Real & Nominal Foreign Exchange Volatility Effects on Exports – The Importance of Timing

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Abstract

This paper compares real and nominal foreign exchange volatility effects on exports. Using a flexible lag version of the Goldstein-Khan two-country imperfect substitutes model for bilateral trade, we identify the overall effect into both a timing as well as a size impact. We find that the size impact of forecasted foreign exchange volatility does not vary according to the measure used in terms of magnitude and direction. However, there are very different timing effects, when we compare real and nominal foreign exchange rate volatility.

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1. Introduction

Mixed findings have been reported for the impact of foreign exchange volatility on exports.[1] A number of possible reasons for the lack of consistency are put forward including the models utilised, the sample period analysed, the countries selected, and the volatility measures chosen. This paper readdresses this latter issue by decomposing the overall impact of foreign exchange volatility and compares the timing and size effects of real versus nominal forecasted exchange rate volatility for a small developing economy. Two questions are addressed separately. Firstly, is the size impact of foreign exchange volatility dependent on the use of real and nominal measures? Secondly, is the timing of any likely impact dependent on these measures? The evidence whilst suggesting that consistent results for the size effect are found using either real or nominal measures of foreign exchange rate volatility (see, Thursby and Thursby (1987)), there is no evidence thus far on the timing effect. One of the main motivations for adopting real rather than nominal exchange rate volatility is the observation that fluctuations in prices and incomes may be a determining influence and may offset such uncertainty (see Gotur, 1985). Given the ambiguity of the point estimate results (size effect) to date, a timing based approach as adopted here is likely to shed greater light on the importance of the two alternatives. In this note, we document that the use of real and nominal foreign exchange forecasted volatility does not influence the size effect, however consistent with the Gotur argument, there is evidence of adjustment accounted by the differential timing effect.

The modelling procedure uses the Goldstein and Khan (1985) two-country imperfect substitutes model for bilateral trade that treats domestic exports and goods produced abroad as imperfect substitutes. We incorporate a flexible lag structure in the model that allows for a non-contemporaneous relationship between exports and the export decision. The application of the model is to a small open developing economy, Ireland that faces a high degree of uncertainty from foreign exchange rate risk.[2] Both Baum et

[1]For example, Koray and Lastrapes (1989) and Fountas and Aristotelous (1999) find a negative relationship, Baum et al (2004) find a positive relationship and Klaassen (2004) finds an insignificant relationship.

[2] Ireland is the most open economy in Europe, with for example, the level of exports to GDP rising from 43% at the start of our sample in 1979 to 94% at the end of sample in 2002. Moreover, since the introduction of the Euro it is still heavily dependent on non-Euro area trade, with its two largest trading

al (2004) and Klaassen (2004) highlight the over reliance on empirical evidence from fully developed markets, and in contrast, this note introduces some evidence for a rapidly developing economy. As volatility is latent and unobservable we retest the model for robustness using a number of volatility forecasts.

The remainder of the paper is organized as follows. Section 2 examines the export model applied to our small open economy. Section 3 provides a description of the volatility measures and their estimation. The empirical findings and their implications are outlined in section 4. Finally, conclusions are offered in section 5.

2. Export model

Our export model adopts the Goldstein and Kahn (1985) two-country imperfect substitutes model for bilateral trade between Ireland and the UK and the US. The model is forward looking at time *t-l* with traders interested in the exchange rate at time *t*. To incorporate this feature, the model is augmented with a flexible lag structure (Poisson) to describe the dynamics of a non-contemporaneous relationship between exporters trade decisions and real export delivery and payment. Our model is:

$$x_t = x(y_{t-l,} E_{t-l}[s_t], \sigma_{s,t-l}[s_t]) \qquad (1)$$

where real exports are dependent on real foreign income (y), the expected real foreign exchange level (s) and exchange rate volatility (σ_s). The model is run using a forecast of both real and nominal exchange rate volatility for time *t* that is unknown to them at time *t-l* to determine if their respective influences vary.

