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Industry Returns and the Fisher Effect

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ABSTRACT

We investigate the cross-sectional relation between industry-sorted stock returns and expected inflation, and we find that this relation is linked to cyclical movements in industry output. Stock returns of noncyclical industries tend to covary positively with expected inflation, while the reverse holds for cyclical industries. From a theoretical perspective, we describe a model that captures both (i) the cross-sectional variation in these relations across industries, and (ii) the negative and positive relation between stock returns and inflation at short and long horizons, respectively. The model is developed in an economic environment in which the spirit of the Fisher model is preserved.

THE FISHER MODEL STATES that expected nominal rates of return on assets should move one-for-one with expected inflation. This belief is generally attributed to Irving Fisher's (1930) work on interest rates, in particular, to his view that the real and monetary sectors are causally independent. In an apparent contradiction to the Fisher hypothesis, however, it is a common empirical finding that stock returns are negatively related to both expected and realized inflation.[1] This negative correlation is especially surprising for stocks, which, as claims against real assets, should compensate for movements in inflation.

We provide two main contributions to the existing literature on the relation between stock returns and inflation. The first contribution of the article is to provide a theoretical description of the cross-sectional relation between stock returns and expected inflation. We describe an asset pricing model that predicts cross-sectional variation in the coefficients of expected inflation across various industry portfolios. An interesting feature of the model is that it synthesizes some of the more palatable features of existing explanations of the negative relation between inflation and returns. Of special interest is the development of the model in a money-neutral world, so that the basic premise underlying Fisher's work is maintained. Since most theoretical models of the

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[1] See, for example, Lintner (1975), Bodie (1976), Nelson (1976), Fama and Schwert (1977), Kaul (1987), and Marshall (1992), among others. Recently, however, Boudoukh and Richardson (1993) provide statistical evidence that this result is horizon specific. They find that, at long horizons, expected stock returns and inflation move closely together.

negative relation between stocks and inflation drop this assumption, our study is unusual in this respect. As an aside, the model provides a possible reconciliation of the negative relation between stock returns and inflation at short horizons and the positive relation at long horizons.

The second contribution of the article is to document empirical evidence of the cross-sectional relation between asset returns and inflation. Consistent with the theory, we find that there is reliable cross-sectional variation in the coefficients describing comovements between inflation and the stock returns of different industries. Since different industries possess different cyclical tendencies with the overall economy, this variation in the coefficients can be directly related to economic fundamentals. For example, a 1 percent increase in expected inflation is associated with a 0.91 percent increase in the expected stock returns of the Tobacco industry, but with a 1.45 percent decrease in expected returns of the Transportation Equipment industry. Consistent with our economic interpretation of these findings, the Tobacco industry is noncyclical—its output growth has a correlation of only 0.11 with aggregate output growth. In contrast, the output growth of a durable manufacturing industry like transportation equipment has a correlation of 0.75 with aggregate output growth.

The article is organized as follows. Section I describes the Fisher model and current explanations of the "anomalous" negative relation between stock returns and expected inflation. In Section II, we describe the theoretical relation between these variables in a Fisherian framework, and develop several empirical implications of our model. Section III investigates these empirical implications. In Section IV, we make some concluding remarks.

I. The Fisher Effect

While there are several versions of the Fisher model, the most common statement of the model is that the expected nominal rates of return on *all* assets move one-for-one with expected inflation:

$$\ln(R^i_{t,t+1}) = \alpha_i + \beta_i \mathrm{E}_t[\pi_{t,t+1}] + \epsilon^i_{t+1} \tag{1}$$

with

$$H_0\colon \beta_i = 1,$$

where

$\ln(R^i_{t,t+1})$ = the continuously compounded nominal return on an asset i
$\pi_{t,t+1}$ = the continuously compounded rate of inflation
$\mathrm{E}_t[\cdot]$ = expectations with respect to the information set available to economic agents at time t
α_i = the unconditional mean of the real return on asset i.

The foundations underlying this model are generally attributed to Irving Fisher's (1930) view that the real and monetary sectors of the economy are independent. Fisher suggests that the real rate is unrelated to the monetary sector, instead being determined solely by real factors like the productivity of capital, time preference, and risk aversion. There is ample empirical evidence, however, that there exists a strong negative relation between expected stock returns and expected inflation.

One explanation for the negative relation between stock returns and inflation is the "proxy" hypothesis first introduced by Fama (1981), and later extended by Kaul (1987). This hypothesis argues that the main determinant of stock prices is the company's future earnings potential. If expected future output in the economy (and hence a company's growth prospects) and inflation are negatively correlated, then inflation will proxy for future real output. This negative correlation may be due to economic agents' money demand (e.g., Fama (1981)) or countercyclical monetary policy (e.g., Kaul (1987)). This then leads to a spurious negative relation between stock returns and inflation in a regression model.[2] Fama (1981) and Kaul (1987) find that, when you include both inflation and a measure of future real output as explanatory variables, this negative relation disappears.[3]

One of the drawbacks of the "proxy" hypothesis is that it provides a qualitative, rather than quantitative, description of comovements between inflation and stock returns. Specifically, it is unclear whether the hypothesis describes the relation between stock returns and expected inflation, stock returns and unexpected inflation, or both. Our goal is to provide a more specific model for the relation between expected stock returns and expected inflation within the Fisherian framework. While the intuition underlying our model is based on the "proxy" effect, the discussion of the model's empirical implications is new.

