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Jakob Lage Hansen

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What drives financial markets? Real-time macroeconomic indicators

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What drives financial markets?
Real-time macroeconomic indicators[1]

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[1] **Useful comments from colleagues at Danmarks Nationalbank are gratefully acknowledged. All remaining errors are mine.** **Contact information: jakoblage@hotmail.com.**

Resumé

Det er vanskeligt at identificere drivkræfterne på de finansielle markeder, da de ikke kan observeres direkte. Papiret argumenterer for, at korrelationerne mellem forskellige finansielle markeder kan anvendes til at udlede hvilke(n) af fem makroøkonomiske faktorer, der driver markederne (vækst og inflation i henholdsvis EU og USA, samt global risikoappetit). Modellen bygger på standard finansieringsteori, men de resulterende indikatorer er nye. Indikatorerne er nyttige, da de er objektive, konsistente, baseret på den faktiske markedsudvikling, kvantitative, samt tilgængelige i real-tid. Den faktiske udvikling i indikatorerne består også et ”kvalitetstjek”.

Abstract

It is difficult to identify the driving forces behind financial market developments as they are not directly observable. The paper argues that correlations between asset prices in different markets can be used to infer which of five macroeconomic factors that drive markets (growth and inflation in the euro area and the US respectively and global risk appetite). The asset pricing in the model follows standard finance theory, but the resulting indicators are novel. The indicators are useful as they are objective, consistent, based on actual market developments, quantitative and available in real-time. The history of the indicators also passes a “reality check”.

1. Introduction and summary

Market commentaries contain many different explanations for developments in financial markets over a given period. These typically give a diffuse picture and often provide stories that are both inconsistent with each other and actual market developments. This probably reflects that it is not directly observable which factors that drives financial markets and that it is ambiguous what the driving force is if it has to be inferred from developments in one single market. For instance, if bond yields rise, it is not apparent whether this is due to rising expectations of growth, rising expectations of inflation, or a rise in risk appetite. The present analysis suggests that it can be inferred from the correlations between asset prices which macroeconomic factors that drive financial markets. For instance, if equity prices fall while yields rise, it indicates that rising inflation expectations is the macroeconomic driver.

The paper quantifies which of five macroeconomic drivers that dominate financial market developments. The five drivers are the expected growth in the euro area and the US, expected inflation in the euro area and the US, and global risk appetite. The analysis could relatively easily be extended to other regions, but focusing on two regions (arguably the two most influential regions in the financial markets at the moment) has the advantage of greater simplicity.

The result of the present analysis are financial market drivers that are *objective* (given the model), based on *actual market developments* in several markets, *consistent* across time, *quantitative,* calculable at *any frequency* and available in *real-time*. The proposed indicators of macroeconomic drivers are therefore useful in the ongoing analysis of financial market developments. The general ideas forwarded can also be used qualitatively when assessing, for instance, market reactions to an economic release. To my knowledge such indicators have not been developed before.

To be able to deduce the expected reaction of financial asset prices to changes in each of the macroeconomic factors a model for the pricing of financial assets is introduced. This model uses standard finance theory. I.e. monetary policy is assumed to follow a traditional Taylor rule, while longer maturity bonds are priced following the expectation hypothesis augmented with term premiums. Stock prices reflect the expected discounted value of dividends. The exchange rate behaves in accordance with the uncovered interest rate parity while the gold price is assumed to react to changes in risk appetite.

Based on this model it can be inferred that higher expected growth in the euro area (US) causes euro area (US) yields to rise, euro area (US) stock prices to rise and the exchange rate, which is dollar pr. euro, to rise (fall). On the other hand, higher expected inflation in the euro area (US) causes euro area (US) yields to rise, euro area (US) stock prices to fall and the exchange rate to rise (fall). Lastly, lower risk appetite leads yields in both regions to fall, stock prices in both regions to fall and the gold price to rise.

If a given macroeconomic factor drives financial markets in a given period it therefore leads to a number of expected correlations between the mentioned assets. These *observable* correlations can then be used to infer what (unobservable) macroeconomic factor(s) that drive(s) the markets. For instance, if there is a positive correlation between euro area stock prices and euro area yields, a positive correlation between euro area yields and the exchange rate and a positive correlation between euro area stock prices and the exchange rate it indicates, that euro area growth is driving the markets. Hence, the indicator for euro area growth is calculated based on the value of these three correlations. If the three correlations are high the indicator has a high value.

When the proposed indicators are calculated back in time they show that inflation in both the euro area and the US was the primary driving forces of financial markets in the 1990s, while the new millennium has seen growth taking over as the primary driver. This is consistent with inflation expectations only recently becoming anchored and the large revisions in growth prospects that have taken place from 2000. According to the indicators US growth has dominated euro area growth in the last five years arguably confirming the recent focus among market participants on the US. The drivers also show that risk appetite was a primary driver in connection with various shocks to the market and that it has been important since 2001. Looking closer at 2006 the drivers also give a credible picture of financial market developments. All in all the indicators seem to pass an informal “reality check”.

The simple model used to deduce the drivers rest on two important assumptions – that causality only runs from the macroeconomic factors to the financial markets and that the five macroeconomic factors are the only factors influencing the markets. The last part of the analysis claims that including feed-back from the financial markets to the macro economy does not alter the interpretation of the drivers. However, introducing other factors that affect financial asset prices in a systematic way can lead to positive values of the proposed indicators. I.e. a positive value of one of the indicators of inflation can be due to shocks to the bond markets, which could arise due to demand or supply effects or from changing rhetoric from the central bank. Also, a positive value of the indicator for economic growth can arise from shocks to the stock markets driving markets broadly. However, these considerations are supplements to the central analysis and do in no way invalidate the proposed indicators.

The paper is organized as follows: Section 2 mentions related literature. Section 3 lays out the model of asset prices and their relation to the macroeconomic factors.

Based on this model, section 4 explains the expected correlations between asset prices given developments in each of the macroeconomic drivers. These considerations lead to quantifiably drivers. Section 5 discusses various issues in connection with the calculation of the drivers, looks at past developments in the financial market drivers and describes their use. Section 6 relaxes some of the initial assumptions of the model and explores the implications. Finally, section 7 concludes.

2. Related litterature

To my knowledge there has been no other work that is directly related to the present analysis. However, there are some areas of research that cover similar subjects.

