Journal of Econometrics 158 (2010) 25–36

Contents lists available at ScienceDirect

Journal of Econometrics

journal homepage: www.elsevier.com/locate/jeconom

Forecasting with equilibrium-correction models during structural breaks

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ARTICLE INFO

Article history:
Available online 11 March 2010

JEL classification:
C1
C53

Keywords:
Cointegration
Equilibrium-correction
Forecasting
Location shifts
Collinearity
M1

ABSTRACT

When location shifts occur, cointegration-based equilibrium-correction models (EqCMs) face forecasting problems. We consider alleviating such forecast failure by updating, intercept corrections, differencing, and estimating the future progress of an 'internal' break. Updating leads to a loss of cointegration when an EqCM suffers an equilibrium-mean shift, but helps when collinearities are changed by an 'external' break with the EqCM staying constant. Both mechanistic corrections help compared to retaining a pre-break estimated model, but an estimated model of the break process could outperform. We apply the approaches to EqCMs for UK M1, compared with updating a learning function as the break evolves.

1. Introduction

Building on the earlier tradition of 'error correction' in Phillips (1954), Sargan (1964) and Davidson et al. (1978), the cointegration revolution sparked by Granger (1981) and Engle and Granger (1987) has greatly improved the econometric modeling of integrated time series: see e.g., Hendry (2004), Hendry and Juselius (2000, 2001) for recent surveys. By imposing convergence to equilibrium trajectories from long-run economic analysis, based on the isomorphism between cointegration and equilibrium-correction mechanisms (EqCMs), many new empirical economic insights have been gained.

Unfortunately, that very strength of cointegration when modeling has proved to be its Achilles heel in forecasting, namely a susceptibility to systematic forecast failure: see Clements and Hendry (1998, 1999). The forms of structural breaks that are pernicious for forecasting with cointegrated systems are location shifts, namely, breaks which change the underlying equilibrium means of the cointegration relationships. When such changes are not modeled, a cointegrated system converges back to its pre-break equilibrium – irrespective of where the post-break data are located – inducing systematic forecast failure: see Clements and Hendry (2002, 2006). Shifts in other parameters of a cointegrated system – when equilibrium means and growth rates are unchanged – are much less damaging to forecasts, and indeed may even be difficult to detect *ex post*: see Hendry (2000). *Ex post*, however, location shifts are relatively easily detected and modeled.

On the other hand, for *ex ante* forecasting, problems abound: predicting the precise timing, form, and magnitude of location shifts seems beyond the scope of present methods. Thus, we consider whether forecast performance can be improved by forecasting during a break, which either alters the parameters of the model in use, or is induced by changes elsewhere in the economy. As shown in Hendry (2006), the class of EqCMs includes most econometric systems without imposed unit roots (regressions, VARs, DSGEs, GARCH and special cases thereof), and they all share a range of generic properties, of which the crucial feature here is their convergence back to a pre-shift equilibrium. Consequently for clarity, we establish the behavior of any proposed solution in the simplest EqCM exemplar, rather than in a general cointegrated system. This serves to highlight the key aspect of each proposal, and guides the empirical modeling illustration.

When a break is not predicted, possible solutions to avoiding continued forecast failure include the well-known techniques of intercept corrections and differencing, both being 'robust' solutions to past unmodeled location shifts. These are considered below as benchmarks against which to judge improvements in forecasting during breaks. For the former, Hendry and Santos (2005) consider 'setting the model on track' at the forecast origin, while Reade (2007) investigates smoothing recent corrections, in both cases for a step shift. Here, we examine their behavior during an evolving break. For the latter, Hendry (2006) proposes an explanation for the forecasting success of so called 'naive' devices, such as differencing, and also derives a hybrid that transforms a vector EqCM to robustify forecasts against past breaks, while

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doi:10.1016/j.jeconom.2010.03.004

retaining the causal information embodied in the cointegration relationships. That approach is investigated here for an evolving break, since it performs well even in the absence of knowledge of the causes of the break when applied to forecast UK M1 after 1984, which is the illustration we use throughout.

While both these 'corrections' can improve dramatically over simply maintaining the system estimated prior to the break, and retain the causal information embodied in the equilibrium-correction terms – of importance in any policy context – neither is optimal: both double the forecast-error variances as a trade-off against reductions in biases. Moreover, little is also known about updating as the time after a break increases. Thus, this paper also considers potential improvements in forecasting during location shifts by estimating the impacts of breaks during their progress. Even if the initial onset of a break is not forecast, since the final effect will generally differ from its impact in dynamic processes, methods for estimating the outcomes of breaks during their progress may still prove valuable. In particular, by modeling the break process, its future progress can be anticipated, which we show could improve forecasts. Doing so requires a modified forecasting model which embodies an 'auxiliary' device to forecast the progress of the break, such that the resulting forecasts are usefully accurate and their forecast-error uncertainty is accurately measured: the type of approach in (e.g.) Pesaran et al. (2006) offers possibilities for the latter, and is not considered here. These are demanding requirements because of the very changes inherently induced by location shifts in equilibria, which thereby automatically alter the pre-break collinearity structure. This can lead to a marked and unavoidable increase in uncertainty with an adverse impact on mean square forecast errors (MSFEs), despite the increased information which results from the break. Such an impact turns out to be unavoidable, so for example, deleting collinear variables does not help unless they are in fact essentially irrelevant: see Clements and Hendry (2005). Nevertheless, Section 3 establishes that rapid information updates at the forecast origin can dramatically reduce the forecast uncertainty deriving from changed collinearities.