II. Stock Returns and Expected Inflation: A Theoretical Explanation

A. The Theory

Following Fisher, suppose that the real and monetary sectors of the economy are causally independent. This type of money neutrality has support in

[2] In contrast, Geske and Roll (1983) extend Fama's (1981) model to include a policy response of debt monetization. This can lead to a causal relation between stock returns and inflation, through the correlation between stock returns and both corporate and personal income.

[3] Another strand of research treats money as an asset and then investigates implications for asset returns and inflation (e.g., Danthine and Donaldson (1986) and Stulz (1986)). A similar branch of this literature, but one which provides a more formal treatment of the role of money, is the cash-in-advance constraints literature (e.g., Svensson (1985) and Marshall (1992)). By construction these models violate Fisher's hypothesis of independent monetary and real sectors, and thus lie outside the scope of this article. Two other explanations, which have less support in the literature, are (i) that the U.S. tax system, via, for example, its treatment of depreciation, leads to high inflation having a negative impact on equities (see Feldstein (1980), Gonedes (1981), and Hasbrouck (1983) for examples of this literature), and (ii) that there is either irrationality on the part of agents or general market inefficiency (e.g., Modigliani and Cohn (1979) and Summers (1983)), such as confusion between nominal and real rates.

the finance literature, especially at longer horizons.[4] In this setting, the price level has no real effects and, thus, is causally unrelated to real variables. However, inflation and output growth can be correlated via, for example, the money supply process. If these variables are correlated, then inflation will covary with agent's marginal rates of substitution. Nevertheless, inflation will still have no impact on real asset prices (see Cox, Ingersoll, and Ross (1985) for a brief discussion of this issue). For example, Boudoukh (1993) investigates an asset pricing model in Lucas' (1978) framework with the price level serving as a unit of account. In this money-neutral setting, real asset prices are the same irrespective of the existing price level.

Within a money-neutral setting, we describe a model for expected returns that has several desirable features. Specifically, the model implies (i) a negative relation between stock returns and expected inflation, (ii) cross-sectional variation in this relation across assets, and (iii) a reconciliation of short-horizon and long-horizon results found in the literature.[5]

Define Q_t and q_t as the nominal and real stock prices. Similarly, D_t (d_t) is the nominal (real) dividend of the stock, C_t (c_t) is nominal (real) aggregate consumption, and p_t is the price level. By the definition of nominal returns,

$$R_{t,t+1} \equiv \frac{Q_{t+1} + p_{t+1}d_{t+1}}{Q_t} = \frac{\dfrac{Q_{t+1}}{p_{t+1}d_{t+1}} + 1}{\dfrac{Q_t}{p_t d_t}\,\dfrac{p_t d_t}{p_{t+1}d_{t+1}}}. \qquad (2)$$

Taking logarithms of both sides of equation (2), and using the above definition of real and nominal variables, we can write

$$\ln(R_{t,t+1}) = \ln\left(\frac{p_{t+1}}{p_t}\right) + \ln\left(\frac{d_{t+1}}{d_t}\right) + \left\{\ln\left(\frac{q_{t+1}}{d_{t+1}} + 1\right) - \ln\left(\frac{q_t}{d_t}\right)\right\}. \qquad (3)$$

Continuously compounded stock returns can be expressed as the sum of three terms: (i) the continuously compounded inflation rate, i.e.,

$$\pi_{t,t+1} \equiv \ln\left(\frac{p_{t+1}}{p_t}\right),$$

[4] See, for example, Black (1990) for a standard view of this literature in finance. For a more complete analysis, King and Watson (1992) provide tests of various neutrality propositions. Their results are mixed with respect to these propositions.

[5] The interested reader will note that the Fisher model has received mixed support when applied to interest rates. For example, Mishkin (1992) provides evidence against the short-run effect, but finds support for the effect in the long run.

(ii) the logarithm of the real dividend growth rate, i.e.,

$$g^d_{t,t+1} \equiv \ln\left(\frac{d_{t+1}}{d_t}\right),$$

and (iii) the difference in the logarithm of the price-dividend ratios from time t to $t+1$, i.e.,

$$\Delta(q_{t+1}/d_{t+1}) \equiv \left\{\ln\left(\frac{q_{t+1}}{d_{t+1}}+1\right) - \ln\left(\frac{q_t}{d_t}\right)\right\}.$$

Taking expectations of both sides of equation (3), and assuming agents process information rationally,

$$\mathrm{E}_t[\ln(R_{t,t+1})] = \mathrm{E}_t[\pi_{t,t+1}] + \mathrm{E}_t\left[g^d_{t,t+1}\right] + \mathrm{E}_t[\Delta(q_{t+1}/d_{t+1})]. \tag{4}$$

Equation (4) provides a general expression for expected stock returns in terms of expected inflation and real variables reflecting fundamentals of the underlying stock. In the Fisherian setting, these real variables—real dividend growth and the difference in real price-dividend ratios—have no causal relation with inflation. Thus, the Fisher model holds in this environment.