Several studies with both theoretical and empirical focus have explored the correlation between financial asset prices as these are essential for evaluating the risk of a portfolio of assets. For instance, Dimson, Marsh and Staunton (2002) examined the correlations between financial markets and countries from 1900 to 2000 and find considerable variation across time in the correlations between financial markets. That correlations vary across time is a premise for this analysis. Many papers have linked changes in correlations to developments in macro economic variables. For instance, Li (2002), Ilmanen (2003) and Connolly, Stivers and Sun (2004) examine stock-bond correlations and relate these to factors that are similar to the ones proposed in this paper.

A related strand of literature uses high-frequency data to explore the reaction in financial markets to news releases. For instance, Andersen, Bollerslev, Diebold and Vega (2005) study the reactions in a number of financial markets to macroeconomic news releases in the US. Recently reactions to news releases in the euro area have been examined by Anderson, Hansen and Sebestyén (2006). In the spirit of this analysis these studies show that different price developments is seen depending on which type of macroeconomic data is released.

However, no studies have to my knowledge “turned things around” and used the correlations between asset prices to systematically infer which macro economic factors that drive markets. Previous work in this spirit covering the stock-bond correlation was done in Hansen (2005). The present analysis is broadened to more assets (currencies and gold) and more than one region. Also, this analysis differs by proposing quantifiable indicators.

Another related area of research has produced real-time indicators of the US macro economy, for instance Evans (2005) and Giannone, Reichlin and Small (2005). These aim to describe the present state of the macro economy by continually using new public information. By being real-time and macro oriented these studies resemble the present analysis. However, my focus is on what macroeconomic factors drive financial markets, not how the macro economy is doing. It seems natural that the components of the macro economy that are more volatile in a given period dominate the pricing of financial assets in that period. However, this needs not always be the case as we live in a world of imperfect information where (1) market participants form a subjective opinion on the state of the macro economy, (2) their focus can change regardless of how the actual macro economy is doing and, crucially, (3) financial asset prices reflect expectations of the *future* macroeconomic environment (although the present is arguably given a disproportionately large share of the attention). Another difference is that the mentioned studies infer the state of the macro economy from economic announcements while I infer which macroeconomic factors drive financial markets from correlations between asset prices. Lastly, I consider the euro area as well as the US.

In financial markets there are instruments available that allow extraction of some of the same information that the indicators developed in this paper do. Inflation-linked bonds can be used to infer changes in the real interest rate of bonds, which can be interpreted as representing changes in expected real activity. Deducting the real rate from a nominal bond with the same maturity leads to the so-called break-even inflation, and changes in this can be interpreted as changes in expected inflation over the given horizon. And changes in the implied volatility of options can be used to infer changes in risk appetite in the markets. These measures are, however, subject to various inaccuracies – as are the indicators derived in this paper. Therefore the two approaches are good supplements to each other.

3. The pricing of financial assets

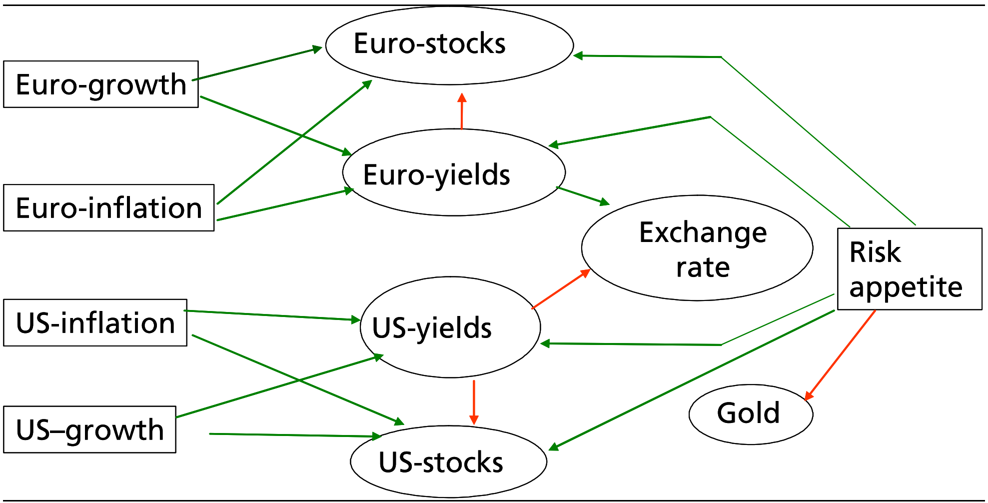
The model assumes that only the five macroeconomic drivers affect the pricing of financial market assets and that the causality only runs from the five drivers to the financial markets. In other words, the five macroeconomic drivers are exogenous, there are no other exogenous variables, and the prices of financial assets are endogenous. This makes it possible to conduct a stringent analysis. However, the assumptions are relaxed in section 6, where the resulting implications are explored.

The five macroeconomic drivers are expected (real) growth[1] in the euro area and the US, expected inflation in the euro area and the US, and risk appetite. Risk appetite falls if either the macroeconomic uncertainty rises or risk aversion rises. The former increases the level of risk while the later increases the compensation that investors demand for bearing a given level of risk (see Gai and Vause (2006) for further details on these concepts). The five macroeconomic drivers can be

[1] Throughout, growth will refer to real growth. When the reference is to nominal growth this will be made explicit.

viewed as aggregate drivers resulting from the actions of many heterogeneous market participants that have different information sets. The causal relationships of the model are illustrated in chart 1 and explained in the following.

CAUSAL RELATIONS IN THE MODEL Chart 1



Note: Boxes indicate (unobservable) macroeconomic driver, while circle indicates (observable) asset price. Arrows indicate causal relationships – green is a positive relationship, while red is a negative relationship.

3.1. Bond yields

It is assumed that monetary policy follows a Taylor rule, cf. Taylor (1993):

$$i_{0,1} = 1{,}5\left(\pi_0 - \overline{\pi}\right) + 0{,}5\left(y_0 - \overline{y}\right) + \overline{\pi} + \overline{y} \quad (1)$$

where $i_{0,1}$ is the one-year rate at time 0 (to ease exposition the one-year rate, and not the short-term money-market rate, is used directly), π_0 is yearly inflation at time 0, $\overline{\pi}$ is the inflation target, y_0 is real growth at time 0 and $\overline{y}$ is trend growth. The rule dictates that policy-rates are raised by more then one percentage point if inflation increases one percentage point, while being raised by less than one percentage point if growth increases by one percentage point. If inflation is at the target level and growth is at trend, the real rate equals the trend growth rate. It is common in the literature to describe central bank behaviour by a Taylor rule and studies have shown that the actual behaviour of both the Fed (Taylor 1999) and the Bundesbank (Clarida, Galí and Gertler 1998) have been in accordance with variants of the rule stated in (1).