The structure of the paper is as follows. Section 2 reviews the forecast failure resulting from location shifts in a cointegrated or equilibrium-correction system using UK M1 as an example, following the Banking Act of 1984, which legalized interest-bearing sight deposits, and hence radically shifted the opportunity costs of holding money, altering demand relative to the prevailing information. Section 3 investigates forecast accuracy following an 'external break' that alters collinearity but leaves the forecasting model unchanged, and demonstrates the advantages of updating parameter estimates in that setting. Section 4 analyzes the relative performance of various forecasting devices during an internal break, including intercept corrections, differencing and estimating a break-adjustment function in a simple setting relevant to the empirical illustration in Section 5. Section 5 investigates forecasting during a break for a model of UK M1, and contrasts the 'agnostic' modeling of the break effects with the learning function approach in Baba et al. (1992) and Hendry and Ericsson (1991) which uses economic theory to constrain the effect through the shift in opportunity costs of holding money. Section 6 concludes.

2. Forecast failure in a cointegrated system

Location shifts – changes in equilibrium means – are the most pernicious form of breaks for cointegrated systems as they induce non-stationarity and systematic forecast failure. The theory behind this claim is established in Clements and Hendry (1998, 2006), and confirmed by their taxonomies of forecast errors. In practice, forecast failure remains common – and systematic – as Fig. 1 illustrates for a model of UK M1 estimated pre-1984: this failure will be the focus of the empirical illustration in Section 5.

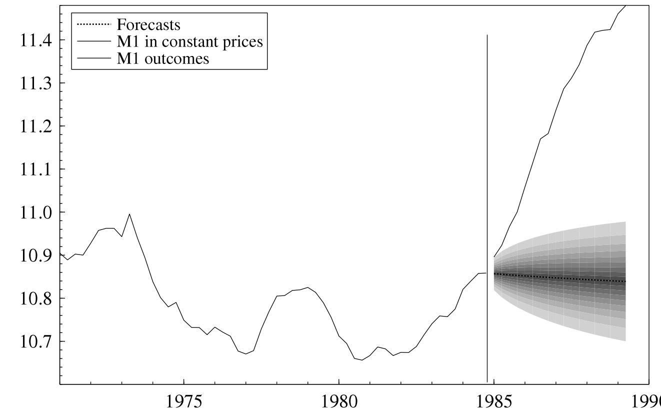

Fig. 1. Outcomes for M1 with 95% forecast interval fans.

The sample of quarterly observations is over 1964(3) to 1989(2), for the following series[1]:

M	Nominal M1
I	Real total final expenditure (TFE) at 1985 prices
P	The TFE deflator
R_{LA}	The three-month local authority interest rate
R_S	The interest rate on sight bank deposits.

The main reason for the drastic failure seen in Fig. 1 is a shift in the equilibrium mean relative to its in-sample value. When that shift is not modeled, the estimated feedback coefficient converges on zero as the estimation sample grows, which allows better tracking of the changing data at the loss of cointegration: see e.g., Perron (1989) and Hendry and Neale (1991). Fig. 2 reports recursive estimates of the associated feedback coefficient for the cointegrating relation $m - p = i - 8.7\Delta p - 6.6R_{LA}$ (lower case denotes logs).[2] As can be seen, the intercept (which measures the growth rate of real money in a differenced relation), falls towards 0.007 (panel a), the estimated feedback coefficient ($\widehat{\alpha}_1$) converges on zero (b), the 1-step ahead forecast errors lie outside the pre-existing 95% forecast interval (c), and the sequence of forecast Chow (1964) tests increasingly strongly rejects (d). The bottom row panels show the improvement in 'tracking' from full sample estimation (*ex post*, panel e), where $\widetilde{\alpha}_1 = -0.05\ (0.01)$ as against *ex ante*, where $\widehat{\alpha}_1 = -0.10\ (0.008)$ (panel f).

Fig. 3 shows how an unmodeled break affects the cointegrating vectors. Both panels show the coefficient on the interest rate R_{LA}, in the long-run money demand vector on the left, and the long-run output vector on the right, when estimated recursively after the break. If the model is left unadjusted, then the impact of the equilibrium-mean shift manifests in the interest rate coefficient in the money demand vector. This tries to adjust to compensate for a fall in the opportunity cost of holding money – which was hitherto measured by R_{LA} – even though, in reality, the slope parameters in the cointegrating relationship have not changed.

Since other (mean-zero) breaks are of less relevance for forecast failure, the crucial information needed to avoid systematic forecast failure in cointegrated systems is to forecast location shifts. As this is currently infeasible in general, one might attempt to forecast their ongoing effects after such shifts occur, as is the

[1] The data terminate in 1989(2) as the conversion to a bank by a major building society (the Abbey National) radically altered M1, when its retail sight deposits became part of M1.

[2] All estimation is conducted using Oxmetrics: see Doornik and Hendry (2006).