 1 for the last day t *before* the festival on which the gold price is still available. Each sequence (d_{it}) consists thus of isolated 1s, surrounded by 0s.

Our goal in the present study is to ascertain the impact of a festival on the distribution of returns on the gold price. To this end, a dummy variable, indicating the first day of a festival in its original form, can be modified (or extended) to reflect anticipation and/or aftereffect of the festival, and the modified form is then plugged into equations (2) and (3). The modifications used in equations (2) and (3) need not be identical, i.e. the festival can impact expectation and volatility in different ways. An extension is designated by a tupel (from, to) where "from" and "to" specify the start and end, respectively, of a sequence of 1s around (or in the vicinity of) the festival day. An example is shown in Figure 3, where t_0 is the first day of the festival (or the last day before the festival on which the gold fixing was available).

a) original:



b) extended, from -3 to $+5$:

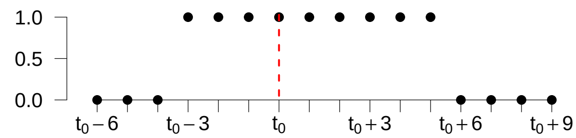


Figure 3: Dummy variables: original and extended

3.3 Search for a good model

The model determined by equations (1), (2) and (3) is fitted to daily return data, plugging in series of extended dummy variables (one for each festival). The model fit is then optimized with respect to AIC over a set of extensions for each dummy variable. It will turn out that this procedure leads to significant parameter estimates. The dummy variable extensions are subject to the following rules (we call extended dummy variables complying with these rules *admissible*):

- The maximum distance between the festival day and the nearest "1" in the dummy is 2. For example, the extension (from, to) = $(2, 5)$ is admissible (reflecting an aftereffect), while (from, to) = $(3, 6)$ is not. This rule guarantees that the time interval between festival and anticipation/aftereffect is not too long.
- The minimum length of a "1" sequence in the extended dummy variable is:
  - 3, if the "1" sequence does not cover the festival day,
  - 2, if the "1" sequence does cover the festival day.

  The rationale for this rule is that we want to make sure that there is no single, random, day which proves significant, but significance should be brought about by a more sustained effect instead, and the idea that the impact should not occur on a single day. Thus, (from, to) = $(-1, 0)$ (length 2, festival day covered) and (from, to) = $(1, 3)$ (length 3, festival day not covered) are admissible, while neither (from, to) = $(1, 2)$ nor (from, to) = $(0, 0)$ are admissible.
- The earliest onset of impact is 15 days before the festival. For example, (from, to) = $(-15, 0)$ is admissible, while (from, to) = $(-20, 0)$ is not.
- The impact dies down no later than 15 days after the festival. For example, (from, to) = $(2, 15)$ is admissible, while (from, to) = $(2, 20)$ is not.

Finding the optimal model then means to find the model with the lowest AIC among all admissible dummy variable extensions and all possible combinations of festivals.

4 Empirical Results

4.1 Parameter estimates

The fitted model structure and the estimated parameters when minimizing AIC with respect to dummy variable extensions are reported in Table 1. The upper part of the table refers to the GARCH specifica-

	from	to	estimate	std.err.	t value	p value
α_0			0.0028	0.0008	3.330	0.001
α_1			0.0697	0.0070	9.896	0.000
β			0.9284	0.0067	138.7	0.000
$\gamma_{\text{Akshaya Tritiya}}$	1	13	0.0168	0.0065	2.594	0.009
$\gamma_{\text{Christmas}}$	-4	4	0.0215	0.0076	2.839	0.005
$\gamma_{\text{Ramadan Eid}}$	-5	13	0.0109	0.0041	2.641	0.008
$b_{\text{Chinese New Year}}$	1	4	0.2076	0.1066	1.947	0.052
$b_{\text{Christmas 1}}$	0	1	0.3434	0.1544	2.225	0.026
$b_{\text{Christmas 2}}$	2	5	-0.2649	0.1093	-2.424	0.015
b_{Dussehra}	-1	7	-0.1875	0.0731	-2.565	0.010
$b_{\text{Ramadan Eid}}$	-10	14	0.1357	0.0431	3.151	0.002

Table 1: Parameters of the fitted model

festival	$s_{\text{festival } i}$	$s_{\text{festival } i}/s_{\text{no festival}}$
Akshaya Tritiya	3.21	2.65
Ramadan Eid	2.68	2.21
Christmas	3.57	2.95

Table 2: Long-run standard deviations with festival impact and long-run multiplier

tion in equation (3) and the lower part to the location specification in equation (2). It turns out that all parameters are significant at the 5% level. It was found appropriate to split the impact pattern of Christmas into Christmas 1 and Christmas 2, with opposite signs of impact ($+0.34$ vs. -0.26). Christmas 1, with (from, to) = $(0, 1)$, specifies an impact right before and right after December 25, according to our convention to bring forward the indicator of Christmas, on which no gold fixing is available.