According to the widely used expectation hypothesis longer maturity government bond yields reflect the average expected future short term yield over the relevant horizon:

$$\left(1 + i_{0,n}\right)^n = E\left[\left(1 + i_{0,1} + tp_{0,n}\right)\left(1 + i_{1,1} + tp_{0,n}\right)\ldots\left(1 + i_{n-1,1} + tp_{0,n}\right)\right] \quad (2)$$

where $i_{t,n}$ is the yield at time *t* of a bond with time-to-maturity of *n* years, *E* denotes expectation and $tp_{t,n}$ is the term premium at time *t* of a bond with time-to-maturity of *n* years. In contrast to the pure expectation hypothesis equation (2) includes a term premium to reflect that longer maturity bonds generally are viewed as more risky than shorter maturity bonds (for an explanation, see Andersen and Hansen 2006). Also, the term premium is time-varying to reflect the empirical fact that this is the case (Best, Byrne and Ilmanen 1998), and as it is important for the model.

The result is that higher expected growth or higher expected inflation increases expected short yields, cf. (1), which in turn increases longer maturity yields, cf. (2). Also, lower risk appetite is assumed to impact bond yields negatively due to "flight-to-quality" effects that increases the demand for bonds. In (2) term premiums fall resulting in lower longer maturity yields for a given expectation of future short-term yields. In other words, in these periods tendency for term premiums to fall due to “flight-to-quality” demand effects arising from investors fleeing more risky assets (such as stocks) are assumed to dominate the tendency for term premiums to rise due to the lower risk appetite. The results in Hansen (2006) support that longer maturity yields do fall when risk appetite decreases.

3.2. Stock prices

Stock prices give the right to the expected future stream of dividends. As is standard in the literature stock prices are assumed to reflect the discounted value of expected future dividends, i.e.

$$S_0 = E\left[\sum_{t=1}^{\infty} \frac{D_t}{(1+i_{0,1}+erp_0)(1+i_{1,1}+erp_0)...(1+i_{t-1,1}+erp_0)}\right] \quad (3)$$

where S_0 is the stock price at time 0, E denotes expectation, D_t is the dividend at time t, $i_{t,1}$ is the one-year yield at time t, and erp_0 is the risk premium demanded at time 0 for holding the more risky stock. Contrary to other studies the interest rate is not assumed to be constant as this is not the empirical case and its variance is important for the model. Also, the risk premium is assumed to be time-dependent as this is an empirical fact (Dimson, Marsh and Staunton 2002) and important for the model. Expected dividends are assumed to vary one-to-one with expected earnings – that is, companies are assumed to pass on a fixed share of earnings to shareholders. The model uses broad stock market indices – hence equation (3) can be seen as being an average over companies in the economy. Reflecting this fact, changes in earnings are assumed to vary one-to-one with expected nominal GDP growth. Tying growth in dividends to GDP-growth is common in the literature.

The result is that higher expected inflation or higher expected growth impacts stock prices positively through higher expected dividends. On the other hand, an expectation of higher interest rates impact stock prices negatively by increasing the discount factor. Also, lower risk appetite will increase the risk premium demanded and thus impacts stock prices negatively.

3.3. Exchange rate

The exchange rate (dollars pr. euro) is assumed to adhere to the uncovered interest rate parity (UIP) for a given horizon *n* (the maturity if yields used in the calculations):

$$i_{0,n}^{euro} = i_{0,n}^{US} - \frac{E(X_n) - X_0}{X_0} \Leftrightarrow X_o = \frac{E(X_n)}{1 + i_{0,n}^{US} - i_{0,n}^{euro}} \quad (4)$$

where $i_{t,n}^{x}$ is the yield at time *t* in region *x* of a bond with maturity *n*, *E* denotes expectation and X_n is the exchange rate at time *n*. According to UIP the expected return from investing in euro bonds and US bonds has to be the same. Thereby the euro bond yield is equal to the US bond yield minus the expected appreciation of the euro versus the dollar. It is assumed that the future expected exchange rate *n* years ahead is fixed. Thereby an increase in the euro yield relative to the US yield induces a euro appreciation (an increase in the exchange rate) so that the higher yield on the euro bond is countered by a lower expected return on the euro currency.

Although UIP is widely used in macroeconomic models it has fared poorly empirically when used to forecast exchange rates at short horizons. However, there are more promising results at longer horizons, c.f. the study of 5-year horizons in Chinn and Meredith (2004) and references therein. The maturities of the yields used in the present calculations are two years – and hence beyond the short horizons that have typically produced unconvincing empirical results. Also, in the present analysis the ability of UIP to *forecast* exchange rates is of small importance as it is the *spot* movement in the exchange rate that is in focus – i.e. the important assumption for the model is that an increase in the interest rate differential between the euro area and the US causes the exchange rate to rise.

Even if one does not accept the UIP (i.e. the causal relationship from the interest rate differential to the spot exchange rate), it is my experience that a positive macroeconomic release in the euro area tends to increase euro yields and the exchange rate, while a positive macroeconomic number from the US tends to increase US yields and reduce the exchange rate (and vice versa). It is this pattern that is crucial for the model below (and not the UIP per se).

3.4. Gold price

The price of gold is connected to both growth (as gold is used for productive purposes), inflation (as gold is a nominal asset), and risk appetite (as gold is viewed as a good store of value protecting returns when large shocks hit the markets). To simplify the analysis the gold price is assumed to be driven solely by safe-haven demand – that is, when risk appetite falls, the price of gold rises. That the gold price on average rises when risk appetite falls is confirmed by a statistically significant positive relationship between changes in the gold price and changes in a risk index introduced in Hansen (2006).

4. Indicators for the macroeconomic drivers

Based on the relationships laid out in section 3, the reaction in financial asset prices to changes in the five macroeconomic factors can be inferred. Hereby the expected correlation between asset prices can be deduced. Based on these expected correlations, indicators for macroeconomic drivers of financial market are constructed. The results of the following analysis are summed up in table 1.

