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On Some Neglected Implications of the Fisher Effect

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Abstract. Following the lead of Fama [American Economic Review 65 (1975) 269-282] and of other influential papers, such as Mishkin [Journal of Monetary Economics 30 (1992) 195-215], it has become standard to interpret the Fisher effect as the ability of short-term interest rate to predict future inflation. However, in this paper we demonstrate that by restricting to zero the instantaneous response of expected inflation to an interest rate shock, one can identify a disturbance that economic agents, according to the Fisherian framework, should evaluate as transitory. An important implication of this result is that short-term nominal interest rates cannot be interpreted as predictors, at least not long-run predictors, of inflation. We illustrate this result with an empirical application to US postwar data.

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1. Introduction

In the last decades, much effort has been devoted to empirical investigation of the Fisher hypothesis, i.e. that movements in the short-term nominal interest rates are explained one-for-one by movements in the expected rate of inflation. It is widely recognized that the Fisher effect is a building block of the classical monetary theory which states that over the longer term the rate of inflation is entirely driven by the rate of growth of the money supply in excess with respect to the normal rate of growth of aggregate output. On the other hand, real variables such as the real rate of interest and the rate of unemployment would gravitate around their natural level explained by real, non-monetary forces.

For instance, some models of intertemporal asset pricing predict that the stochastic process of the real interest rate depends on the dynamic process of consumption growth and also on some parameters reflecting the agents' impatience and the elasticity of intertemporal substitution.

As far as the time series properties of the variables are concerned, if one assumes that both inflation and nominal rate exhibit a stochastic trend, then a long-run effect requires comovements at frequency zero, whereas a short-run effect requires that a change in expected inflation be associated with a change in short-term nominal interest rates (*e.g.* Mishkin, 1992).

In recent decades, following Fama's (1975) interpretation, in turn supported by some other influential papers, such as Mishkin (1992), it has become a standard view to interpret the Fisher effect as the ability of short-term interest rate to predict future inflation.

However, in the present paper we argue that the Fisher hypothesis makes more than a prediction of comovements at frequency zero, since it also establishes a long-run causal relation between the two variables: there is undirectional long-run causality running from expected inflation to nominal interest rates.

It is possible to show that, in turn, this allows a more structural interpretation of the Fisher effect, implying that a change in the short-term nominal rate of interest, holding fixed within the period expected inflation, does not permanently affect both inflation and interest rate. In other words, it is possible to use the economic theory underlying the Fisher effect in order to select a particular orthogonalization. For, if the instantaneous response of expected inflation to an interest rate shock is restricted to zero, then we are identifying a structural disturbance that should be evaluated as transitory.

Note that Cochrane in his 1994 paper uses the Permanent Income Hypothesis in order to identify a shock to GNP, with consumption fixed, that consumers view as transitory; where this identifying restriction descends from the PIH prediction that only changes in consumption may exert permanent effects on both GNP and consumption.

As far as the Fisher hypothesis is concerned, the following conclusion should be drawn: short-term nominal interest rates cannot be interpreted as predictors, at least not long-run predictors, of inflation.

Thus, it seems that the famous assertion by Fama (1975) *i.e.* interest rates as predictors of inflation, is inconsistent with the Fisher hypothesis or at its best might hold only for the very particular case in which the economy exhibits both a constant real rate of interest and a negligible stochastic component in the inflation risk premium.

Thus, a reasonable conclusion is that the real interest rate is a stationary process subject to only transitory shocks.

The Fisher relation has been subject to intense investigation in the last 50 years. The results are controversial since, for instance in the framework of bivariate cointegrated systems, the one-for-one relation between inflation and interest rate does not receive a great empirical support (see, *e.g.* Crowder and Hoffman 1996). Further, some studies find that the stochastic process of the real interest rate may exhibit a unit root (cf. Rose, 1988).

Evans and Lewis (1995) suggested that the non-stationarity detected in the real rate of interest in the postwar period might be explained by the presence of structural breaks in the inflationary expectations. The authors maintain that when these infrequent shifts in the inflation process are taken into account a long-run Fisher relation in the US economy cannot be rejected.

In a very recent paper, Christopoulos and Ledesma (2007) have argued that another possible explanation for the scant support received by the Fisher hypothesis in the empirical literature may rest on the presence of non-linearities in the long-run equilibrium relation between the two series.

However, in order to illustrate the analytical results, in the final part of this paper we undertake an empirical investigation based on a linear approach and concerning postwar US data. We find that a Fisher relation might characterize the US economy for the period 1960-2006 and, as a consequence, expected inflation explains low frequency movements in the nominal interest rate. The conclusion therefore is that inflation is a predictor of the nominal rate and not viceversa.

Some important differences with respect to the conclusions reached in the majority of studies concerning the Fisher effect may be due to the different sample periods considered or, more relevant in our opinion, to the choice regarding the indicator of expected inflation. For, we chose a measure of inflation given by the annual rate of change of the CPI ex food and energy. The motivation for this choice is that the rate of change of the CPI ex food and energy may be interpreted as a potential indicator of trend inflation. In our view, this measure is a more solid anchor for inflationary expectations, also in the light of the attention paid by the central bank to this core inflation indicator.