To see this via a particular example, consider the aforementioned nominal Lucas-type (1978) economy in which money is neutral. The price level serves as a unit of account, so that agents do not have a preference for money or face cash-in-advance constraints. Moreover, although possibly correlated, consumption growth and inflation are not causally related.[6] The representative agent's first-order condition from this model is given by:

$$\mathrm{E}_t\left[B\frac{U'(c_{t+1})p_t}{U'(c_t)p_{t+1}}(1+R^i_{t,t+1})\right] = 1 \quad \forall i$$

where

$U(\cdot)$ = the representative agent's utility function
B = the rate of time preference.

For purposes of illustration, assume that the representative agent has preferences with constant relative risk aversion. Under this assumption, it is possible to derive the real price-dividend ratio for a particular asset i:

$$\frac{q_{i,t}}{d_{i,t}} = \sum_{k=1}^{\infty} \mathrm{E}_t\left[B^k\left(\frac{c_{t+k}}{c_t}\right)^{-\gamma}\left(\frac{d_{i,t+k}}{d_{i,t}}\right)\right], \tag{5}$$

where γ is the coefficient of relative risk aversion. Since the above real price-dividend ratio depends only on comovements of real variables, and these variables are not causally related to inflation, the Fisher model holds.

[6] Note that in the reduced form, consumption growth and inflation may be modeled as a vector autoregression, but this apparent functional relation is used only as a convenient representation of the time-series properties of the two series rather than as a statement about economic linkages (see Boudoukh (1993)).

If money neutrality is a good approximation of reality, as many researchers believe (especially at long time horizons), then why does the Fisher model appear to do so poorly in the data? That is, why, in complete contrast to the model in equation (1), are stock returns and expected inflation negatively correlated? The answer to this question does not necessarily rely on dropping the assumption that the real and monetary sectors are causally independent.

In particular, by regressing stock returns on expected inflation, the coefficient on expected inflation will not necessarily equal the Fisher model's value of one. This is because expected inflation may be partly proxying for expectations about future real rates. Specifically,

$$\begin{aligned}\beta &= \frac{\mathrm{cov}(\ln(R_{t,t+1}), \mathrm{E}_t[\pi_{t,t+1}])}{\mathrm{var}(\mathrm{E}_t[\pi_{t,t+1}])} \\ &= \frac{\mathrm{cov}\big(\mathrm{E}_t[\pi_{t,t+1}] + \mathrm{E}_t\big[g^d_{t,t+1}\big] + \mathrm{E}_t[\Delta(q_{t+1}/d_{t+1})] + \epsilon_{t+1}, \mathrm{E}_t[\pi_{t,t+1}]\big)}{\mathrm{var}(\mathrm{E}_t[\pi_{t,t+1}])} \\ &= 1 + \frac{\mathrm{cov}\big(\mathrm{E}_t\big[g^d_{t,t+1}\big] + \mathrm{E}_t[\Delta(q_{t+1}/d_{t+1})], \mathrm{E}_t[\pi_{t,t+1}]\big)}{\mathrm{var}(\mathrm{E}_t[\pi_{t,t+1}])}. \qquad (6)\end{aligned}$$

The coefficient equals the hypothesized value of one plus an adjustment factor due to the covariance between expected inflation and expected future values of real variables—in particular, expectations about future dividend growth rates and price-dividend ratios. As described above, these correlations are not necessarily zero in a money-neutral setting.

Several observations are in order. First, if these covariances are sufficiently negative, then negative β coefficients are possible. Thus, previously documented negative β estimates may be consistent with the Fisher model. Second, the magnitude of the second term in equation (6) depends on (i) the stock's own dividend growth, and (ii) the change in its price-dividend ratio through time. Since these will, in general, vary across assets, it becomes apparent how cross-sectional variation in the β coefficients can arise. Third, equation (6) holds for all horizons. This is important because equation (6) can potentially explain the apparent contradictory results for stock returns and inflation at short and long horizons (see Boudoukh and Richardson (1993)). In particular, if dividend growth, changes in the price-dividend ratio, and inflation are not i.i.d., then long-horizon betas can differ substantially from short-horizon betas. All these issues are explored in more detail below for a particular approximation of equation (6).