MACROECONOMIC DRIVERS AND FINANCIAL ASSETS — Table 1

	Euro-area		US			
	Stocks	Yields	Stocks	Yields	Exchange rate	Gold
Euro-growth	↑	↑			↑	
US-growth			↑	↑	↓	
Euro-inflation	↓	↑			↑	
US-inflation			↓	↑	↓	
Risk appetite	↑	↑	↑	↑		↓

Notes: The table shows the expected development in financial assets when each of the five macroeconomic drivers rises. The exchange rate is dollars pr. euro.

Note that the drivers are based on correlations and thus do not contain information about the *direction* of market expectations. For instance, if the driver for euro growth has a high value it indicates that changes in the perception of euro area growth has dominated developments in financial markets, but it does not say whether growth expectations rose or fell or were merely volatile. To evaluate this, the movements in stock prices or yields over the period can be consulted – for instance, if these have risen, it indicates improved growth expectations.

4.1. Growth

4.1.1. Euro area growth

If the expected growth of the euro area increases bond yields rise due to an expectation of tighter monetary policy, cf. equation (1), which in turn pushed longer maturity yields upwards, cf. equation (2). The expected dividends also rise, cf. equation (3) and the discussion in section 3. The increase in bond yields decreases the expected discounted value of dividends, while the increase in expected dividends increases the expected discounted value of dividends, cf. equation (3). As monetary policy follows a traditional Taylor rule the policy rate increases less then one-to-one with growth, cf. equation (1), and hence yields increase “moderately”, cf. equation (2). Therefore the rise in expected dividends dominates the rise in the discount factor resulting in an increase in stock prices.

This proposition is proven formally in the appendix. As euro yields rise relative to US yields the exchange rate increases, cf. equation (4).

Hence, a number of correlations arise if changed expectations of euro area growth drive the markets: euro yields and euro stock prices correlate positively; euro yields and the exchange rate correlate positively; and euro area stock prices and the exchange rate correlate positively.

Based on these results, the following indicator measures to what degree euro area growth drives financial markets in a given period:

Euro-growth = 0.6 (EU-Y,EU-S) + 0.3 (EU-Y, EURUSD) + 0.1 (EU-S, EURUSD)

where (X,Y) is the correlation between series X and series Y in the given period, EU-Y is euro yields, EU-S is euro stock prices and EURUSD is the exchange rate (dollar pr. euro). If all three correlations behave as the model predicts when expectations of euro area growth drives the markets (that is, they are all 1), the indicator for euro growth has the value 1. The more the correlations differ from this scenario, the smaller is the indicator. If the indicator is below 0 it signals that euro area growth did not drive markets.

4.1.2. US growth

Similar considerations give rise to the following expected correlations, if changes in expected US growth drive the financial markets: US yields and US stock prices correlate positively; US yields and the exchange rate correlates negatively; and US stock prices and the exchange rate correlates negatively. This gives rise to the following indicator for US growth:

US-growth = 0.6 (US-Y,US-S) – 0.3 (US-Y, EURUSD) – 0.1 (US-S, EURUSD)

The difference to the euro-growth indicator is the use of US stock prices and US yields, and the opposite expected correlation between these and the exchange rate.

4.1.3. Additional considerations

Expected growth in the euro area and the US are interdependent. A part of euro area growth is based on exports to the US, while a part of the US growth is based on exports to the euro area. Hence, higher expected growth in the US can impact the expected growth in the euro area (and vice versa), and in this way drive stock and bond markets in both regions. This would lead to positive correlations between stock prices and yields in both regions, cf. the discussion above. As the upward revision in growth expectations "originates" in the US, the rise in US yields can be expected to be larger than the rise in euro yields. Therefore the exchange rate can be expected to fall. Under this scenario (where no other forces drive the markets) the US-growth indicator is 1 and the euro-growth indicator is 0.2 (as the EU-S/EU-

Y correlation is 1 while the EU-Y/EURUSD and EU-S/EURUSD correlations are -1). Generally, if growth is driving the markets in both regions, the indicators can be compared to judge where the growth originates or is strongest. If the sizes of the indicators are similar it indicates that growth revisions in both regions have a similar impact on markets.

4.2. Inflation

4.2.1. Euro area inflation

Higher expected inflation in the euro area causes market participants to expect tighter monetary policy, cf. equation (1), which in turn puts upwards pressure on longer maturity yields, cf. equation (2). As expected dividends vary one-to-one with expected *nominal* growth, expected dividends also rise. However, the discount factor in equation (3) dominates the increase in expected dividends due to yields rising more than one-to-one with expected inflation – a result of the central bank following a Taylor rule. Hence, stock prices fall when expected inflation rises. This is proved formally in the appendix. As euro yields rise, the euro appreciates causing the exchange rate to increase, cf. equation (4).

In other words, the following correlations result if changing expectations of euro area inflation drives the markets: a negative correlation between euro area yields and stock prices; a positive correlation between euro area yields and the exchange rate; and a negative correlation between euro area stock prices and the exchange rate.

This leads to the following indicator measuring to what degree euro area inflation drives financial markets:

Euro-inflation = - 0.6 (EU-Y,EU-S) + 0.3 (EU-Y, EURUSD) - 0.1 (EU-S, EURUSD)

4.2.2. US inflation

An analogue analysis of the US leads to the these correlations, if changes in expected US inflation drives financial markets: a negative correlation between US yields and stock prices; a negative correlation between US yields and the exchange rate; and a positive correlation between US stock prices and the exchange rate.

Therefore an indicator measuring to what degree US inflation drives financial markets is:

US-inflation = - 0.6 (US-Y,US-S) – 0.3 (US-Y, EURUSD) + 0.1 (US-S, EURUSD)

4.2.3. Additional remarks

Expected inflation in the euro area and the US depend to some extend depend on common factors such as increases in commodity prices. If such common factors affect inflation in both regions, and this in turn drives markets in both regions, the yield-stock correlation in both regions becomes -1, while the various correlations involving the exchange rate are pushed to 0. Hence the two inflation indicators take on the same value of 0.6. If the reaction is different in the two regions, the size of the two indicators can be compared to asses where the impact has been higher (as this will show up in the correlations with the exchange rate).

Also, common factors can change both expected growth and expected inflation in either of the regions, as higher growth typically lead to higher inflation with a lag due to a tighter labour market creating wage and price pressure. This interdependence is ignored in the explicit model. The relation between growth and inflation is not trivial and depends, among other things, on whether a shock to the economy is related to aggregate demand or supply. However, the model does not rule out that both growth and inflation in a region drives the markets and the drivers can be used to expose the strength of each. For instance, in periods where both expected growth and inflation in the euro area drive markets these indicators can be compared to understand which driver is strongest. If both drivers are of equal “strength” (and no other factors impact markets) the result is that the EU-S / EU-Y and the EU-S/EURUSD correlation both will be 0 (as the two drivers pull in opposite directions) while the EU-Y / EURUSD correlation will be 1 (as the two drivers pull in the same direction). Hence both the indicator for euro area growth and euro area inflation get the value 0.3.