Indeed, as stressed by Bernanke and Mishkin (1997), those countries which embrace an inflation-targeting regime usually choose some variant of the CPI index; moreover, a focus on core inflation is not so infrequent. The authors justify this choice by observing that monetary policy should influence trend inflation, thus neglecting short-run movements in the price series.

Section 2 presents some known theoretical foundation for the Fisher hypothesis. In section 3 we explore the structural implications for the joint dynamics of expected inflation and the nominal interest rate. In section 4 an empirical investigation concerning postwar US data is undertaken. We detect the presence of a long-run stationary linear combination of inflation and nominal interest rate. Moreover, since the hypothesis of exogeneity of inflation cannot be rejected, a recursive structure with the rate of inflation ordered first in the causal ordering allows a permanent and a transitory shock to be separated; where the permanent inflation shock explains low-frequency movements in the short-term nominal interest rate.

The innovations analysis shows that the short-term nominal interest rate has almost no power in forecasting the variability of inflation at all horizons. Section 5 concludes.

2. Inflation and the real interest rate

In our empirical analysis we investigate the hypothesis that the real interest rate is a stationary process which may hence be affected by only transitory disturbances. Instead, inflation and nominal interest rates are taken as stochastic processes subject to permanent shocks. This characterization for the real interest rate is indeed consistent with some standard models of intertemporal asset pricing.

The Fisher equation is given by:

$$i_t^{t+k} = r_t + E_t(\pi_t^{t+k}) \quad [1]$$

Hence, the nominal interest rate, i_t^{t+k}, earned by holding a financial asset over the period between t and $t+k$ and known at time t, is composed of the real interest rate, r_t, and of expected inflation, $E_t(\pi_t^{t+k})$, from time t and $t+k$, where k is the maturity of the asset.

Expected inflation is, of course, a non-observable variable but if one assumes that expected inflation is given by the sum of actual inflation plus a forecast residual, then we have:

$$E_t(\pi_t^{t+k}) = \pi_t^{t+k} + e_t \quad [2]$$

where e_t is a stationary forecast error term.

The Fisher equation can then be expressed by:

$$i_t^{t+k} = r_t + \pi_t^{t+k} + e_t \quad [3]$$

Equation [3] implies the existence of a one-for-one relation between inflation and the nominal interest rate. By assuming that inflation is a process subject to permanent disturbances, it follows that also the nominal interest rate is a stochastic process which exhibits non-stationarity. In this context the presence of a Fisher effect can then be tested in the framework of the following cointegrating regression:

$$i_t^{t+k} = \psi_0 + \pi_t^{t+k} + \phi_t \qquad [4]$$

where ϕ_t is an error term. In the presence of cointegration and of a unitary coefficient on inflation, the Fisher hypothesis would not be rejected by data.

Notice that this is equivalent to testing for the hypothesis of stationarity of the real interest rate[1].

Hence, given some assumptions concerning inflationary expectations, it is possible to study the joint dynamics of inflation and nominal interest rate.

It is worth observing that if inflation follows a random walk, then expected inflation is of course the exogenous variable of the bivariate dynamical system which also includes the nominal interest rate. Moreover, if the assumption of stationarity of the real interest rate is satisfied, then the stochastic trend of nominal interest rate is given exactly by (expected) inflation and in this case the nominal interest rate does not contain any information for the future path of inflation.

Clearly, this case would be in line with the prediction made by the Fisher hypothesis. Yet in the next section we aim to show that the same conclusion may hold also by relaxing the assumption of a random walk process for inflation.

[1] Nevertheless, more general versions of the Fisher equation also add on the right hand side of [4] an inflation risk premium component: in a stochastic environment future inflation is not known with certainty, then the nominal interest rate on a financial asset should exhibit an expected real return in excess on a riskfree nominal bond. But when the possibility of an inflation risk premium is taken into account, the existence of a cointegrating relation between the two variables is not an obvious implication of equation [3] or [4], since it is not possible to rule out, on *a-priori* grounds, the possibility of non-stationarity in the risk premium component. Notice that the constant term would include, in this case, the deterministic component of both the real rate of interest and the risk premium, whereas the error term, ϕ_t, would be a linear combination of the forecast residual and of innovations in the inflation risk premium.

3. The Fisher effect and the implied restrictions for the joint dynamics of inflation and nominal interest rates

Taking the ex post inflation rate as a proxy for inflationary expectations and assuming that both inflation and the nominal interest rate are I(1) variables, then their joint dynamics can be expressed by:

$$\begin{pmatrix} \Delta\pi_t^{t+k} \\ \Delta\ i_t^{t+k} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} C_{11}(L) & C_{12}(L) \\ C_{21}(L) & C_{22}(L) \end{pmatrix} \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} \qquad [5]$$

where $\Delta = I - L$ and L is the lag operator, with $C(0) = I$. $\epsilon_t = (\epsilon_{1t}, \epsilon_2)'$ is the (2x 1) vector of reduced-form disturbances such that $E(\epsilon_t) = 0$ and $E(\epsilon_t\epsilon_t') = \Omega_\epsilon$.

We state that the Fisher hypothesis holds if the following three conditions are satisfied:

(i) the matrix of long-run multipliers, C(1), has reduced rank 1, *i.e.* inflation and the interest rate are cointegrated.

