ASSET PRICES AND MACROECONOMIC FUNDAMENTALS IN THE EURO AREA*

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1. INTRODUCTION

This study puts forward a new methodology for constructing indicators of asset price misalignments based on macroeconomic fundamentals. The basic hypothesis is that asset prices have a long run relation with macroeconomic fundamentals, namely with economic activity and interest rates. Generally, asset prices close to the levels implied by such long-run relation may be considered to be “fair” or normal levels. Large deviations from the levels implied by the fundamentals could be a sign of over or under valuation.

In the literature, several benchmarks for assessing asset price valuations have been proposed. Such indicators are useful as it is generally thought that it is undesirable that asset prices deviate too much from the levels implied by fundamentals. In particular, the development of speculative bubbles in asset prices that may later burst is a concern from the point of view of macroeconomic and financial stability. Thus, while recognising that it is difficult to determine the fundamental or “normal” value of an asset, there is a need for such benchmark indicators. This is reflected in the number of reference indicators that are commonly used with this aim, such as historical patterns of price-earnings, dividend yields, methods based on discounted cash flows, etc. (for a recent overview of this literature see Gürkaynak, 2005).

In a recent study of 18 OECD countries, Detken and Smets (2004) use a methodology based on deviations from a long-run trend for detecting periods of over or undervaluation in asset prices. More precisely, periods of overvaluation correspond to periods where a real composite index of asset prices (including house prices and equity prices) is continuously more than 10% above its long-run trend, which represents its fundamental value(1). Implicit in this definition of periods of overvaluation is the notion of the quantiles of the conditional distribution of the asset prices. In fact, implicit in such definition is an assessment of the likelihood of such occurrences. Periods of excessive valuation should correspond to extreme cases. In the method of Detken and Smets implies a price level 10% or more above the trend. However, this assessment is not quantified in probabilistic terms.

This article presents the results of a new methodology for detecting asset price misalignments using non-parametric quantile regressions which can complement other methods, such as the one of Detken and Smets. With our approach the whole conditional distribution of asset prices is estimated which makes it possible to assess with higher precision whether the periods identified by other methods correspond to situations of excessive valuation or not. With the estimates of the quantile approach it is also possible to analyse the evolution of dispersion and asymmetry of the distribution of share prices over time. One advantage of the method is that macroeconomic fundamentals can be taken into account in the analysis.

The quantile approach can also be useful for computing Value at Risk (VaR) measures of assets as a function of macroeconomic variables, finan-

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(1) The trend is computed recursively using a Hodrick-Prescott filter.
cial variables or risk indicators. Recent examples of this approach are given by Engle and Manganelli (1999) and Chernozhukov and Umantsev (2001). As in the current article, the basic idea is that the VaR should be measured conditionally. For example, at times of economic slowdown, it is more likely that firms make losses than in expansions. Therefore, VaR, measured as the maximum loss expected for a given asset and for a given probability, should rise in recessions and decline in expansions.

In this article, the quantile methodology is illustrated by an application to the euro area equity prices. The method consists in estimating the distribution of share prices, in real terms, conditional on its fundamental determinants. It can be shown that changes in the fundamental determinants alter not only the location of the conditional distribution of equity prices but also its shape. Periods of over or undervaluation correspond to values in the tails of the distribution.

The remainder of the article is organised as follows. Section 2 presents the main features of the quantile regression approach used. Section 3 presents the empirical results for the estimation of different specifications of the conditional distribution of equity prices in the euro area (EMU price Index). Section 4 presents the main conclusions.

2. METHODOLOGY

The methodology is based on the estimation of the probability distribution of real asset prices conditional on the macroeconomic fundamentals. The basic hypothesis is that the probability distribution of asset prices is not constant over time but changes as a function of the macroeconomic environment. Thus, a given asset price may be considered to be too high, “normal” or excessively low depending on the concurrent macroeconomic conditions.

In order to illustrate how quantile regressions can be helpful for detecting periods of abnormal returns, Chart 1 shows the effect of a rise in potential GDP on the conditional distribution of the real stock prices represented by a box and whiskers chart. All other things constant, a rise in real GDP is expected to lead to an upward movement in the conditional distribution of real stock prices. As shown in the chart, this implies that if a particular real stock price level would fall in the region of “too low” or “too high” stock prices in the previous period, it may now be considered as normal, given the more benign macroeconomic conditions. For instance, in period 0 and given a level of potential real GDP ($y_0$), the real stock price $p_1$ can be considered as being excessively high. However, with a higher level of real GDP growth ($y_1$) in period 1, the same real stock price can be considered as being within normal levels given the improvement in fundamentals. In turn, price $p_2$, which at the level of potential output $y_0$ could be considered as normal, is considered to be excessively low when potential output increases to $y_1$.