The adopted model allows us the examine the timing impact of exchange rate volatility by having a flexible lag structure that uses *l* lags ranging from the export decision to payment at time *t*. We expect that real foreign income will have a positive

partners, the US and UK, being the destination for approximately 40% of its total exports and is an ideal economy to examine the influence of foreign exchange volatility on exports.

effect and real foreign exchange level a negative effect.[3] There is a large amount of empirical work that has investigated the impact of foreign exchange volatility using either real or nominal measures (see McKenzie (1999) for a review). The vast majority of recent studies have found a positive relationship between foreign exchange volatility and exports. Franke (1991) follows a real options based approach to explain the positive effect of volatility. The real options approach finds that once the expected cash flows from exporting as a result of volatility are greater than the entry and exit costs, then there is likely to be a positive relationship.

However, with the exception of some recent studies, all of the empirical papers investigating the impact of foreign exchange volatility effects on exports have only investigated the direct (size) impact of volatility. Here, we also take account of the likely timing effects and so investigate whether the adoption of real or nominal foreign exchange rate volatility forecasts has any implications on when impact occurs.

Our real exports model will have the following form;

$$x_t = \beta_0 + \sum_{l=1}^{30} [\beta_{1l} y^*_{t-l} + \beta_{2l} E_{t-l} s_t + \beta_{3l} \sigma_{s,t-l}] \qquad (2)$$

In order to model the impact using a flexible lag approach, we adopt a Poisson lag structure (see Baum et al (2004) and Klassens (2002)). Alternative, but more restrictive, approach's include the geometric and the polynomial lag specification. For example the geometric approach implies that β_l is decreasing as the lag increases.[4] The Poisson lag approach is derived from the Poisson probability distribution;

$$\beta_{kl} = \beta_k . \frac{(\lambda_k - 1)^{l-1}}{(l-1)!} \exp[-(\lambda_k - 1)] \qquad (3)$$

[3] Consistent with previous studies, we find that Irish exports are cointegrated with real foreign income and real exchange rates. Results are available upon request.
[4] See Klaassen (2002) for a detailed discussion of the problems associated with geometric and polynomial lags in the current setting.

for $\lambda_k \geq 1$ and k = y*, s, σ_s and λ is the lag at which the maximum effect occurs. One important advantage of the Poisson lag approach is the number of parameters to be estimated is minimized, $2k + 1$, where k is the number of independent variables. As can be seen the parameters $\lambda_1, \ldots, \lambda_k$ enter into the equation in a non-linear fashion. In order to calculate the parameters $\lambda_1, \ldots, \lambda_k$, we use the simulated annealing optimization technique (see, Goffe et al. 1994).[5] Once the parameters, $\lambda_1, \ldots, \lambda_k$, have been obtained from the non-linear optimization technique, the estimated coefficients, $\beta_1, \ldots, \beta_k$, are calculated using OLS.

3. Volatility measures

Recently much work has concentrated on modelling (foreign exchange) volatility that is directly unobservable. The literature relies on many types of volatility measures (McKenzie, 1999). In contrast to exchange rates that are available contemporaneously, exchange rate volatility is modelled ex-post leading to a major research agenda in modelling volatility through analysis of its distributional and dynamic characteristics. Our model is run with the three forecasts of volatility to determine their explanatory power for multi-period or l lags. Our GARCH forecast of volatility is computed recursively following Engle and Bollerslev (1986). We also recursively fit an AR(1) model to the aggregated squared and absolute returns to obtain non-constant forecasts of these measures for l periods. Major developments have been made in modelling the time-variation of volatility and its persistence and we incorporate three of these models. In addition, to ensure that robustness occurs for assessing the effects of foreign exchange volatility the separate separate choices for the volatility proxy are examined. These include Absolute and Squared based measures of volatility from the microstructure literature and the more general time-varying GARCH type process.

[5] An important advantage of the simulated annealing optimisation routine is that it escapes from local maxima and local minima and can maximise or minimise functions that are difficult to optimize. We use the GAUSS code by E.G. Tsionas to run the procedure.

Specifically, the Absolute and Squared measures are model free that aggregate daily associated realisations over monthly intervals that capture many features of the dynamics of financial time series (see Andersen et al, 2001). The estimates are underpinned by the theory of power variation that requires aggregation from high to low frequency observations has been advocated with many illustrations for volatility modelling (see references in Andersen et al, 2003). The practical implementation of the theory simplifies into constructing volatility estimators using aggregated squared or absolute exchange rate changes and their variants for any month t with m daily intervals. The most common approach suggests the use of aggregated squared exchange rate changes over a period, say for example, aggregating daily realisations to obtain monthly estimates instead of using a single estimate from the monthly exchange rate changes (see Baum et al, 2004; Klaessens, 2002). This estimate is closely associated with the variance. We also analyse aggregated absolute realisations that evolves from the same theoretical framework, known as realized power variation (see Barndorff-Nielsen and Shephard, 2003), as exchange rate changes have the stylized property of exhibiting fat-tails due to excessive large-scale movements and modelling with absolute realisations is more robust in the presence of this property (Davidian and Carroll, 1987).