B. Empirical Implications

B.1. The Negative Relation Between Stock Returns and Expected Inflation

Note that the regression coefficient in equation (6) depends on the specific model used to derive price-dividend ratios. In order to avoid describing a specific model for asset prices, we consider an approximation of the coefficient in equation (6). Specifically, if expectations of changes in real price-dividend ratios do not vary much over time, i.e., $\mathrm{E}_t(\Delta(q_{t+1}/d_{t+1})] \approx k$, then equation (6) reduces to

$$\begin{aligned}\beta &\approx 1 + \frac{\operatorname{cov}\left(\mathrm{E}_t\left[g^d_{t,t+1}\right], \mathrm{E}_t[\pi_{t,t+1}]\right)}{\operatorname{var}(\mathrm{E}_t[\pi_{t,t+1}])} \\ &\equiv 1 + \frac{\rho_{g\pi}\sigma_g}{\sigma_\pi},\end{aligned} \tag{7}$$

where $\rho_{g\pi}$ denotes the unconditional correlation between conditional expectations of dividend growth and inflation, σ_g denotes the standard deviation of expected output growth, and σ_π denotes the standard deviation of expected inflation. Equation (7) shows that the coefficient describing the relation between stock returns and expected inflation differs from unity depending on the correlation between that stock's expected dividend growth rate and the overall expected inflation rate in the economy.

If expected future *real* dividend growth and expected inflation are negatively correlated, then the coefficient, β, is less than one. Moreover, if $\rho_{g\pi} < -\sigma_\pi/\sigma_g$, then the coefficient on expected inflation is negative. Note that, within these models, dividend policy is irrelevant, so that there is no theoretical distinction between real cash flows and real dividends. That is, the true real value of the asset reflects its future real cash flow (or in this case real dividends). Dividend smoothing aside, then, it is possible that the volatility of the expected growth rate in cash flows will dominate the volatility of expected inflation. This being the case, it is clear why coefficients on expected inflation can be negative. This is true even if inflation has no real effect on asset prices.

B.2. Cross-sectional Variation in Expected Inflation Betas

With respect to the estimated coefficients, the βs will vary across assets, depending on (i) the correlation between the asset's expected dividend growth and expected inflation, and (ii) the asset's own volatility of expected dividend growth. There are strong reasons to believe that these population moments will vary across stocks in different industries. For example, some industries (such as those involved in the manufacturing of durable goods) are highly procyclical, while others (such as those that provide necessities) are much less so. To the extent that expected inflation is correlated with the aggregate economy, the correlation $\rho_{g\pi}$ should vary across cyclical and noncyclical industries. Further, the magnitude of this effect should depend upon the variability of expected growth rates of future cash flows, which will also depend on the characteristics of the industry.

B.3. Long Horizons versus Short Horizons

A natural question to ask is whether this model can explain the differences between the short-horizon and long-horizon relations between stock returns and inflation (e.g., Boudoukh and Richardson (1993)). It is possible to show that the counterpart to equation (7) for long-horizon regressions is

$$\beta_J \approx 1 + \frac{\operatorname{cov}\left(\mathrm{E}_t\left[g^d_{t,t+J}\right], \mathrm{E}_t[\pi_{t,t+J}]\right)}{\operatorname{var}(\mathrm{E}_t[\pi_{t,t+J}])}. \tag{8}$$

Over the course of the business cycle (that is, over a long horizon), we might expect the second term in equation (8) to diminish, leading to a β_J coefficient closer to one. To see this, note that the second term can be expressed as the product of (i) the multiperiod correlation between expected dividend growth and expected inflation, and (ii) the ratio of these variables' standard deviations. If business cycles can be described by autoregressive cash flow growth and inflation rates, then the multiperiod correlation will get *relatively* smaller as the horizon increases. Furthermore, since cash flow growth tends to be less autoregressive than the inflation rate (see Boudoukh (1993)), the ratio of standard deviations also declines. Boudoukh and Richardson (1993) find that, in contrast to the short-horizon evidence, aggregate stock returns and expected inflation are positively correlated at long horizons. Within the industry setting of this article, we provide additional evidence of this phenomenon in the next section.

III. Industry Returns and Expected Inflation: Empirical Evidence

The empirical evidence in the literature is concerned almost exclusively with the relation between the *aggregate* stock market and inflation, usually over relatively short horizons. Very little is known about either the cross-sectional variation in this relation across stocks or the extent to which it is horizon dependent.[7] This is unfortunate because many of the existing theories have implications both for cross-sectional variation in the relation between inflation and stock returns and for how this relation may vary with the time horizon. In particular, the empirical implications from a money-neutral model in which the Fisher model holds are discussed in the previous section.