The model fitting procedure is illustrated in Figure 4, showing a plot of the fitted (ν_t), Figure 5, showing a plot of the fitted (η_t), and Figure 6, showing a plot of $(\nu_t - \eta_t)$. The plots of (ν_t) and (η_t) will differ only around festival dates, according to equation (2). Keeping in mind that var$(\nu_t) = 1$, the plot of the difference $(\nu_t - \eta_t)$ gives an idea of the magnitude of festival impact as compared to news in general.

4.2 Impact on conditional volatility

In order to assess the impact of festival i on gold return volatility, α_0 can be related to γ_i by observing that the long-run standard deviation of returns is given as:

$$\begin{cases} s_{\text{no festival}} = \sqrt{\dfrac{\alpha_0}{1-\alpha_1-\beta}} & \text{in the absence of festivals,} \\ s_{\text{festival } i} = \sqrt{\dfrac{\alpha_0+\gamma_i}{1-\alpha_1-\beta}} & \text{in the presence of festival } i. \end{cases} \tag{4}$$

The first value equals 1.21. The long-run standard deviations in the presence of those festivals which were found to have a significant impact are shown in Table 2, together with long-run multipliers due to the festival, i.e. the ratio $s_{\text{festival } i}/s_{\text{no festival}}$, acting as a "news-magnifier" according to equation (1). The volatility of gold price changes can obviously increase substantially during festival impact periods.