(ii) the cointegrated vector has the form $(1, -1)'$;

(i) and (ii) are the necessary conditions which are usually explored in the empirical literature but they are not sufficient to validate the Fisher hypothesis. For this set of conditions leaves open the possibility that long-run movements of inflation be explained by the nominal interest rates, thus generating a reverse long-run causality with respect to the prediction of the Fisher effect. Hence, we state that the following condition is also required:

(iii) There is one-way causality at frequency zero running from expected inflation to the nominal interest rate. In the context of a cointegrated system this implies that inflation does not adjust to long-run equilibrium or, in other words, that inflation is the weakly exogenous variable of the dynamical system.

As a further step, one might wonder if, on the basis of the Fisher hypothesis, it is possible to give a more structural interpretation of the joint dynamics of inflation and nominal interest rates. The answer is a qualified yes, since starting with the reduced form [5], we can recover the structural shocks affecting the variables by observing that the set of conditions from (i) to (iii) has the following implication: an unexpected change in nominal interest rate, with inflation contemporaneously fixed, has only a transitory effect on both the variables. Thus, we maintain that the structural form underlying the Fisher hypothesis is a Wold recursive structure with inflation ordered first in the causal ordering. Moreover, an interesting peculiarity of this recursive structure is that only shocks affecting expected inflation exert a permanent effect on both the variables.

Let us indicate with η_{1t} and η_{2t} the two structural shocks of this dynamic system. As far as the conditional expectation $E_t(\pi_{t+h})$ for long forecast horizon with respect to the past history is concerned, we have the following results:

$$\lim_{h\to\infty} \frac{\partial E_t(\pi_{t+h})}{\partial \pi_t} \neq 0 \quad [6]$$

$$\lim_{h\to\infty} \frac{\partial E_t(\pi_{t+h})}{\partial i_t} = 0 \quad [7]$$

The joint set of conditions also has an important implication for the conditional expectation of $E_t(i_{t+h})$, since we have:

$$\lim_{h\to\infty} \frac{\partial E_t(i_{t+h})}{\partial \pi_t} = \lim_{h\to\infty} \frac{\partial E_t(\pi_{t+h})}{\partial \pi_t} \neq 0 \quad [8]$$

$$\lim_{h\to\infty} \frac{\partial E_t(i_{t+h})}{\partial i_t} = \lim_{h\to\infty} \frac{\partial E_t(\pi_{t+h})}{\partial i_t} = 0 \quad [9]$$

Equations 6 to 9 summarize the relevant points related to the Fisherian theory of interest. For, let us suppose that we know that at date t the inflation rate is higher than previously expected and hence η_{1t} is positive. Then, this event will cause a positive revision in our long-run forecast of both inflation and nominal interest rate. If, instead, we know that the nominal interest rate at date t is higher than expected, this event will induce a revision of both the variables for short horizons, but the long-run forecast will be unchanged. Moreover, in the presence of an increase of short-term nominal interest rate with expected inflation fixed, *i.e.* in the presence of a positive η_{2t}, the revision in the forecast of inflation should be toward a (temporary) decrease rather an increase since, if the positive innovation in the nominal interest rate is interpretable as a transitory risk premium shock, then the economic system might undergo a slowdown. Clearly, in this scenario, it would be paradoxical un upward revision of inflationary expectations by agents.

We can also express the revision of the conditional expectation, in this structural context, in terms of long-run response of the variables to the two structural shocks.

$$\lim_{h\to\infty} \frac{\partial \pi_{t+h}}{\partial \eta_{1t}} = \lim_{h\to\infty} \frac{\partial i_{t+h}}{\partial \eta_{1t}} \neq 0 \quad [10]$$

Moreover, as far as the response of inflation to an interest rate shock is concerned, we have the following, important result:

$$\frac{\partial \pi_t}{\partial \eta_{2t}} = \lim_{h\to\infty} \frac{\partial \pi_{t+h}}{\partial \eta_{2t}} = 0 \quad [11]$$

Thus the impact effect and the long-run effect on inflation of an interest rate shock are both equal to zero.

In order to demonstrate this assertion, let us indicate with β a $2x1$ vector of coefficients in the cointegrating vector and with α a $2x1$ vector of loadings. Then, as shown in Johansen (1991), in the presence of cointegration the matrix of long-run total multipliers is given by: $C(1) = \beta_\perp \Phi \alpha'_\perp$, where $\beta_\perp$ and $\alpha_\perp$ are, respectively, the orthogonal complements to the matrix of cointegration vectors and to the matrix of error corrections coefficients, such that $\beta' \beta'_\perp = 0$, $\alpha' \alpha_\perp = 0$. As for Φ, let us consider the vector autoregressive representation:

$$\begin{pmatrix} \Gamma_{11}(L) & \Gamma_{12}(L) \\ \Gamma_{21}(L) & \Gamma_{22}(L) \end{pmatrix} \begin{pmatrix} \Delta \pi_t^{t+k} \\ \Delta\ i_t^{t+k} \end{pmatrix} = \begin{pmatrix} \gamma_1 \\ \gamma_2 \end{pmatrix} + (\alpha_1 \ \ \alpha_2) \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix} \begin{pmatrix} \pi_{t-1}^{t+k} \\ i_{t-1}^{t+k} \end{pmatrix} + \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} \qquad [12]$$

Where $\Phi = (\alpha'_\perp \Gamma(1) \beta'_\perp)^{-1}$.