In the context of cross-sectional variation, it is natural to study portfolios of industry-sorted stocks. At an intuitive level, it is clear that aggregate output will have different joint distributional properties with output of different

[7] Bernard (1986) does investigate the effects of nominal contracting on firm value by examining cross-sectional variation in the relation between stock returns and unanticipated inflation. He shows that in regressions of industry stock returns on various factors, the coefficient on the product of the average market beta of the firms within the industry and unanticipated inflation is significantly negative. This result is consistent with the proxy hypothesis of Fama (1981) and the results presented in this article. Other articles also perform cross-sectional estimation for a variety of assets (other than stocks). For example, Fama and Schwert (1977) perform their analysis on different bonds, real estate, and the aggregate stock market. In addition, Boudoukh and Richardson (1993), Gultekin (1983), and Kaul (1987) look at the relation between stock returns and inflation for different countries. Boudoukh and Richardson (1993) also examine the relation at different horizons.

industries. For example, some industries are less affected by economy-wide changes that take place during business cycles, while others are more affected. Examples of noncyclical industries include Food and Beverage, Tobacco, and Utilities, all of which provide economic "necessities," and therefore are, for the most part, recession proof. In contrast, industries involved in the manufacture of durable goods, such as Nonelectrical Machinery, Electrical Machinery, and Transportation Equipment, are severely impacted by economic downturns.

In Section III.*B*, our attention is devoted to the cross-sectional characteristics of industry outputs and their comovements with aggregate output and inflation. In Sections III.*C* and III.*D*, we investigate the statistical relation between industry-sorted stock returns and expected inflation. We then link the analyses (Section III.*E*), and examine how the relation between industry stock returns and expected inflation varies across horizons (Section III.*F*). First, however, we describe the data and our methodology.

A. Data Description

Stock data come from the monthly CRSP tapes, and only firms trading for any full calendar year in the period 1953 to 1990 are considered. Firms are sorted into industry portfolios at the start of a calendar year according to their two-digit Standard Industry Classification (SIC) code. Industry portfolio returns are the equally weighted average of the individual firms' returns within the portfolio. We confine our attention to industries for which there exists a matching series of industrial production data. Monthly real industrial production data are taken from Statistical Release G12.3 of the Board of Governors of the Federal Reserve System (recorded by Citibase, Chapter VI), for the period 1952 to 1990. The data are monthly and seasonally adjusted, and they cover durable and nondurable manufacturing, as well as utilities and mining. In total, there are 22 industry portfolios, all of which correspond to a single two-digit SIC code, with the exception of Mining.

Industrial production is chosen as our measure of industry output for a combination of reasons. First, it is reported at a level of detail that allows us to perform a detailed cross-sectional analysis. Alternative measures such as GNP or national income are reported only for durable and nondurable manufacturing, without an industry breakdown. Second, industrial production is a reasonable proxy for the theoretical construct called "dividends" in our model. Industrial production is also a better measure of output than individual firms' earnings, dividends, or other accounting measures that can be found on COMPUSTAT. The analysis is performed using aggregated quarterly and annual returns and industrial production data. Aggregation to a quarterly frequency represents, in our view, the best tradeoff between sample size and sampling problems. In analyzing the data at the annual frequency, we employ overlapping data.

The empirical work in this article employs measures of expected output growth. Thus, it is necessary to model expected industrial production growth for each industry. It is fairly common in finance to describe movements of industrial production via lagged values (see, for example, Chen (1991)). Therefore, we model expected industrial production growth as a function of one lag of that industry's industrial production growth, and one lag of aggregate industrial production growth. To coincide with this structure, we assume that aggregate output follows a first-order autoregressive process.

The analysis performed in this article also requires a proxy for expected inflation. In the financial economics literature, expected inflation is measured in numerous ways. We choose a stylized model for expected inflation, which combines known time-series properties of inflation (e.g., inflation is highly autocorrelated), with the information that can be obtained from nominal interest rates (see Fama (1975)). In particular, expected inflation is estimated from an ordinary least squares (OLS) regression of the current inflation rate on past inflation and current interest rates (of the appropriate maturity). Note that the estimation is always performed jointly with the other regression equations that use the expected inflation measure. Our results are insensitive to the particular model for expected inflation. Inflation data are calculated using the consumer price index, and interest rates are taken from the Fama and Fama-Bliss CRSP bond files.

B. Industry Output and Inflation: Cross-sectional Evidence

As a first look at cross-sectional differences in the industry data, Table I documents the correlation of output growth in each industry with both aggregate output growth and inflation. There is substantial variation in these correlations across industries. In particular, the industrial production growth rates of some industries have relatively low correlations with aggregate industrial production growth; Food and Beverage, Tobacco, and Utilities have correlations of 0.33, 0.11, and 0.36 with aggregate industrial production growth. These industries are often considered noncyclical in nature, and this characterization seems to be confirmed by the small comovement of their output growth with aggregate output growth. In contrast, the outputs of other industries tend to move much more closely with aggregate output. As a representative sample, consider the industries Nonelectrical Machinery, Electrical Machinery, and Transportation Equipment. These durable equipment-based industries tend to move with the aggregate economy and their correlations with aggregate output growth are relatively high—namely, 0.71, 0.80, and 0.75, respectively.