4.3. Risk appetite

When risk appetite increases, investors generally buy more risky assets and sell less risky assets. This causes stock prices to rise, while gold and bond prices fall (leading to higher yields). The risk appetite is assumed to be global and hence stock and bond markets in the two regions are impacted in a similar fashion.

Hence, the following correlations can be expected if changes in risk appetite drive the financial markets: a negative correlation between gold and euro stock prices; a negative correlation between gold and US stock prices; a positive correlation between euro yields and euro stock prices; a positive correlation between US yields and US stock prices; a positive correlation between euro yields and US yields; and a positive correlation between euro stock prices and US stock prices.

These considerations lead to the following indicator measuring to what degree risk appetite drives financial markets:

Risk = - 0.3 (EU-S,Gold) - 0.3(US-S,Gold) + 0.1 (EU-Y,EU-S) + 0.1 (US-Y,US-S) + 0.1 (EU-S,US-S) + 0.1 (EU-Y,US-Y)

Table 2 sums up the weighted correlations of the five indicators of macroeconomic drivers.

INDICATORS FOR MACROECONOMIC DRIVERS Table 2

	-------------------------Correlations-------------------									
	EU-Y EU-S	EU-Y EURUSD	EU-S EURUSD	US-Y US-S	US-Y EURUSD	US-S EURUSD	EU-S US-S	EU-Y US-Y	EU-S Gold	US-S Gold
	-----------------------Weights -----------------------									
Euro-growth	0.6	0.3	0.1							
US-growth				0.6	-0.3	-0.1				
Euro-inflation	-0.6	0.3	-0.1							
US-inflation				-0.6	-0.3	0.1				
Risk appetite	0.1			0.1			0.1	0.1	0.3	0.3

Notes: The table shows the calculation of the five indicators of macroeconomic drivers of financial markets. Each indicator is calculated by weighing a number of correlations between asset prices. EU is euro area, Y is yield, S is stock price and EURUSD is dollar pr. euro.

4.4. A note on weightings of the correlations

The weighting of the correlations somewhat subjective but primarily reflects a wish to differentiate the indicator from each other. Therefore the correlation between stock prices and yields is given high weighting in the indicators for growth and inflation as this is the differentiating factor between the two, while the correlation between gold and stocks is given high weighting in the indicator for risk appetite to differentiate it from the indicators for growth.

Having said this, the weights could be derived by a more "objective" procedure – i.e. estimated such that the indicators on average in the past captured as much of the financial market volatility as possible. This is bound to be difficult, as the whole point of the indicators is that they capture information that is not available elsewhere. However, it might be possible under certain assumptions and clever econometrics, and it points to potentially fruitful future work.

5. Developments in the indicators

5.1. Calculation

The indicators can be calculated in different ways. The frequency of the observations and the number of observations included in the calculation of correlations is variable. The choice depends on the purpose. For ongoing analysis if the latest developments in financial markets, short frequency (such as daily or hourly) and a relatively limited number of observations (say, 20) gives most value. In this way the indicators capture changes in driving forces faster. For studies of longer periods with less focus on current developments, a lower frequency and more observations can be useful as it results in less volatile series. Additionally, most time series at daily frequencies have the problem that the closing prices of the different series often are at different points in time, which distorts the picture. By using weekly frequency (or lower) such problems are reduced.

Also, correlations can give equal weight to all observations or give more weight to more recent observations[2]. Again, the purpose dictates what is preferable. By weighing recent observations more, the indicators respond more quickly to new developments and less when observations leave the rolling window. This is valuable when the indicators are used in daily monitoring of market developments. On the other hand, the higher volatility of weighing observations differently speaks for equal weighting when longer, past periods are ascertained.

Lastly, correlations can be calculated between either levels or changes of the underlying series. Since correlations between the level of series often are subject to "spurious regressions", that is correlations that is due to coincidence rather than actual interdependence, correlations between changes in the series are preferable.

For ongoing monitoring of market developments, I prefer indicators based on daily changes in a 20 day rolling window weighing recent observations higher (using a decay factor of 0.85)[3]. For analysis of longer past periods, I use indicators based on weekly changes over a 52 week rolling window with equal weights to all observations.

The series used to calculate the indicators below are benchmark 2-year yields of Germany and the US, Euro Stoxx 50 (euro area stock prices), S&P 500 (US stock prices), the euro-dollar exchange rate (dollars pr. euro) and the spot gold price (US market). All prices are close prices provided by Bloomberg.

5.2. So, what has driven markets?

Chart 2 depicts the macroeconomic drivers over a long period. There has been a change from inflation (of both regions) to economic activity (of both regions) driving markets. This seems consistent with surveys showing that inflation expectations declined until around 2000 - and since then having been stable. The spikes of US growth around 2000 also seem consistent with the revisions in productivity that drove stock markets up – and down. In the last half of the period US growth seems to have dominated euro-area growth, which seems consistent with the general focus on the US economy that has prevailed among market participants in the later years.

The indicator for risk has spikes in the period that coincide with large shocks to the global economy – the gulf war in 1991 (the first observation covers the year 1991), the Peso Crisis in 1994/5, the Asian crisis in 1997, the Russian Crisis in 1998, 9/11