Turning to the theoretical framework we illustrate for aggregate absolute realisations by defining the price process that is underpinned by realised power variation. Volatility of this price process defined as integrated volatility is said to be unobservable. The framework incorporates the popularly used quadratic variation that details the use of aggregated squared realisations and absolute power variation using aggregated absolute realisations. We analyse the price process that has m evenly spaced compounded returns per month (approximately 20). Importantly, realised power variation that incorporates realised absolute variation, namely the sum of absolute realisations, equate with integrated volatility, making volatility of the price process observable.

The GARCH measures uses the APARCH specification fitted at monthly intervals that is flexible to allow for many stylized features of exchange rate series including asymmetric effects and nests seven separate GARCH models (see Ding et al, 1993 for further details). The key too GARCH models in modelling exchange rate volatility is

that they adequately capture volatility clusters in the data (Bollerslev et al, 1994). As well as encompassing three ARCH specifications (ARCH, Non-linear ARCH and Log-ARCH), two specifications of the GARCH model (using standard deviation and variance of returns), it also details two asymmetric models (both ARCH and GARCH versions). A Box-Cox allows for different specifications of the residuals process encompassing the different GARCH models. As well as describing the time-variation in exchange rate changes, it also allows for the possibility of leverage effects, by letting the autoregressive term of the conditional volatility process be represented as asymmetric absolute residuals. The model is fitted with a conditional student-t distribution thereby allowing for fat tails.

3. Empirical findings and discussion

We estimate our export model from May 1979 through December 2002 at monthly intervals.[6] The export model is run using forecasted volatility with a Poisson lag structure for 3 separate measures of real and nominal volatility for each country pair.[7] The flexible lag structure allows for an investigation of the overall impact of exchange rate volatility broken into an examination of the size impact as well as the likely timing of such impacts. Details of the lag structure (panel A) and model coefficients (panel B) are given in table 1. The size and sign of the coefficients on foreign income and the real exchange rate are consistent with previous results from the international literature.

Specifically addressing the two questions raised in this note we find that there is a timing effect between real and nominal foreign exchange forecasted volatility although it does not feed into the size effect. If we consider the lag structure (panel A), we see there is a substantial difference for foreign exchange volatility between adopting real versus nominal measures, regardless of the proxy employed. In

[6] We use exports deflated by export unit value for real exports, UK and US industrial production at constant prices for income, and foreign currency per unit of Euro adjusted for relative prices for exchange rates.

[7] The estimated models were adjusted for the exchange rate crisis 1992/1993 and the regime switch to the Euro in 1999.

particular this result emerges for exports to the UK as evidenced in the lag structure plot in figure 1. Here, we find that although the pattern of the distributed lag appears reasonably similar, the largest effect varies from using real and nominal volatility measures. For instance for the UK, in terms of the nominal measure of foreign exchange rate volatility, the maximum effect occurs only after 19-20 months, while the affect using real foreign exchange rate volatility occurs within the year. A positive relationship between foreign exchange rate volatility and exports is found. This is consistent across the various measures of volatility adopted and real versus nominal measures. The positive relationship is also consistent with both the theoretical and empirical evidence in the literature.[8] Given the different volatility measures chosen, there is considerable variation in the size effects. Although there is consistency in the sign of the effect, the timing impact indicates differences between adopting real versus nominal measures. The positive benefits on exports from higher exchange rate volatility occur with greater speed for the real measure of exchange rate volatility. The results imply that when the real measure is adopted, the positive benefits of volatility are intensified by the movements in income and prices. The results reported here do infer that the variation in prices and income as highlighted by Gotur (1985) is likely to have an influence, although our results indicate that it is likely to be a timing influence rather than a size influence.