As additional evidence of the cyclicality of particular industries, Table I also presents a related measure—the aggregate output growth beta for each industry. This beta is defined as the coefficient from a regression of the industry's output growth on aggregate output growth. There is substantial variation in these betas across industries, ranging from a low of 0.17 for both Food and Beverage and Tobacco to highs of 1.84 and 2.89 for Transportation Equipment and Primary Metals, respectively. Since the standard errors

Table I

Correlation Between Industrial Output Growth and the Overall Economy

This table provides evidence of the relation between production growth in each industry and aggregate output growth and inflation. In particular, the correlation between the growth of industrial production for twenty-two industries and the growth of aggregate industrial production; the correlation between these industries' production growth and inflation; and each industry's output growth beta (i.e., the coefficient from the regression of industry output growth on aggregate output growth) are provided. The sample covers quarterly data over the 1953 to 1990 period.

	Aggregate Output		Aggregate Output		Inflation	
Industry	Beta	(Std. Error)	Corr.	(Std. Error)	Corr.	(Std. Error)
Food and Beverage	0.171	(0.052)	0.333	(0.080)	−0.124	(0.093)
Tobacco	0.174	(0.134)	0.114	(0.082)	0.009	(0.076)
Utilities	0.310	(0.054)	0.360	(0.051)	−0.273	(0.077)
Printing and Publishing	0.387	(0.049)	0.564	(0.065)	−0.212	(0.069)
Petroleum Products	0.407	(0.088)	0.382	(0.067)	−0.206	(0.102)
Leather	0.564	(0.094)	0.395	(0.060)	−0.114	(0.091)
Instruments	0.637	(0.061)	0.699	(0.053)	−0.038	(0.071)
Mining	0.654	(0.134)	0.521	(0.074)	0.070	(0.095)
Lumber	0.712	(0.186)	0.377	(0.073)	−0.250	(0.087)
Apparel	0.742	(0.136)	0.620	(0.078)	−0.122	(0.083)
Paper	0.779	(0.123)	0.690	(0.059)	−0.196	(0.084)
Chemicals	0.796	(0.080)	0.792	(0.040)	−0.258	(0.073)
Miscellaneous Manufacturing	0.865	(0.092)	0.682	(0.048)	−0.227	(0.078)
Clay, Glass, and Stone	0.949	(0.086)	0.739	(0.044)	−0.230	(0.072)
Furniture	0.976	(0.105)	0.747	(0.051)	−0.223	(0.075)
Textiles	0.991	(0.128)	0.615	(0.078)	−0.145	(0.083)
Nonelectrical Machinery	1.036	(0.104)	0.708	(0.051)	0.044	(0.073)
Electrical Machinery	1.124	(0.090)	0.802	(0.049)	−0.095	(0.076)
Metal Products	1.236	(0.051)	0.917	(0.019)	−0.164	(0.081)
Rubber and Plastics	1.272	(0.198)	0.649	(0.093)	−0.208	(0.079)
Transportation Equipment	1.844	(0.142)	0.746	(0.047)	−0.156	(0.077)
Primary Metals	2.894	(0.343)	0.763	(0.034)	−0.063	(0.082)

around these estimates are fairly tight, Table I provides strong evidence of variation across industries.

With respect to other cross-sectional features of the data, Table I provides the contemporaneous correlation between the output growth of each industry and inflation. Inflation is, for the most part, negatively correlated with output growth industry-by-industry. For example, nineteen of the twenty-two industries presented in Table I have output growth that is negatively correlated with inflation. While the correlation is not large, the magnitudes are often more negative than -0.20. In contrast to industry correlations with aggregate output growth, there is less of a pattern with respect to inflation. If anything, the cyclical industries tend to be more negatively correlated.

Consistent with the arguments in Section II, the results in this section demonstrate the potential source of cross-sectional variation in the relation between stock returns and inflation across industries.

C. Industry Returns and Inflation: Cross-sectional Evidence

Table II provides results for regressions of stock returns (of different industries) on expected inflation, using the regression model given in equation (1). The regressions for all industries are performed jointly using the generalized method of moments. Hence we obtain a heteroskedasticity-consistent covariance matrix of the regression coefficients. There is substantial cross-sectional variation in the betas across industries. Of particular interest, the variation coincides closely with our earlier intuition. Noncyclical industries, such as Food and Beverage, Tobacco, and Utilities, have either positive or small negative coefficients. In contrast, cyclical industries, such as

Table II

The Relation Between Industry Portfolio Returns and Expected and Unexpected Inflation

The table reports each industry's expected and unexpected inflation beta (i.e., the coefficient from the regression of industry returns on expected and unexpected inflation) and the corresponding standard errors. The sample covers quarterly data over the 1953 to 1990 period. Expected inflation is based on a time-series model using past inflation and the current risk-free rate. All estimation is performed jointly, and the standard errors are adjusted for heteroskedasticity.