We want to recover the structural shocks which hit the dynamical system. Let H(0) be the unique lower triangular matrix such that $H(0)H(0)' = \Omega_\epsilon$. The Wold causal form with inflation ordered first in the causal ordering is given by:

$$\begin{pmatrix} \Delta \pi_t^{t+k} \\ \Delta\ i_t^{t+k} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} H_{11}(L) & H_{12}(L) \\ H_{21}(L) & H_{22}(L) \end{pmatrix} \begin{pmatrix} \eta_{1t} \\ \eta_{2t} \end{pmatrix} \qquad [13]$$

where $H(L) = C(L)H(0)$, $\eta_t = H(0)^{-1}\epsilon_t$ and $E(\eta_t \eta'_t) = I$. $\eta_t = (\eta_{1t}, \eta_{2t})'$ is a $(2x1)$ vector of structural disturbance. Under this structural representation a change in the nominal interest rate does not exert effects on expected inflation within the period. Yet an important implied result is that such a change is also neutral in the long run. Note that the structural long-run multiplier matrix, H(1) is given by:

$$\begin{pmatrix} H_{11}(1) & H_{12}(1) \\ H_{21}(1) & H_{22}(1) \end{pmatrix} = \begin{pmatrix} \beta_{1_\perp} \Phi \alpha_{1_\perp} & \beta_{1_\perp} \Phi \alpha_{2_\perp} \\ \beta_{2_\perp} \Phi \alpha_{1_\perp} & \beta_{2_\perp} \Phi \alpha_{2_\perp} \end{pmatrix} \begin{pmatrix} H_{11}(0) & 0 \\ H_{21}(0) & H_{22}(0) \end{pmatrix} \qquad [14]$$

Hence, the crucial identifying restriction of this structural model is that the contemporaneous effect on inflation of a change in the nominal interest rate is restricted to zero. That is the impact effect of the second shock on expected inflation, $\frac{\partial \pi_t}{\partial \eta_{2t}}$, equals zero. Nevertheless, the long-run response of the variables to an interest rate shock, is given by:

$$\lim_{h \to \infty} \frac{\partial \pi_{t+h}}{\partial \eta_{2t}} = (\beta_{1_\perp} \Phi \alpha_{2_\perp}) H_{22}(0) \qquad [15]$$

$$\lim_{h\to\infty}\frac{\partial i_{t+h}}{\partial \eta_{2t}} = (\beta_{2_\perp}\Phi\alpha_{2_\perp})H_{22}(0) \qquad [16]$$

Condition (iii), *i.e.* one-way causality at frequency zero running from expected inflation to the nominal interest rate, is satisfied if $\alpha_{2_\perp} = 0$. Hence, in this case, we have $\beta_{1_\perp}\Phi\alpha_{2_\perp} = \beta_{2_\perp}\Phi\alpha_{2_\perp} = 0$ and it immediately follows that $H_{12}(1) = H_{22}(1) = 0$.

Thus, the conclusion is that an unexpected change to the nominal interest rate, with expected inflation contemporaneously fixed, produces only a transitory effect on inflation. The economic rationale for this result is that by specifying an instantaneous response of expected inflation to an interest rate shock which is restricted to zero, we are identifying a shock that economic agents should regard as vanishing in the long run.

Remark 1. If inflation follows a random walk, then the short-term nominal interest rate does not Granger-cause inflation at all frequencies and, as a consequence, the response of this variable to an interest rate shock is completely flat at any horizon. Instead, if a more general process characterizes inflation, then there are swings in the dynamic response at some horizons. Nevertheless, the prediction of the Fisher hypothesis - the nominal interest rate does not Granger-cause inflation at frequency zero - implies that despite these swings, *i.e.* despite the possible presence of a transitory component for inflation, the permanent long-run movements of the nominal interest rate are completely explained by expected inflation.

Note, also, that if inflation follows a random walk, then both weak exogeneity and strong exogeneity are present. But this last condition is too strong for the validity of the Fisher effect.

Remark 2. Cochrane (1994) has shown that if consumption follows a random walk, a recursive VAR interpretation of the joint dynamics of consumption and income leads to the conclusion that only shocks to the variable ordered first (consumption) exert a permanent effect on both the variables. Instead, shocks affecting total income have only a transitory effect. Hence, in this case, Sims (1980) orthogonalization, with consumption first in the causal ordering, and Blanchard-Quah (1989) orthogonalization, with long-run restriction, are equivalent. Ribba (1997) shows that it is not necessary to restrict the dynamic shape of the variables ordered first to a random walk process, since an assumption of weak exogeneity implies an equivalence between short-run and long-run identifying restrictions in VEC models.

An empirical application of this last result, concerning an evaluation of some core inflation measures, is provided in Ribba (2003). In a very recent paper Fisher and Huh (2007) have proposed a further generalization of these equivalence results, for cointegrated systems, in the case of more than two variables. Moreover the authors have shown that when the number of common trends and the number of weakly exogenous variable are coincident then a recursive structure, with the weakly exogenous variables ordered first, generates an orthogonal decomposition with permanent shocks equivalent to the one generated by the Gonzalo and Ng (2001) decomposition[2].

Remark 3. The Fama effect is conceptually and operationally different from the Fisher effect. Indeed, given (i) and (ii) which are necessary conditions for both the effects to hold, it is possible to establish that the Fama hypothesis, *i.e.* nominal interest rates interpreted as predictors of future inflation, holds if also a third condition is satisfied: there is one-way causality at frequency zero running from the short-term nominal interest rate to inflation.