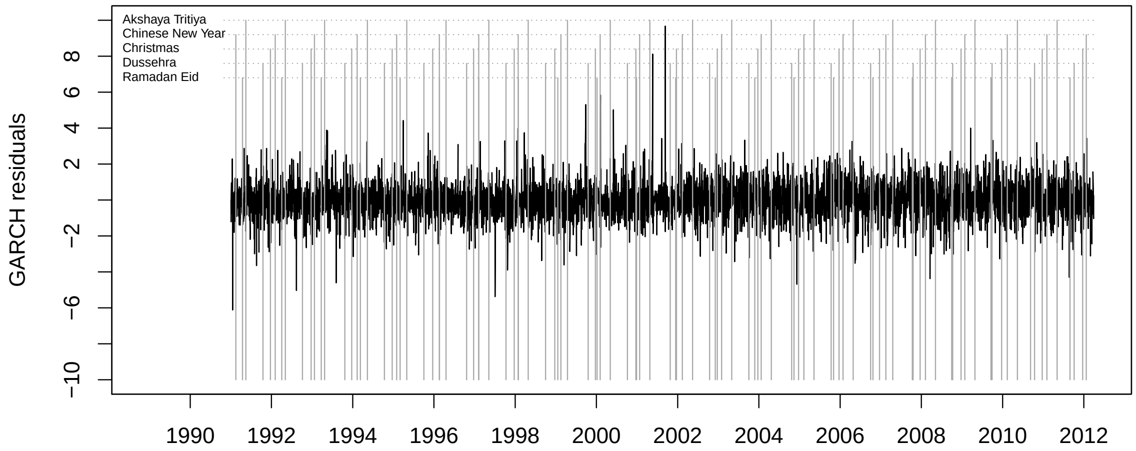


Figure 4: GARCH residuals and festival dates

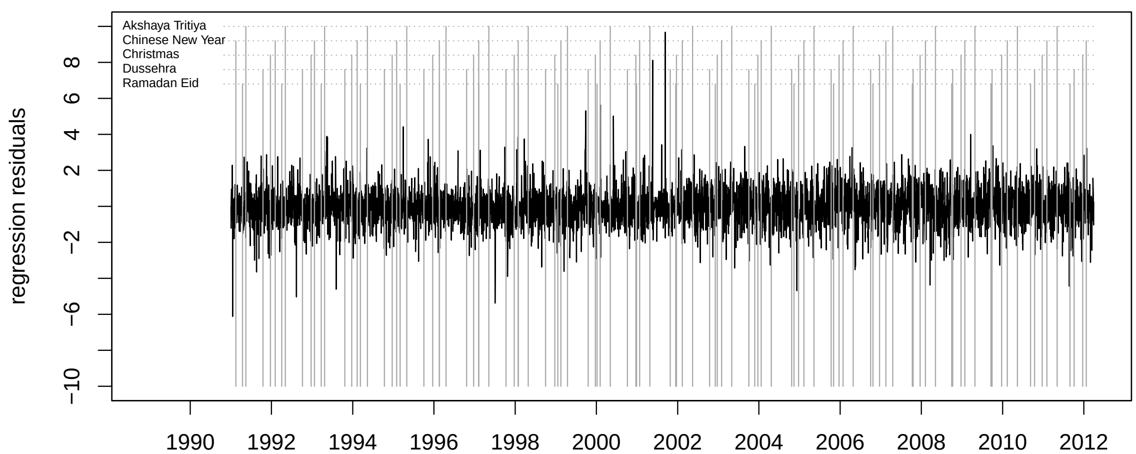


Figure 5: Regression residuals and festival dates

4.3 Impact on return location

As we have seen earlier, festivals impact the location of returns via the coefficients b_i. For Christmas 1, this implies a systematic increase in daily return in a magnitude of about 1% (namely, $b_{\text{Christmas 1}} \cdot s_{\text{Christmas 1}}/s_{\text{no festival}} = 0.34 \cdot 2.95$, according to Tables 1 and 2).

5 Model Robustness

In order to make sure the results of the last section are valid, arguments should be found that these results can be seen as actual effects of festivals, and they are not the outcomes of random events not connected with festivals. In the present section, we discuss four aspects of robustness providing evidence for the validity of our results.

5.1 Do results depend on a single outlier?

The largest absolute daily return close to a festival in the period considered could be observed on Monday, 2000-02-07, right after Chinese New Year, which was celebrated on Saturday, 2000-02-05, marking the beginning of the "Year of the Metal Dragon". This situation is shown in Figure 7. Day 0 designates