	Expected Inflation		Unexpected Inflation	
Industry	Beta	(Std. Error)	Beta	(Std. Error)
Tobacco	0.910	(1.186)	−4.300	(1.271)
Food and Beverage	0.044	(1.260)	−4.421	(1.390)
Utilities	−0.209	(1.086)	−3.161	(0.820)
Leather	−0.520	(1.504)	−4.539	(1.875)
Printing and Publishing	−0.580	(1.414)	−4.707	(1.701)
Petroleum Products	−0.629	(1.246)	−0.218	(1.488)
Furniture	−0.639	(1.487)	−4.821	(1.967)
Chemical	−0.674	(1.191)	−3.639	(1.503)
Metal Products	−0.791	(1.381)	−3.407	(1.666)
Mining	−0.868	(1.669)	1.677	(1.794)
Instruments	−1.026	(1.552)	−4.193	(1.910)
Electrical Machinery	−1.123	(1.627)	−4.648	(1.995)
Paper	−1.128	(1.270)	−4.329	(1.660)
Clay, Glass, and Stone	−1.176	(1.429)	−3.897	(1.760)
Primary Metals	−1.186	(1.295)	−2.207	(1.591)
Miscellaneous Manufacturing	−1.299	(1.637)	−5.599	(2.005)
Rubber and Plastics	−1.309	(1.514)	−4.129	(1.894)
Textiles	−1.393	(1.528)	−5.902	(1.919)
Transportation Equipment	−1.447	(1.466)	−4.919	(1.856)
Apparel	−1.457	(1.618)	−5.270	(2.017)
Nonelectrical Machinery	−1.582	(1.432)	−3.548	(1.817)
Lumber	−1.903	(2.265)	−5.789	(2.453)

those involving durable goods (e.g., Machinery and Equipment industries) and manufacturing (e.g., Metal Products and Petroleum Products), all have negative coefficients. For example, the Tobacco industry has a β coefficient of 0.91 versus a coefficient of -1.45 for the Transportation Equipment industry.

For comparability with earlier studies, Table II also provides coefficient estimates from multivariate regressions of industry returns on expected and unexpected inflation. Unexpected inflation is proxied for by the residual series from the estimation of expected inflation. Since this series is orthogonal to the expected inflation series by construction, the coefficients on expected inflation are identical to those found in a univariate regression. In the context of the theoretical model presented in Section II, unexpected inflation will be related to stock returns due to the Fisher effect and to the extent that shocks to inflation influence expectations of future real economic activity. In other words, given that inflation is negatively related to future economic activity, a positive shock to inflation may lead to a decrease in stock prices. This effect is apparent in the 21 negative coefficients (out of 22 industries) in Table II. The only clear pattern in the results is that stock returns of industries that produce raw materials (e.g., Petroleum Products, Mining, and, to a lesser extent, Primary Metals) have a less negative reaction to unexpected inflation than other industries.

A quick glance at Tables I and II shows that the ordering of the industries' output growth betas (i.e., output on aggregate output growth) and expected inflation betas (i.e., returns on expected inflation) are remarkably similar. As an informal test of this link, we regress the expected inflation betas of each industry on their corresponding output betas. The coefficient from this regression equals -0.49 (with a corresponding t-statistic of -2.61). This result provides further support for the inverse relation between cyclicality and expected inflation betas.

While the betas are quite different, the cross-correlations between the β estimates of the industries (obtained from the estimated covariance matrix) are large. In particular, over 75 percent of the 231 pair-wise correlations between the beta estimates of the twenty-two industries exceed 0.80. Furthermore, only 5 percent of these correlation estimates lie below 0.60. As an illustration, Table III, Panel A provides the correlation among the β coefficients for the six industries described earlier: Food and Beverage, Tobacco, Utilities, Nonelectrical Machinery, Electrical Machinery, and Transportation Equipment. Even though the noncyclical industries and cyclical industries have very different β coefficients, the correlations between their β estimates range from 0.57 to 0.87. This fact is especially important for interpreting the cross-sectional variation of these coefficients across industries.

At first glance, a survey of the expected inflation betas in Table II is somewhat unappealing. That is, while the expected inflation betas exhibit a pattern consistent with variation in output cyclicality across industries, the standard errors appear too large to identify statistically significant cross-sectional variation in the betas. However, combining the large cross-sectional differences with the high correlation among the estimates imposes sharp

Table III

Tests for Cross-sectional Variation of the Relation Between Stock Returns and Expected Inflation

This table provides statistical tests of cross-sectional variation of stock returns and expected inflation for representative industries (chosen ex ante on the basis of their cyclicality with the economy), as well as the cross-correlation of returns. Specifically, we look at differences between noncyclical industries (e.g., Food and Beverage, Tobacco, and Utilities) and cyclical industries (e.g., Nonelectrical Machinery, Electrical Machinery, and Transportation Equipment). The correlations between the beta estimates (from Table II) are provided, as well as joint tests of the hypothesis that (i) the coefficients are equal, (ii) the average cyclical and noncyclical coefficients are equal, and (iii) the coefficients within both cyclical and noncyclical industries are equal, respectively.