Thus, the Fama effect requires a condition of weak exogeneity for the interest rate since, in this case, this variable contains all the information concerning permanent long-run movements of inflation.

Remark 4. In the very particular case of a constant real rate of interest, since expected inflation is the permanent component of the nominal interest rate then this last variable, in the presence of efficient markets, could be a reliable indicator of future inflation which, after all, is an unobservable variable.

This is the case originally considered by Fama (1975). In the subsequent years this hypothesis was mainly criticized on a empirical ground (see, for example, Carlson 1977). However, if a further stochastic component, *e.g.* the risk premium, enters the nominal interest rate relation and, moreover, if an assumption of stationarity is made for the risk premium, then the nominal interest rate will be subject to transitory movements. In this case, economic agents need to distinguish movements in interest rate due to changes in the risk premium (or to other temporary factors) from movements due to changes in expected inflation.

Hence, even in the presence of a constant real interest rate, it seems that we are left in a sort of circular argument since the short-term nominal rate may be informative for the future path of inflation only under the condition that we can identify movements in the interest rate that are due to changes in expected inflation.

[2] It is worth noting that condition (iii), *i.e.* inflation is the weakly exogenous variable of the dynamical system, implies that the error correction term does not enter the inflation equation. Pagan and Pesaran (2008) show that in the more general case, with a multiplicity of permanent shocks, the error correction terms do not enter the structural equations with known permanent shocks.

Garratt *et al.* (2006) instead propose, in the context of cointegrated systems, an alternative derivation of the multivariate Beveridge-Nelson decomposition, in which permanent and transitory components are related to observable stationary processes.

4. An empirical investigation for the US economy

In order to illustrate the analytical results of the previous section, we have undertaken an empirical investigation for the US economy in the postwar period. We investigate the existence of a one-for-one long-run relation between inflation and the nominal interest rate and test for the presence of one-way causality at frequency zero running from inflation to interest rate.

In sum, we test for the existence of a Fisher effect in the US economy and as a subsequent step we draw the implication for the structural representation of the bivariate dynamic system.

We consider a bivariate VAR including a measure of expected inflation and the short-term nominal interest rate, for the sample period 1960: 1 - 2006:12. The short-term nominal interest rate is the three month treasury bill. The series are taken from FRED at the St. Louis FED Web site.

An important question to tackle in this empirical analysis concerns the selected indicator of the rate of change of the price level. If we interpret the Fisher effect as a long-run phenomenon, then we should pay close attention to the selected measure of inflation. Indeed, it is well known that, for example, the rate of change of the CPI contains high frequency noise and is subject to transitory movements. For these reasons, it is not necessarily a good reference for the low-frequency movements of the nominal interest rate.

Thus, our selected measure of expected inflation is the year-on-year rate of change of CPI ex food and energy for the next three months. This series is a potential indicator of the long-run component of inflation. Moreover, it is worth stressing that the rate of change of CPI ex food and energy is monitored, as a measure of core inflation, by the central bank and hence it is a more solid anchor for inflationary expectations.

More precisely, in the empirical analysis, we take the average value of CPI inflation ex food and energy over the next three months. For, note that we include the three month bill and hence, by using data with monthly frequency, we believe that a better measure for expected inflation over the bill duration is a three month average.

Ribba (2003) shows that the traditional measure of core inflation meets some criteria which allow an indicator of trend inflation to be identified.

As shown in table 1, on the basis of Johansen' s trace test[3] the existence of a long-run equilibrium relationship between inflation and nominal interest rate cannot be rejected[4].

Some other interesting results are presented in table 2. In particular, it is shown that all the three conditions established in section 3 for the existence of a Fisher effect are satisfied. In other words, the joint hypothesis that the cointegration space contains (a) a one-for-one movement between inflation and

[3]We used the Hannan-Quinn criterion for the selection of lag length. Accordingly, a VAR model was specified with sixteen lags.

[4]The usual battery of unit root tests (not reported) reveals that the hypothesis of a unit root for both the series may be consistent with the data.

nominal interest rate in the long run; and (b) that the error correction term does not cause inflation at very low frequencies, is not rejected by data.

We have also tested for the joint hypothesis that the cointegration space contains (a) a one-for-one movement between inflation and nominal interest rate in the long run; and (b) that the error correction term does cause not the nominal interest rate inflation at very low frequencies, *i.e.* we have also tested for the existence of a Fama effect. Given the sample period and the estimated cointegrated VAR model, the presence of a Fama effect is clearly rejected.

Insert table 1 about here

Insert table 2 about here

The final step of this empirical investigation consists in recovering the structural disturbances affecting the dynamic system and in conducting an innovations analysis. The results from tests concerning the cointegration space allow a causal ordering, with inflation ordered first, to be built. Such a causal ordering: (a) is consistent with the Fisherian framework; (b) implies the separation of a permanent shock from a transitory shock, where the permanent shock coincides with the inflation shock.