5. Conclusions

This paper studies the timing and overall effects of real versus nominal exchange rate forecasted volatility for a small developing economy. The vast majority of previous work assumes the former remains constant and focuses on exports from fully developed markets. Two questions are addressed separately. Firstly, is the size impact of foreign exchange volatility dependent on the use of real and nominal measures? Secondly, is the timing of any likely impact dependent on these measures? We find that the size impact of foreign exchange rate forecasted volatility is not affected by the use of either real or nominal measures of foreign exchange rate

[8] The positive effect of foreign exchange volatility is consistent with the results reported by Franke (1991) and Baum et al. (2004).

volatility. However, there is a substantial difference, when we move to the timing results and in particular for exports to the UK. We find that the positive benefits on exports from higher exchange rate volatility occur with greater speed for the real measure of exchange rate volatility. The results imply that the fluctuations between the foreign exchange rate and prices lead to a faster impact when the real measure is adopted.

References:

Andersen, T.G., T. Bollerslev, F.X. Diebold and P. Labys (2001), 'Modeling and Forecasting Realized Volatility," *NBER Working Paper No. 8160.*

Andersen, T. G., T. Bollerslev, and F. X. Diebold (2003), 'Parametric and nonparametric measurement of volatility', In Y. Ait-Sahalia and L. P. Hansen (Eds.): *Handbook of Financial Econometrics*, North Holland.

Barndorff-Nielsen, O. E. and N. Shephard (2003), 'Realised power variation and stochastic volatility', *Bernoulli* 9, pp. 243-265.

Baum, C. F., M. Caglayan, and N. Ozkan (2004), 'Nonlinear Effects of Exchange Rate Volatility on the Volume of Bilateral Exports', *Journal of Applied Econometrics*, 19, 1-23.

Bollerselv, T., R.F. Engle and D.B. Nelson (1994), 'ARCH Model', pp. 2959-3038, In R.F. Engle and D.C. McFadden (eds.) *Handbook of Econometrics*, Amsterdam: Elsevier Science.

Davidian, M., & Carroll, R. J. (1987), 'Variance Function Estimation', *Journal of the American Statistical Association*, 82, pp. 1079-1091.

Ding, Z., C. Granger, C. W. J., and R. F. Engle (1993), 'A Long Memory Property of Stock Returns', *Journal of Empirical Finance*, 1, 83-106.

Engle and Bollerslev (1986) Engle, R.F. and T. Bollerslev (1986), 'Modeling the Persistence of Conditional Variances,' *Econometric Reviews*, 5, 1-50.

Fountas, S. and Aristotelous, K. (1999), 'Has the European Monetary System Led to More Exports? Evidence From Four European Union Countries', *Economic Letters*, 62, 427-431.

Franke, G. (1991), 'Exchange Rate Volatility and International Trading Strategy', *Journal of International Money and Finance*, 10, 3-29.

Goldstein, M. and M.S. Khan, (1985), 'Income and Price Effects in Foreign Trade', in *Handbook of International Economics*, Volume II, R. W. Jones and P. B. Kenen, eds, North-Holland.

Goffe, W. W., G. D. Ferrier and J. Rogers, (1994), 'Global Optimisation of Statistical Functions with Simulated Annealing', *Journal of Econometrics*, 60, 65-100.

Gotur, P. (1985), 'Effect of Exchange Rate Volatility on Trade: Some Further Evidence', *IMF Staff Papers*.

Klaassen, F. (2004), 'Why is it so Difficult to Find an Effect of Exchange Rate Risk on Trade?', *Journal of International Money and Finance*, Forthcoming.

Koray, F. and W. D. Lastrapes, (1989), 'Real Exchange Rate Volatility and U.S. Bilateral Trade: A VAR Approach', *Review of Economics and Statistics*, 71, 708-712.

McKenzie, M.D. (1999), 'The Impact of Exchange Rate Volatility on International Trade Flows', *Journal of Economic Surveys*, 13, 71-106.

Thursby, J. & Thursby, M. (1987), 'Bilateral Trade Flows, the Linder Hypothesis and Exchange Risk', *The Review of Economics and Statistics*, 69, 488-495.