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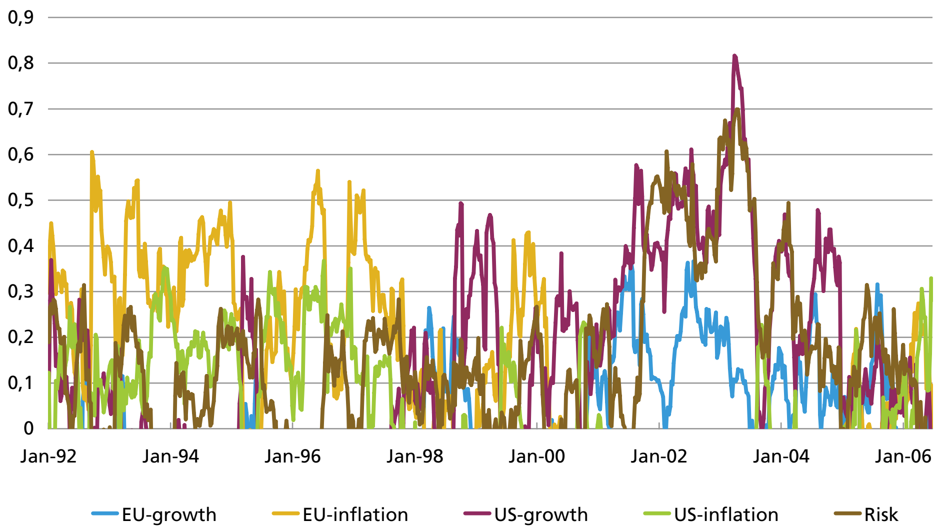
[2] The weighted correlation between two series X and Y are calculated as corr(X,Y) = Cov(X,Y)/(sd(X)*sd(Y)), where Cov(X,Y) = (1-d) $\sum^{n}_{i=1} d^{(i-1)} (x_i - x)(y_i - y)$ and sd(X) = sqr ((1-d) $\sum^{n}_{i=1} d^{(i-1)} (x_i - x)^2$). sqr (Z) is the square root of Z , n is the number of observations and d is the decay factor (set between 0 and 1). For further details, see J.P.Morgan (1996).

[3] Thereby the most recent observation weighs 16 pct. while the observation leaving the calculation weighs less than 1 pct.

in 2001, the accounting scandals in the US in 2002 and the run-up to the gulf war in 2003. All in all the macroeconomic drivers paint a credible picture of the broad developments since 1992.

MACROECONOMIC DRIVERS OF FINANCIAL MARKETS Chart 2

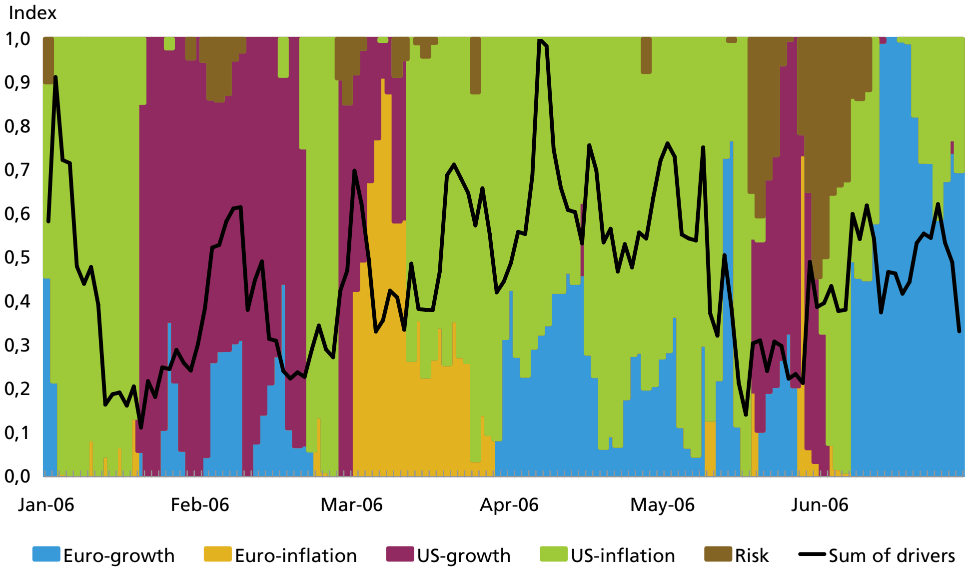


Notes: Before 1999 the DEM-USD exchange rate is used. Correlations are based on weekly changes that are weighed equally over a 52 week rolling window. For calculation, see text.
Source: Bloomberg and own calculations.

Chart 3 takes a closer look at recent developments. The drivers are calculated at higher frequency with fewer observations that are weighed exponentially. They are scaled so that positive drivers at a given point in time sum to 1. This makes it easier to grasp what is going on. The line in the graph indicates the sum of the drivers (before they were scaled to 1). If this value is low it either indicates that there are no clear drivers in the market (which "muddles" the correlations) or that the model does not capture market developments well. The line can thus be seen as a loose "explanatory power" of the model.

The calculation results in swifter changes in the dominant drivers than the first calculation. The beginning of 2006 saw quick changes among different drivers before US inflation evolved as a dominant force in March and remained so for a few months. In this period a number of US price indicators surprised on the upside and oil prices peaked. US growth and risk appetite took over at the end of May and beginning of June, coinciding with the worldwide "flight-to-quality", which the drivers indicate had to due with US growth revisions. Subsequently euro area growth has taken over as the dominant driver. Although a number of strong euro area macroeconomic figures have been released, which has helped the rise in risk premiums to reverse and heightened speculation over ECB monetary policy, the dominance of this driver can be seen as somewhat surprising – also given the decent "explanatory power" of the model during this period. This points to an additional value of the indicators as they periodically expose a driver that is not clearly reflected in market commentaries.

MACROECONOMIC DRIVERS OF FINANCIAL MARKETS Chart 3



Note: For calculation of drivers, se text. Correlations are based on daily changes that are weighed exponentially with decay factor 0.85 over a 20 day rolling window. The drivers that are positive on a given day are scaled so they sum to 1. "Sum of drivers" is the sum of the drivers before scaling which in turn is scaled so the largest value during the period is 1. The line gives an indication to what degree the model explain market developments.
Source: Bloomberg and own calculations.

The bottom line is that the picture depicted by the indicators pass a rough “reality check”.

5.3. The use of the macroeconomic drivers

The macroeconomic drivers are useful in the analysis of financial markets as they provide a *consistent, quantitative overview* in *real-time* based on *actual market developments*. This is in contrast to market commentaries that are typically based on changing sources; are so numerous that it can be hard to get the big picture; are verbal and hence only subjectively can be compared; and are sometimes misleading with respect to what actually took place.