The quantile regression approach consists in estimating each quantile of the distribution as a function of economic variables such as real potential GDP. In the case of this study, we aim at estimating a function $g_p$ of a vector of conditioning variables $X$ corresponding to the quantile $p$ (a value between 0 and 1), such that:

$$P(p_t \leq g_p(x)|X_t = x) = p$$

Where $p_t$ is a share price index in real terms. Thus, once the value assumed by the variables $X_t$ is known, the quantile regression provides an estimate of the corresponding $p$th quantile of the distribution of the real share price index. For instance, if $p=0.5$ then the quantile regression provides a representation of how the median share
price changes as a function of the macroeconomic background. Repeating this estimation for various values of p between 0 and 1 it is possible to characterise the whole conditional distribution of share prices. Lastly, with such estimate it is possible to assess, in probabilistic terms, a given level of share prices. For example, if on a given moment the real share price index is above the estimate of the 90% quantile (given by \( g_{0.9}(x) \)), then, with high likelihood, such value represents an overvaluation given that the probability of the real share price being above such value, taking the macroeconomic situation into account, is smaller than 10%.

There are several possible specifications for the quantile function. In this study we have opted for non-parametric specifications based on the approaches proposed by Koenker et al. (1994), He and Ng (1999) and Koenker and Mizera (2003). The methods were implemented using the statistical software R(2).

As for the conditioning variables, two possibilities were considered. In a first case, a time index was chosen as the only conditioning variable. This approach is close to the one of Detken and Smets (2004). In a second estimation the conditioning variables are economic activity and the real interest rate.

3. APPLICATION TO THE EURO AREA REAL SHARE PRICE INDEX

3.1. Data used

The data on stock prices used corresponds to the EMU Price Index taken from Datastream and expressed in euros. As for the fundamental variables, the real GDP series (as well as the nominal GDP data used for the calculation of the GDP deflator) is constructed by aggregating logarithms of seasonally adjusted national accounts data (ESA95 whenever available). Potential real GDP has been obtained by applying the HP filter to quarterly real GDP data and setting the parameter equal to 1600. The short-term interest rate corresponds to a weighted average of euro-11 (euro-12 from January 2001) short-term interest rates. The weights correspond to 2001 GDP weights at Purchasing Power Parity exchange rates. Up to the end of 1999, national interest rate series are obtained from the Bank for International Settlements. After 1999, the short-term interest rate corresponds to the three-month EURIBOR (from Reuters). The real interest rate is obtained by subtracting the annualised month-on-month inflation rate from the nominal rate. Similar to GDP, the real interest rate is also smoothed with the HP filter. The data cover the period from December 1980 to December 2003(3).

3.2. Conditioning on a time index

The simplest choice for the conditioning variable of the distribution of real asset prices is a time index. This model is estimated using the COBS (Constrained B-splines Smoothing) algorithm (He and Ng, 1999; Ng, 2005). The method can be seen as analogous to an HP filter, as it aims at smoothing the fluctuations of the real stock price index around a time index. In order to avoid that the smoothed real stock price index would follow too closely the actual stock price index, we imposed the restriction that the real stock price is non-decreasing with time. This does not seem to be an excessively restrictive restriction given that, theoretically, the real stock price index should rise over time in expanding economies.

Chart 2 shows the real stock price index and the several deciles of the estimated conditional distribution. The darkest line represents the median while the several inter-decile intervals are shown as grey areas that become lighter with the distance from the median. The lower limit of the band is given by the first decile (i.e. the probability of the real share price index being lower than that limit in each period is 10%) while the upper limit is given by the 9th decile.

As can be seen in the chart, there is clear evidence that the conditional distribution of real stock prices varies over time. For instance, the distribution is narrower until 1997, becoming wider at the end of the sample. According to the results,


(3) The quarterly data on real GDP and the GDP deflator were converted into monthly data using a cubic interpolation.
at the end of the sample relatively pronounced fluctuations in the share prices around the median could be considered as being within normal bands.

The chart also shows the results of using a methodology similar to the one of Detken and Smets (2004) consisting in applying a Hodrick-Prescott filter to the time series of real stock prices, applying a high value to the smoothing coefficient ($\lambda=1000$) and multiplying the result by a factor of 1.1. This variable is chosen as the reference for identifying periods of overvaluation of asset prices (i.e. periods when the real stock price index is continuously more than 10% above its trend). Assessing the results of the HP filter in the light of the quantile approach it can be concluded that in some periods the measure based on the HP trend is too restrictive regarding the definition of the overvaluation periods. In fact, in some periods the HP trend is significantly above the 90% quantile thereby attributing a very low probability to the occurrence of an overvaluation. In other periods, the HP trend is lower than the median of the conditional distribution, consequently implying a too low threshold for defining the periods of excessively high share prices.

3.3. Conditioning on macroeconomic variables

In the literature, several authors have found evidence that the distribution of stock returns changes with the business cycle. For instance, Schwert (1989) and Hamilton and Lin (1996) find that the volatility of stock returns increases during recessions and decreases in periods of strong economic expansion. More recently, Péres-Quirós and Timmerman (2001) show that stock returns vary with the business cycle in the United States.