Table 1. Export model for UK and US

Panel A. Lag structure

	Nominal			Real		
	Squared	**Absolute**	**APARCH**	**Squared**	**Absolute**	**APARCH**
UK						
Y	12.05	11.77	12.16	15.07	15.07	16.15
S	1.91	1.56	1.37	8.94	8.89	9.26
σ_s	21.35	20.74	18.67	8.89	8.12	8.07
US						
Y	0.99	1.03	0.46	0.87	0.27	0.63
S	0.02	0.00	0.00	0.09	0.04	0.15
σ_s	13.75	12.34	7.41	14.49	13.75	10.91

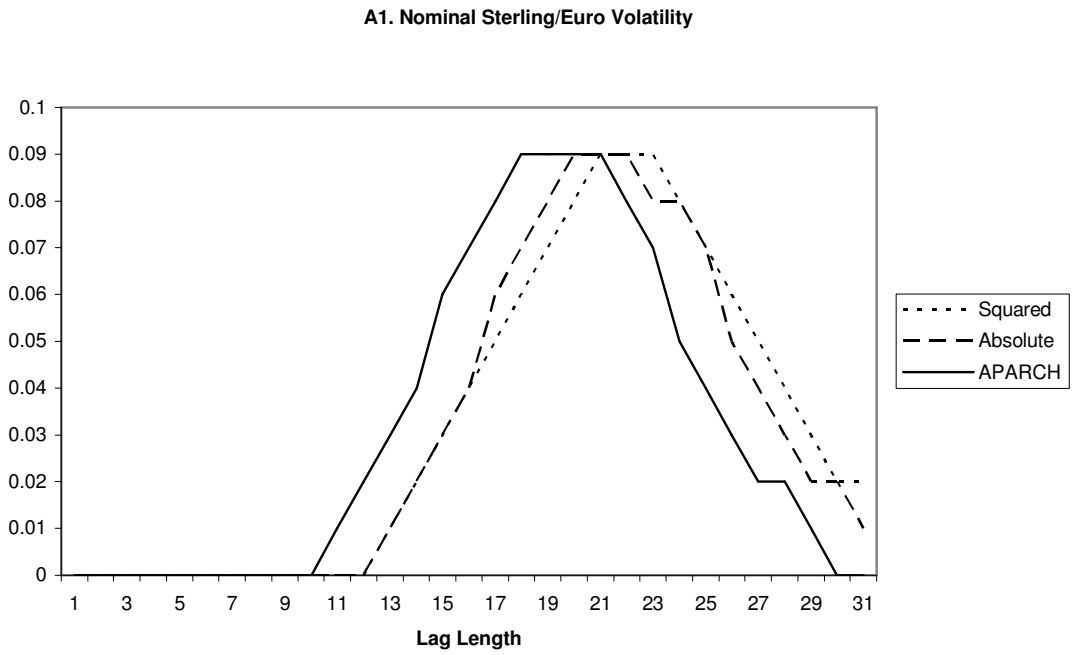
Panel B. Model coefficients

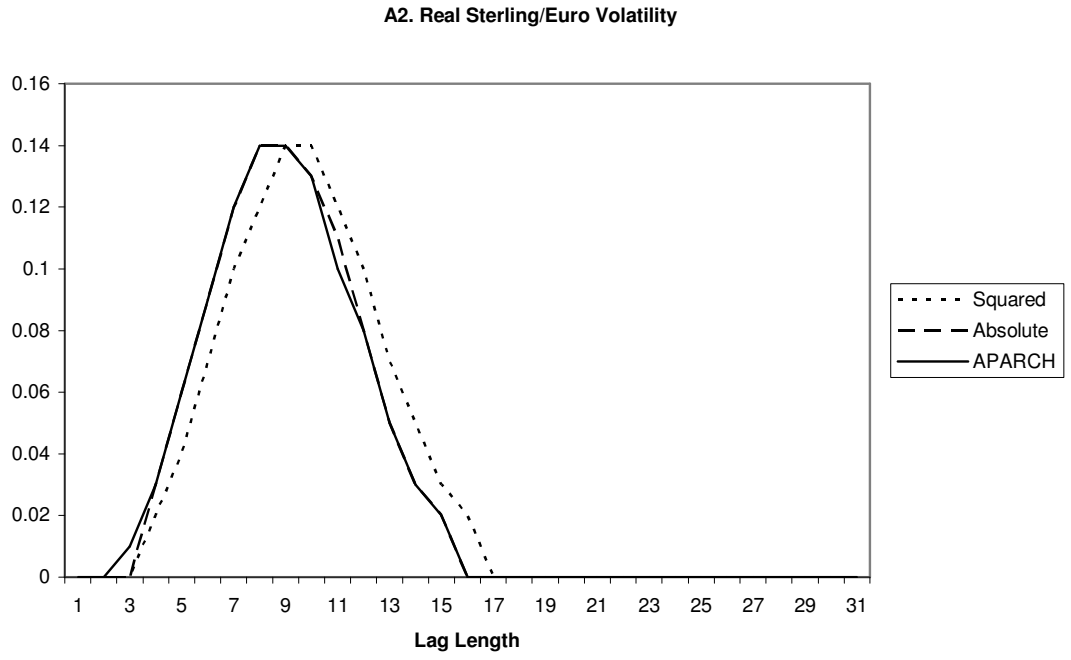
	Nominal			Real		
	Squared	**Absolute**	**APARCH**	**Squared**	**Absolute**	**APARCH**
UK						
Y	3.63*	3.78*	4.07*	3.82*	3.82*	3.88*
	(18.92)	(17.95)	(22.01)	(22.71)	(22.87)	(22.21)
S	-1.24*	-1.25*	-1.20*	-1.29*	-1.27*	-1.27*
	(-9.57)	(-9.74)	(-9.86)	(-8.79)	(-8.64)	(8.64)
σ_s	0.01	0.08	0.19*	0.04	0.08*	0.11*
	(0.46)	(1.41)	(4.20)	(1.89)	(2.00)	(2.48)
US						
Y	4.62*	4.60*	4.53*	4.71*	4.83*	4.64*
	(43.02)	(42.08)	(46.09)	(44.65)	(43.89)	(45.73)