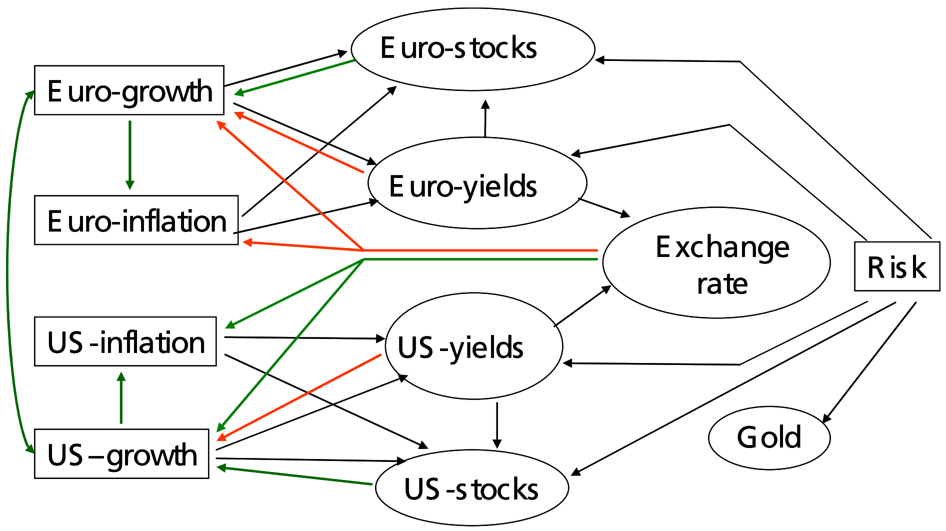
The setup can be used in investment decisions to understand the current market drivers – which should be a first step in any investment decision. In this way they lay the ground for forward-looking analysis. If the market is dominated by a particular driver, forming an opinion on this particular component becomes important. Hence, forming an opinion on euro-area growth seems very relevant at the time of writing. If one has a clear opinion on what "should" have driven markets, and this differs from actual developments, it also opens investment opportunities. For example, if one has the view that market participants have a too benign expectation of inflation in the euro-area, which is not in focus according to the drivers, one could position oneself for increasing area inflation becoming a driver.

6. Expanded model

The model introduced above rests on a number of simplifying assumptions – i.e. that causality is only from the macroeconomic factors to the financial markets and that only the five macroeconomic factors affect financial asset prices. This section relaxes these two simplifications and draws out the implications. The advantage of the assumptions was that it made a stringent analysis possible. By relaxing the assumptions the discussion invariably becomes somewhat less rigorous.

The model is expanded to also consider the effects financial markets have on the macro economy as sketched in chart 4. They should all be pretty standard in the macroeconomic literature. Specifically, higher yields in the euro area (US) are assumed to impact euro area (US) growth negatively due to a decrease in investment and consumption. Additionally, higher stock prices in the euro area (US) increase euro area (US) growth due to the positive impact on consumption as consumers' wealth increases. Lastly, an increase in the exchange rate impacts euro area growth negatively due to loss of competitiveness, while euro area inflation falls due to cheaper imports. On the other hand, US growth and inflation increases.

CAUSAL RELATIONS IN THE EXPANDED MODEL — Chart 4



Note: Boxes indicate (unobservable) macroeconomic driver, while circle indicates (observable) asset price. Arrows indicate causal relationships. Colored arrows are additions in the expanded model relative to the model introduced earlier – green is a positive relationship, while red is a negative relationship.

The first subsection discusses the implications this expanded model has for the interpretation of the macroeconomic drivers. The second subsection explores the effect other factors have on the model by considering shocks to the individual financial markets. In this second sub-section the interdependence between the macroeconomic factors will also be drawn into the analysis explicitly. Specifically, economic growth is assumed to impact expected inflation positively as a tighter labour market increases wages and inflation. Also growth in each region is assumed to impact growth in the other region positively due to bilateral trade.

6.1. Implications of the expanded model

If it is still assumed that only the five exogenous variables are the five macroeconomic drivers then I believe that the interpretations laid out earlier are still valid if "feed-back" from the financial markets to the macro economy is considered explicitly.

For instance, if higher growth expectations in the euro area drive the markets it leads to higher stock prices and yields in the euro area and a rise in the exchange rate. These in turn influence expected euro growth – higher yields and a stronger euro has a negative impact, while higher stock prices have a positive impact. If the two former are strongest, the net effect is a more moderate increase in growth expectations than the initial impact – which in turn moderates the movements in the financial markets. And so on. However, it does not change the fact that growth expectations increased, that this drove financial markets, and that the movements in the markets (and hence correlations between asset prices) are qualitatively identical to those resulting from the "simple" model. In other words, the interpretation of the indicators does not change with the elaborated model.

6.2. Implications if other factors drive financial markets

Naturally a whole number of other factors influence financial markets. If these resemble "white noise" and move markets at random, it will tend to pull the correlations towards 0. This will probably tend to reduce the value of positive indicators (who are typically positive as some correlation has a high absolute value). That the values of positive indicators are reduced if other factors influence markets is not a problem. On the contrary it is a nice feature that is consistent with other factors dominating financial market developments.

However, if other factors influence markets systematically over a period it can push correlations away from zero and thereby push the value of indicators up. This subsection considers how various systematic factors might impact markets and discusses what this means for the interpretation of the indicators. It does so by considering how a shock to yields, stock prices and the exchange rate respectively impacts correlations.

6.2.1. Shock to yields

If changes in yields in the US (or equivalently the euro area) in a period are dominated by exogenous shocks (not originating from the five macroeconomic drivers) it can drive markets. Such shocks could, for example, originate from changing rhetoric from the central bank (given static expectations of growth and inflation), changes in the governments deficit (supply effects) or changes in central bank's foreign reserve management (demand effects).

If yields for one of these reasons rise, it reduces the expected growth in the US due to the negative impact from yields on investment and consumption. This is turn impacts expected inflation negatively, which moderates the rise in yields. The lower growth and inflation expectations and higher yields causes stock prices to fall, while the higher yields cause a dollar appreciation (the exchange rate falls). Hence, the observed movements in asset prices resemble those that arise if US inflation drives markets. In other words, a positive value of the indicator for US inflation can be due to shocks to US yields driving financial markets in general. This might be a supplementary explanation for the dominance of the driver for US inflation in January 2006 (cf. chart 3) when Bernanke took over as Fed chairman as his first statements were followed closely, and again in April/May 2006 where market participants speculated when the US tightening cycle would end (after a prolonged period of gradual tightening).

The spill-over to the euro area is ambiguous. Expected euro area growth (and hence inflation) is impacted negatively by the fall in expected US growth, while the fall in the exchange rate causes inflation and growth expectations in the euro area to rise.

The bottom line is that a positive indicator for inflation can be caused by systematic shocks to the relevant bond market. This should be kept in mind when interpreting the indicators.

6.2.2. Shock to stock markets

Shocks to the stock markets could arise from changed expectations about the remuneration of the production factors (leading to revisions of expected dividends) or from new information about corporate earnings.