In figure 1 the impulse-response functions with the 90 per cent confidence bounds[5] are presented. The response of inflation to a transitory shock deserves some attention: an unexpected increase in the nominal interest rate, with no contemporaneous change in expected inflation, vanishes in the long run and hence provokes only a transitory reduction in inflation. Moreover, this effect reveals a good deal of persistence since it vanishes after about 4 years. Thus, at least in the long run, changes in the interest rate do not explain movements in inflation. The response of the interest rate to a transitory shock is also persistent.

It is worth stressing that the transitory shock could be interpreted as a temporary tightening in monetary policy or, alternatively, as a temporary increase in the risk premium and hence the negative response of expected inflation exhibits the correct sign. Instead, note that interpreting, in this case, the increase in the nominal interest rate as a signal of an increase of future inflation would have the following, curious implication: an event which can potentially push the economic system into a recession, should at the same time induce an upward revision of inflationary expectations.

[5]These asymptotic confidence bounds are based on the analytical formulae proposed in Amisano and Giannini (1997). The authors point out that some caution is required in applying asymptotic results and, in particular, in the case of small sample sizes. Nevertheless, in our empirical investigation we cover around 50 years and dispose of 564 observations. In a recent paper, Brüggemann (2006) investigates, in the context of finite samples, the properties of confidence intervals for cointegrated structural VARs which use long-run identifying restrictions, and makes a comparison among the methods most used in applied research.

As predicted by the Fisher hypothesis, a permanent change in expected inflation translates one-for-one in the long run into an increase in the nominal interest rate.

Insert figure 1 about here

Some interesting considerations are also stimulated by the decomposition of forecast-error variance (see figure 2). The most relevant result is that the permanent shock, *i.e.* the expected inflation shock, explains almost all of the forecast error variance of inflation at all horizons. Hence, and obviously, the transitory shock, *i.e.* the nominal interest rate shock, has almost no power in predicting the variability of inflation.

Thus, the conclusion to be drawn is that, as far as the sample period is concerned, the short-term nominal interest rate has no power in predicting the variability of future inflation.

This is an important result since it is worth pointing out that the estimated structural model imposes only a contemporaneous restriction, which is in this case equivalent to a long-run restriction, whereas the dynamic interaction at medium and low frequencies is not restricted.

Instead, as far as the interest rate is concerned, the contribution of the transitory shock is dominant at medium-high frequencies and becomes negligible only at medium-low frequencies.

Insert figure 2 about here

A somewhat surprising outcome of empirical research is the limited support which is obtained by the Fisher hypothesis.

An unexpected result was presented by Rose (1988), who found evidence of a unit root in the real interest rate.

Evans and Levis (1995) proposed an explanation for this result based on the idea that the inflation process is subject to infrequent breaks and that agents incorporate these infrequent shifts in their inflationary expectations.

The use of cointegration techniques in testing for the Fisher effect was first introduced by Mishkin (1992), whose results showed that the effect in the US economy holds only in periods characterized by the presence of a unit root both in inflation and nominal interest rate.

Our approach to empirical investigation of the Fisher relation is similar to that of Crowder and Hoffman (1996). The authors search for a Fisher effect in the US and the period covered is 1952-1991. They find evidence of a cointegrating relation between inflation and the nominal interest rate, but the existence of a cointegrating vector $(1, -1)'$ is rejected by data since results show that a 1 per cent increase in inflation causes 1.34 per cent increase in the nominal interest rate. They maintain that this result can be accommodated by including tax effects which may influence the long-run relation.

However, they use, as an inflation indicator, the price deflator for total consuption expenditures. In this paper we have argued that the CPI inflation ex food and energy may be a more reliable indicator for long-run inflation and hence a better guide for inflation expectations.

Note, moreover, that Crowder and Hoffman also find evidence of weak exogeneity of inflation. They comment on the results obtained by observing that although there is evidence of the Fisher effect it is not possible to confirm, given the sample period, the causal structure implied by the Fama assertion concerning the ability of nominal interest rate to predict future inflation.

Indeed, in the present paper, we have shown that once a Fisher effect is detected in the economy then the presence of a Fama effect is logically excluded.

In a recent paper Christopoulos and Ledesma (2007) have used non-linear cointegration techniques and have found evidence of a long-run Fisher effect for the US postwar economy. The authors maintain that the scant support for the Fisher effect, which is often observed in empirical literature, might be due to the lack of consideration of these non-linearities.

Although it is possible that a non-linear representation of the long-run Fisher relation fits the postwar US data better, in this paper we have suggested that, in the context of dynamic linear models, another possible explanation for the little empirical support to the one-for-one long-run relation between inflation and nominal interest rate may rest on the choice concerning the proxy for expected inflation.

5. Conclusions

In this paper we have argued that it is important to distinguish a Fisher effect, *i.e.* permanent changes in expected inflation cause a one-for-one permanent change in the nominal interest rate, from a Fama effect, *i.e.* short-term nominal interest rates are predictors of future inflation. They are equivalent only in the particular case in which both the real interest rate and the risk premium are constant. In other words, they are equivalent if the only stochastic component which may affect the nominal interest rate is contained in inflationary expectations.

Despite the implausibility of these restrictions and the lack of empirical support to the hypothesis of a constant real rate, it has become a pre-eminent view to treat the Fisher effect and the Fama effect as equivalent propositions and, as a consequence, it has become a widely shared practice to use the short-term nominal interest rate in order to extract expectations of future inflation (for an assessement see Soderlind, 1998.)