Given these results, in this second specification the vector $X_t$ includes a measure of potential GDP and the real short-term interest rate. A rise in potential GDP is expected to lead to an upward movement in the conditional distribution of the real stock price index while a rise in the short-run real interest rate should lead to a downward movement of the conditional distribution.

The estimation method used corresponds to the approach of Koenker and Mizera (2003) based on penalized triograms\(^4\). A previous analysis has shown that GDP should be introduced with a lag of two months while the trend real interest rate is lagged one month. These lags can be justified on the basis of information delays in the dissemination of the relevant macroeconomic information.

The results are shown in Chart 3. According to the results, changes in potential GDP and in the real short-term interest rate alter the shape of the conditional distribution of the real stock price index. The distribution narrows significantly during the period from 1991 to 1993, a period of slow growth (at times negative) and high real interest rates. After this period, the conditional distribution of equity prices continued to move upwards (reflecting the rising trend of potential GDP and the decline of the real interest rate) and at the same time became wider. Thus, recently, the range over which the real stock price index can be considered as in line with the macroeconomic fundamentals is wider than in the past.

The periods when the real stock price index moves beyond the limits given by the first and ninth deciles can be interpreted as periods of excessive deviation from “reasonable” levels given

\[^4\text{The value of the smoothing parameter was set to 3.5 and no other restrictions were imposed as to the relation between the variables.}\]
the macroeconomic fundamentals\((5)\). Given these definitions, two clear asset price overvaluation periods and two periods of undervaluation can be identified. The first period of undervaluation occurred at the beginning of the eighties. Afterwards, the period before the 1987 stock market crash is, according to the method, considered as one of excessive valuation of stock prices\((6)\). The second episode of overvaluation occurs in the year 2000, following a long period of rising real stock prices. Afterwards, there seemed to be a downward correction leading to an undervaluation episode at the end of 2002/beginning of 2003. More recently, stock prices have continued to rise. However, according to more recent estimates of the conditional distribution of the stock price index there is no evidence of an overvaluation of share prices. In fact, estimates with a more recent sample confirm that the real stock price index moved towards the central deciles of the conditional distribution. Thus, the real share price in the euro area in the more recent months is at a level that can be considered as consistent with a normal pattern given the macroeconomic fundamentals.

Charts 4 and 5 show the periods of over and undervaluation using the first and ninth deciles as a criterion for defining the interval over which real stock price levels can be justified by fundamentals. The charts show the periods when the real stock price index moves outside these limits.

As can be seen in the charts, there seems to be a tendency for periods of over or undervaluation to be concentrated in time. In addition, and contrary to the methods based only on the level of the real stock price index, the periods of strong increases in stock prices do not necessarily correspond to

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\(5\) Even though there is some arbitrariness in this choice of quantiles, the option of basing the identification of asset price misalignments on extreme quantiles of the distribution allows a greater degree of confidence in the identification of such periods.

\(6\) Note that during this period the real stock price remained relatively constant which, based only on this observation, would not necessarily be interpreted as a period of excessive valuation. However, when the macroeconomic fundamentals are taken into account, the overvaluation becomes clear. It should also be noted that the correction implied that the index moved towards the median of the distribution.
overvaluation periods. For instance, during the period from 1984 and up to mid-1986, the strong rise in the real stock price index appeared to be justified by the macroeconomic fundamentals. Another example is given by the stock market movements in 1987. According to the method, the stock market crash in 1987 was not a period of undervaluation. In fact, during the year before the crash, the real stock price index is frequently above the 9th decile or within the range defined by the eight and ninth deciles (see Chart 3). A possible interpretation of these results is that the 1987 stock market crash was a correction that led to real stock prices more in line with the macroeconomic fundamentals. It is also possible to identify periods when the real stock price index remained relatively constant but, given the economic conditions, could be considered as periods of excessive valuation (as in 1989-1990). Finally, according to the method, there is a period of overvaluation in 2000 but only after a prolonged upward period of real stock prices. In fact, the period from 1997 to 2000 is frequently characterised as one of overvaluation (see Bordo and Wheelock, 2004). After 2000, there is a correction, with the index declining to levels consistent with an excessive undervaluation in 2003. After 2003, the real stock price index evolved towards the median of the conditional distribution of share prices.

4. CONCLUSIONS

The development of speculative bubbles in asset prices that may later burst is a concern from the point of view of macroeconomic and financial stability. Thus, it seems useful to have indicators of asset price misalignments.

This article shows the results of a new methodology for detecting periods of over and undervaluation of asset prices. The basic assumption is that the probabilistic distribution of asset prices is not constant over time but changes as a function of the macroeconomic situation. Thus, a given asset price can be considered as being too high, “normal” or excessively low depending on the macroeconomic conditions.

An application to the euro area provides some interesting conclusions. In particular, contrary to the methods based only on the level of the real stock price index, periods of strong increases in real stock prices do not necessarily correspond to periods of excessive valuation.

REFERENCES