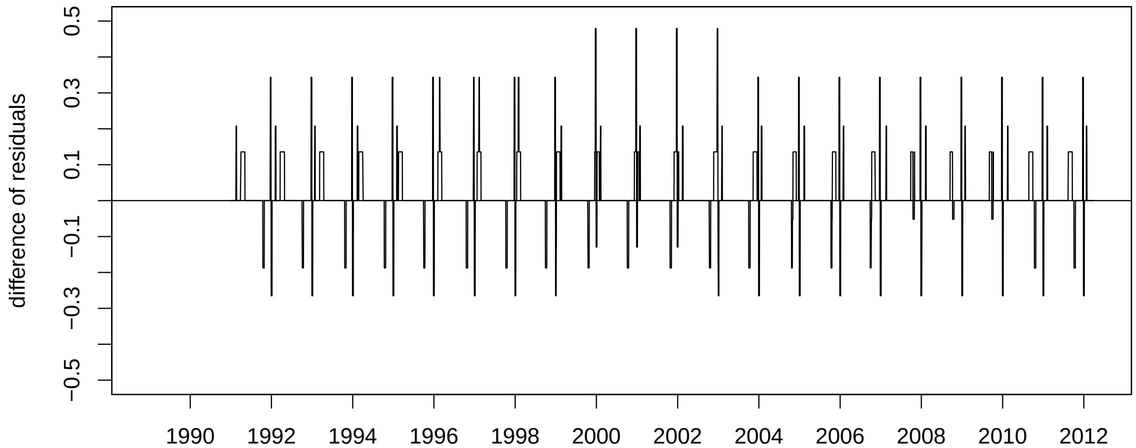


Figure 6: GARCH residuals minus regression residuals

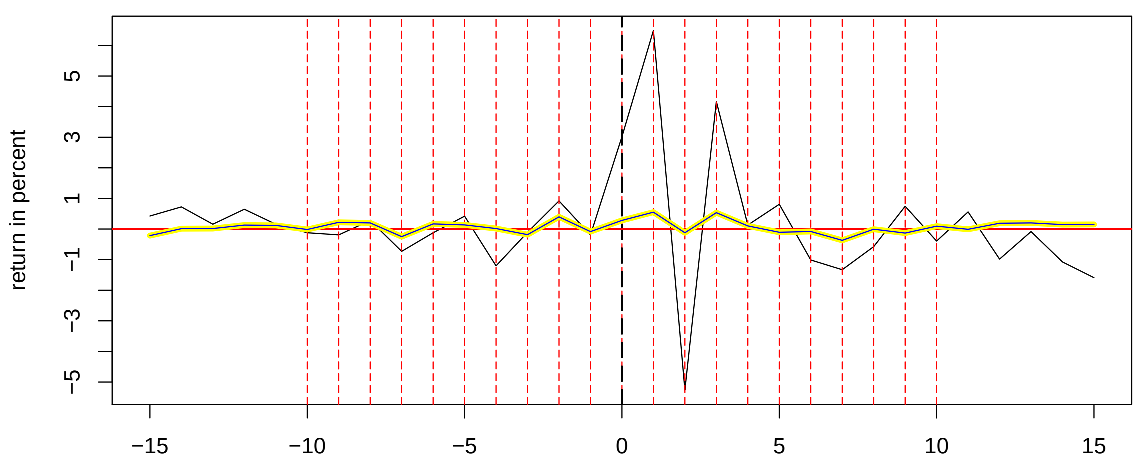


Figure 7: Gold price changes around Chinese New Year

from	to	α_0	α_1	β	γ	AIC
1	13	0.0042	0.07338	0.9259	0.0132	13361.826
2	12	0.0042	0.07315	0.9262	0.0153	13361.987
−2	14	0.0042	0.07352	0.9259	0.0104	13362.152
−3	15	0.0042	0.07354	0.9258	0.0093	13362.206
−1	13	0.0041	0.07259	0.9267	0.0116	13362.222
2	11	0.0042	0.07311	0.9263	0.0157	13362.628
−1	12	0.0042	0.07274	0.9267	0.0109	13363.038
⋮	⋮	⋮	⋮	⋮	⋮	⋮

Table 3: Searching for an impact pattern — the case of Akshaya Tritiya, GARCH

Chinese New Year, the solid black line shows returns in 2000. (According to our convention, the Chinese New Year indicator is shifted to Friday, 2000-02-04; the next day on which a return is available is Monday, 2000-02-07.) The yellow line in the plot marks the average returns, 1991–2012. Omitting this outlier will still leave a significant impact of Chinese New Year, so that its impact revealed by the model is not due to this particular outlier. This provides a strong argument that outliers do not distort the overall picture. See also Section 5.4 below.

5.2 Are impact patterns consistent and plausible?

Searching for an impact pattern in the form of a dummy variable extension involves estimating parameters and computing the AIC for different extensions. An example (with extensions of the Akshaya Tritiya festival indicator when fitting the GARCH, equation (3)) is shown in Table 3, where extensions are ordered with respect to AIC from smallest — i.e. optimal in this sense — onward. It turns out that extension patterns do not differ very much as AIC gradually grows larger — there is no “jump” in extension patterns. In other words, similar patterns of festival impact are similarly plausible, lending evidence to pattern stability, or robustness.

A further argument for pattern plausibility can be derived indirectly from Table 3: generally, no extension with an extreme impact pattern, lying at the border of the admissible region (such as (from, to) = $(-15, +15)$) was found to deliver a low AIC. Clearly, those patterns attributing festival impact to a compact interval close to the festival day were preferred in this sense. Similar observations were made for the other festivals.

5.3 Checking for impacts with random days

Randomly selected days not coinciding with any festivals were analyzed in the same way as festival days; no significant impact pattern could be detected.

5.4 Splitting the time period

The analysis undertaken in this study extends over a period from 1991 through 2012. Although the number of days is large (5330), there are only about 20 observations of returns in connection with festivals, so that the test of a null hypothesis that a festival has no impact will not be very powerful. When splitting the period into two almost equally long parts (1991–2000, 2001–2012), the power will decrease even further.

However, searching for an impact pattern by minimizing AIC is also meaningful for sub-periods and results in patterns similar to those displayed in Table 1, even though parameters need not be significant

	festival	period 1991 – 2012	1991 – 2000	2001 – 2012
	Akshaya Tritiya	**		**
GARCH	Christmas	**	**	
	Ramadan Eid	**	**	
	Chinese New Year	**		**
	Christmas 1	**		**
regression	Christmas 2	**	**	
	Dussehra	**		**
	Ramadan Eid	**	*	**

Significance indicators: "**" at the 5% level; "*" at the 10% level

Table 4: Fitting models, sub-periods

anymore; see the results in Table 4. A notable exception is Chinese New Year, whose impact popped up in 2000 abruptly and has persisted since then.

6 Summary and Conclusions

The purpose of the present study was to ascertain the character of the impact of a selection of festivals on the expectation and volatility of daily price changes in the spot gold market. We developed a framework which combines a regression and GARCH specification with covariates. These covariates are defined on the basis of dummy variables indicating the first day of a festival; a set of dummy variable extensions allow for modeling different patterns of festival anticipation and aftereffects. The covariates are added on in the GARCH term and in the conditional expectation formula. This implies that the magnitude of a festivals's impact on conditional expectation of price changes is measured in units of the current standard deviation acting as a "news magnifier". The empirical basis of the study consists of data from January 1991 through March 2012. The robustness of results was tested under various aspects.

Festivals which were found to have an impact on the distribution of gold price changes are Akshaya Tritiya, Chinese New Year, Christmas, Dussehra, and Ramadan Eid, but the impact's character may be quite different. For example, we observed that volatility is increased significantly after Akshaya Tritiya, without a discernible increase in expectation. A substantial increase in volatility can as well be located around Christmas, and Ramadan Eid. While prices tend to increase during the impact period of Ramadan Eid, opposite signs proved significant for the impact right before and right after Christmas. Finally, our findings suggest the onset of a Chinese New Year impact in 2000 — it was the "Year of the Metal Dragon".

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