Instead, in the more general case, given I(1) variables, both the effects share the prediction that inflation and the nominal interest rate exhibit a long-run equilibrium relationship and that, moreover, the cointegrating vector has form $(1, -1)'$.

Yet there is a quite different prediction which concerns long-run causality relationships. For, the Fisher effect predicts that expected inflation is not caused at frequency zero by the nominal interest rate whereas the Fama effect predicts the opposite causal relation, *i.e.* the short-term nominal interest rate is not caused in the long run by inflation.

In this paper we also investigated the US economy for the postwar period. The results show that the Fisher hypothesis cannot be rejected. In the empirical investigation we used a measure of inflation given by the CPI inflation ex food and energy. Indeeed, it is well known that the central bank views this variable as an indicator of the trend component of inflation and thus it is a more reliable guide for inflationary expectations.

We believe that our choice of the inflation rate indicator could potentially explain the different result, with respect to some other studies, that we find concerning the one-for-one relation between inflation and the nominal interest rate.

In the final section of the paper following an important implication of the Fisher hypothesis - *i.e.* a shock to the nominal interest rate, with a contemporaneous restriction to zero for the effect on expected inflation, is evaluated as transitory by agents- we have identified a structural, recursive VAR model with inflation ordered first in the causal ordering.

An interesting result shown by the empirical investigation concerns an assessment of the ability of the short-term nominal interest rate to explain the variability of inflation at different horizons. The forecast-error variance analysis has in fact revealed that the nominal interest rate has no power in predicting inflation at all horizons, whereas the restriction imposed on the structural model and deduced by the Fisher hypothesis implies only the inability of the short-term nominal interest rate to cause the variability of inflation in the long run.

In conclusion, it is worth emphasizing that we do not regard this empirical investigation as a test of the analytical results presented in section 3. In other words, in our view detecting or not the effectual presence of a Fisher effect in the data does not represent a confirmation or, alternatively, a falsification of the central point maintained (and we hope also shown) in this paper, namely that the internal consistency of the Fisherian theory of interest implies that short-term nominal interest rates are not long-run predictors of inflation.

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Table 1. Johansen's Cointegration Rank Tests

H_0: rank	Trace	95 % c.v.	97.5 % c.v.
$r = 0$	18.80	15.49	17.45
$r \leq 1$	5.01	3.84	5.12

Notes: Results for the period 1960:1 - 2006:12 are based on a reduced form model which includes CPI inflation ex food and energy and a short-term interest rate. The estimated VAR includes 16 lags in levels

Table 2. Parameter Estimates and Analysis of the Cointegration Space

	inflation	nominal interest rate
Normalized cointegration vector	1	-1.176 (0.188)
Loading coefficients	0.002 (0.0018)	0.0334 (0.0092)
H_0: The cointegration space contains		
the cointegrating vector	1	-1
and		
the loading coefficients	0	α_2
$\chi^2_{(2)} = 0.735$ P-value 0.692		
H_0: The cointegration space contains		
the cointegrating vector	1	-1
and		
the loading coefficients	α_1	0
$\chi^2_{(2)} = 13.73$ P-value 0.0011		

Notes: The numbers in parentheses are standard errors. The null of a cointegrating vector $(1, -1)'$ and of unidirectional long-run causality, $(0, \alpha)$ is a joint test for conditions (ii) and (iii) of Section 3. Johansen's likelihood ratio test of restrictions on the cointegrating vectors and on the loading coefficients is distributed as a chi-squared with degrees of freedom equal to the number of restrictions tested.