S	-0.95*	-0.90*	-0.83*	-1.03*	-1.05*	-1.01*
	(-16.60)	(-14.83)	(-13.16)	(-18.80)	(-19.39)	(-18.05)
σ_s	0.09*	0.15*	0.08*	0.16*	0.41*	0.12*
	(4.42)	(3.85)	(5.10)	(6.02)	(7.04)	(5.95)

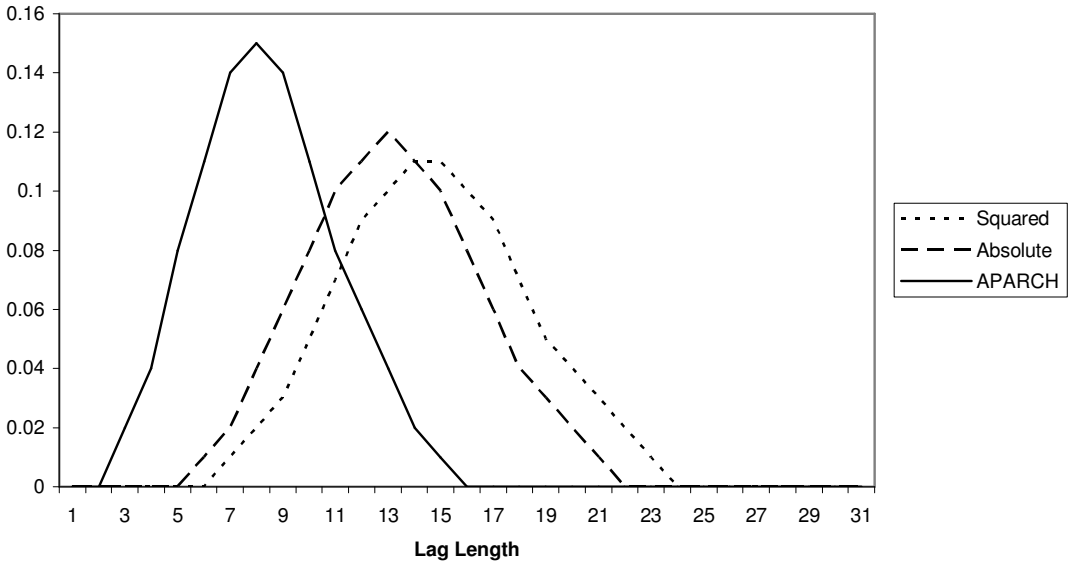
Note: this table gives the lag structure (Panel A) and model coefficients (Panel B) from our export model run using real and nominal foreign exchange forecasted volatility as described in the text. Significant model coefficients are given by * with t-statistics in parenthesis.

Figure 1. Lag structure of real and nominal exchange rate forecasted volatility





A3. Nominal Dollar/Euro Volatility



A4. Real Dollar/Euro Volatility