If stock prices rise in the US it has a positive impact on US growth and hence in US inflation expectations. The latter moderates the rise in stock prices. Higher growth and inflation expectations impacts yields positively, while the exchange rate falls. Hence, the arising correlations are identical to those used in the driver for US macroeconomic growth, and a positive value of this indicator can thus be a consequence of shocks to US stock markets driving financial markets. The high value of the indicator for US growth in 2002, cf. chart 2, could be due to global investors’ focus on the accounting scandals in the US which resulted in revised expectations of corporates’ actual earnings.

The euro area will be impacted through an increase in euro area growth expectations. The movements in euro area stocks and yields are thus parallel to those in the US, but can be expected to be of smaller magnitude. The rise in euro yields thus dampens the fall in the exchange rate.

The bottom line is that a positive value for an indicator of growth can be due to systematic shocks to stock markets driving financial markets.

6.2.3. Shock to the exchange rate

Lastly, shocks to the exchange rate can also drive financial markets in periods. This could be due changed expectations of the future exchange rate (for instance, due to a growing US current account deficit) or temporary supply and demand effects (for instance, due to changes in Asian countries' exchange rate policy).

A higher exchange rate (stronger euro / weaker dollar) puts downward pressure on euro area inflation and growth resulting in lower euro yields. On the other hand the effect on stock prices is ambiguous as the impact from inflation and growth pull in opposite directions. In the US the effect on yields is positive while the effect on stock prices is ambiguous. Hence, financial market reactions do not resemble any of those put forward in connection with the indicators. It points out that negative correlation between yields in the US and the euro area can be due to shocks to the exchange rate driving markets.

The bottom line is that systematic shocks to the exchange rate do not impact the interpretation of the macroeconomic drivers forwarded.

7. Conclusion

The analysis has made the point that looking at developments across financial markets reveals substantial information on which macroeconomic factors that drive the individual markets. The points made in this paper can be used qualitatively in the analysis of market behaviour. Additionally, as financial asset pricing data is readily available the correlations between asset prices can be used to quantify real-time macroeconomic drivers that are objective, consistent and based on actual market developments. The analysis has done just that and the emerging picture passes a reality check. The results point to the usefulness of the indicators in the ongoing analysis of financial markets.

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9. Appendix

The appendix shows formally that changes in growth expectations cause a positive correlation between stock prices and bond yields, and that changes in inflation expectations cause a negative correlation between stock prices and bond yields. To ease exposition I introduce the nominal growth rate at time *t* as $g_t \equiv y_t + \pi_t$

First, I will look at the effect of changed growth and inflation expectations in period 0.

Equation (3) can be rewritten as

$$S_0 = \frac{D_1 + S_1}{(1 + i_{0,1} + erp_0)} \quad (5)$$

To ease exposition I have left out expectations and will assume that the expected nominal growth rate and one-year yield rate from period 1 onwards are constant at *g* and *i* respectively. According to Gordon (1962) this allows the stock price to be calculated as

$$S_1 = \frac{D_2}{(i + erp_0 - g)} \quad (6)$$

under the reasonable assumption that $i + erp_0 > g$. Using the fact that $D_t = D_{t-1}(1+g_{t-1})$ and substituting (6) in (5) yields

$$S_0 = \left(\frac{1}{(1 + i_{0,1} + erp_0)} \right) \left(D_0(1+g_0) + \frac{D_0(1+g_0)(1+g)}{i + erp_0 - g} \right)$$

which can be rewritten as

$$S_0 = \frac{1+g_0}{(1+i_{0,1}+erp_0)} c \quad \text{where } c = D_0 + \frac{D_0(1+g)}{i + erp_0 - g} \quad (7)$$

Equation (7) leads to the following partial derivatives:

$$\frac{\partial S_0}{\partial g_0} = \frac{c}{(1+i_{0,1}+erp_0)} \quad (8)$$

$$\frac{\partial S_0}{\partial i_{0,1}} = -\left(\frac{1+g_0}{(1+i_{0,1}+erp_0)^2} \right) c = -\frac{c}{(1+i_{0,1}+erp_0)} \frac{1+g_0}{1+i_{0,1}+erp_0} \quad (9)$$

If growth is revised up in period 0 it impacts the interest rate by half, cf. equation (1), while of course impacting nominal growth one-to-one. Hence using equation (8) and (9) and that the interest rate changes by half the change in nominal growth when growth is revised leads to

$$\frac{\partial S_0}{\partial y_0} = \frac{c}{(1+i_{0,1}+erp_0)} \left(1 - \frac{1}{2} \frac{1+g_0}{1+i_{0,1}+erp_0} \right) \quad (10)$$

For reasonable values of g_0, $i_{0,1}$ and erp_0 the value of (10) is positive and hence stock prices increase when the expected growth in period 0 is revised upwards.

If inflation is revised up in period 0 it impacts the interest rate by 1.5, cf. equation 1, while impacting nominal growth one-to-one. Hence using equation (8) and (9) and that the interest rate changes by one-and-a-half the change in nominal growth leads to

$$\frac{\partial S_0}{\partial \pi_0} = \frac{c}{(1+i_{0,1}+erp_0)}\left(1-\frac{3}{2}\frac{1+g_0}{1+i_{0,1}+erp_0}\right) \quad (11)$$

For reasonable values of g_0, $i_{0,1}$ and erp_0 the value of (11) is negative and hence stock prices decrease when the expected inflation in period 0 is revised upwards.

To prove that the result is general, I will look at changed expectations of growth and inflation in period 1:

Equation (3) can be rewritten as

$$S_0 = \frac{D_1}{(1+i_{0,1}+erp_0)} + \frac{D_2+S_2}{(1+i_{0,1}+erp_0)(1+i_{1,1}+erp_0)}$$

Using similar transformations as above this leads to

$$S_0 = \frac{D_0(1+g_0)}{(1+i_{0,1}+erp_0)} + \frac{1+g_1}{(1+i_{1,1}+erp_0)}k \quad (12) \quad \text{where}$$

$$k = \frac{D_0(1+g_0)}{(1+i_{0,1}+erp_0)}\left(1+\frac{1}{i+erp_0-g}\right)$$

Comparing (12) with (7) it can be seen that the reaction in the stock price from changes in expectations of growth or inflation in period 1 will be qualitatively identical to the ones derived in (10) and (11) for changed expectations regarding period 0 (the only difference in the results being *k* in the place of *c*). This will also be the case if calculations were made for subsequent periods.