FIGURE 1 IMPULSE RESPONSE FUNCTIONS

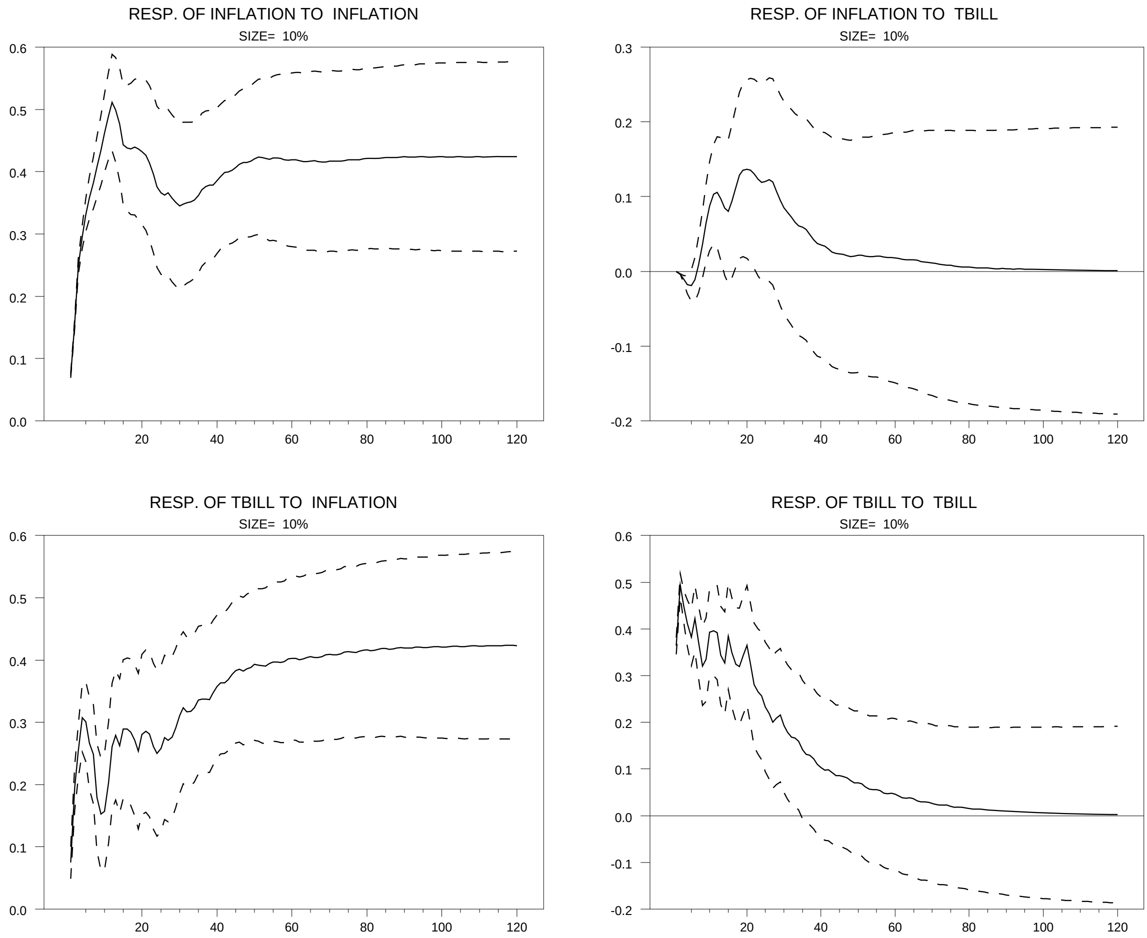
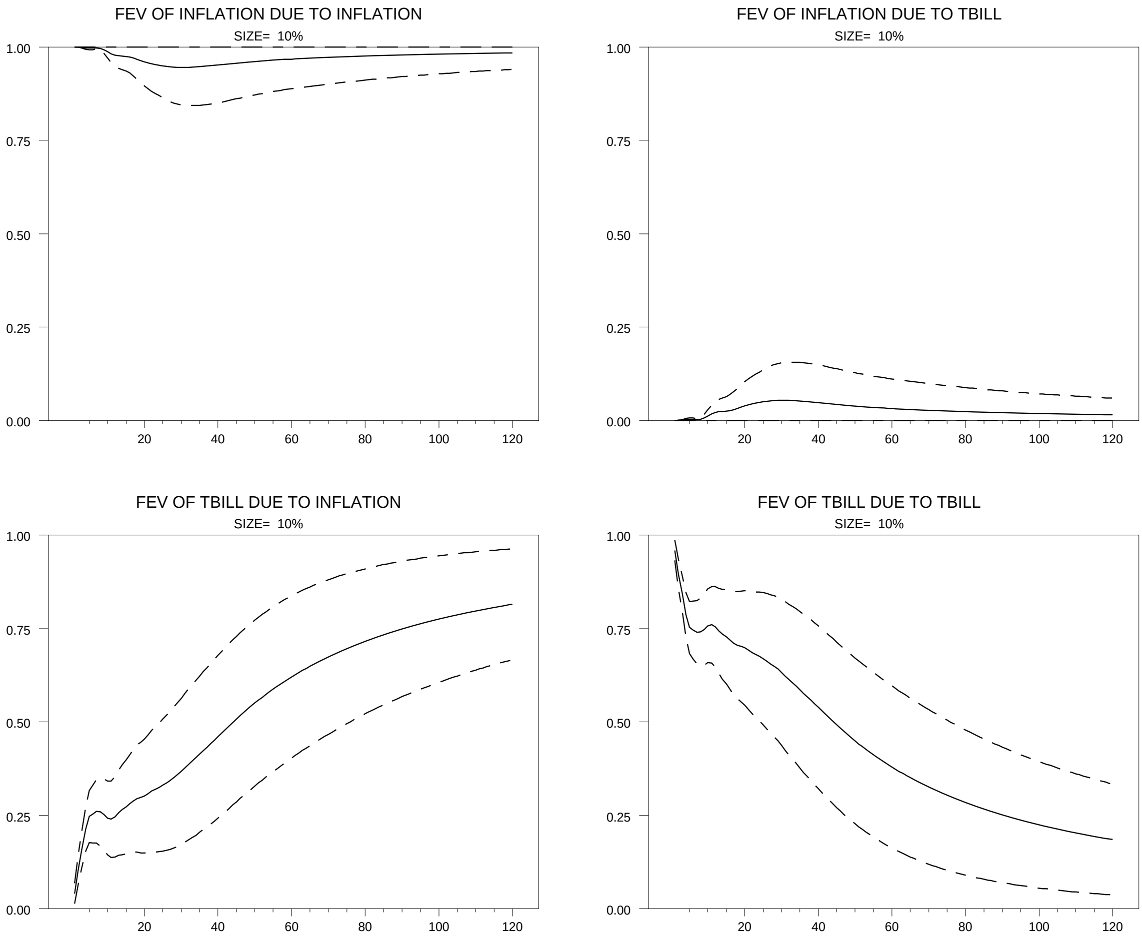


FIGURE 2 FORECAST ERROR VARIANCE (FEV) DECOMPOSITION



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