Panel A: Correlation Matrix of Beta Estimates

	Food	Tobacco	Utilities	Nonelectrical Mach.	Electrical Mach.	Transportation Equip.
Food	1	0.902	0.862	0.871	0.853	0.824
Tobacco	0.902	1	0.749	0.768	0.766	0.757
Utilities	0.862	0.749	1	0.660	0.638	0.573
Nonelectrical Mach.	0.871	0.768	0.660	1	0.963	0.932
Electrical Mach.	0.853	0.766	0.638	0.963	1	0.948
Transportation Equip.	0.824	0.757	0.573	0.932	0.948	1

Panel B: Statistical Tests

Type of Test	Statistic	P-Value
All coefficients equal	$\chi_5^2 = 10.932$	(0.053)
Noncyclical coefficients equal	$\chi_2^2 = 2.772$	(0.250)
Cyclical coefficients equal	$\chi_2^2 = 1.058$	(0.589)
Average noncyclical equals average cyclical coefficient	$\chi_1^2 = 3.465$	(0.063)

Panel C: Correlation Matrix of Realized Returns

	Food	Tobacco	Utilities	Nonelectrical Mach.	Electrical Mach.	Transportation Equip.
Food	1	0.838	0.785	0.883	0.872	0.889
Tobacco	0.838	1	0.663	0.707	0.708	0.729
Utilities	0.785	0.663	1	0.637	0.627	0.637
Nonelectrical Mach.	0.883	0.707	0.637	1	0.958	0.951
Electrical Mach.	0.872	0.708	0.627	0.958	1	0.956
Transportation Equip.	0.889	0.729	0.637	0.951	0.956	1

restrictions on the data. Therefore, we are able to provide reliable evidence of cross-sectional variation in the β coefficients, in spite of the fact that the estimates have large standard errors (see Table III, Panel B).

To see this, consider testing the null hypothesis $\beta_i = \beta_j$ using the regression model in equation (1). If stock returns are conditionally homoskedastic, then it is possible to show that the difference between the OLS estimates, $\hat{\beta}_i$

and $\hat{\beta}_j$, is asymptotically distributed under the null as:

$$\sqrt{T}\left(\hat{\beta}_i - \hat{\beta}_j\right) \sim N\left(0, \frac{1}{\sigma_\pi^2}\left(\sigma_{\epsilon_i}^2 + \sigma_{\epsilon_j}^2 - 2\rho_{\epsilon_i\epsilon_j}\sigma_{\epsilon_i}\sigma_{\epsilon_j}\right)\right), \tag{9}$$

where $\rho_{\epsilon_i\epsilon_j}$ is the cross-correlation between industry i's and industry j's returns (net of the expected inflation component), and σ_{ϵ_i} is the volatility of industry i's return (net of expected inflation). Assuming that these volatilities are equal across industries, the asymptotic variance of $(\hat{\beta}_i - \hat{\beta}_j)$ in equation (9) reduces to

$$2\left(\frac{\sigma_\epsilon^2}{\sigma_\pi^2}\right)\left(1 - \rho_{\epsilon_i\epsilon_j}\right). \tag{10}$$

There are two components to the variance in equation (10). The first component reflects the individual standard errors of the $\hat{\beta}$ estimates. To the extent these are high in Table II, there is less chance of identifying cross-sectional variation in the coefficients across industries. The second component, however, reflects the cross-correlation across industry return regression errors. If the cross-correlation is high, then, even with large standard errors, it is possible to differentiate the beta coefficients. The intuition is as follows: can sampling error (as evidenced by the large standard errors) be the cause of the divergence between the empirical estimates? If asset returns are highly correlated (and this correlation is not being driven by expected inflation), then we should expect to find common sampling error in the estimates. Therefore, in the presence of highly cross-correlated asset returns, deviations in the estimates cross-sectionally are most probably not due to common sampling error, but rather due to violations of the null hypothesis.

As an example, using the six aforementioned industries (which were picked a priori), we test various characteristics of the cross-sectional relation between the betas of the cyclical and noncyclical industries. As a summary of the evidence presented in Table III, Panel B, three observations are made. First, the Wald statistic that all six β coefficients are the same equals 10.93. With a corresponding asymptotic χ_5^2 distribution, this statistic represents a p-value of 5.3 percent. The high value of the Wald statistic is due to the high correlation between the estimates; for example, the correlation between the expected inflation beta estimate for Food and Beverage versus Electrical Machinery is 0.85. Underlying these results are the actual cross-correlations across asset returns (due to comovements at, for example, the market level). These are provided in Table III, Panel C and demonstrate the importance of taking into account cross-correlation in trying to analyze cross-sectional variation in the expected inflation betas.

Second, the joint test that the average β coefficient of the noncyclical industries is greater than that of the cyclical industries is significant at the 3.15 percent level. Equivalently, for a two-sided test (i.e., one without priors on the betas of the industries), the p-value is 6.3 percent.

Third, within the particular subgroup of industries chosen (i.e., cyclical versus noncyclical), the data is too noisy to differentiate the beta coefficients. Specifically, Wald tests (with χ_2^2 distributions) that the coefficients are equal within a subgroup of noncyclical and cyclical industries are 2.77 and 1.06, with corresponding p-values of 25 and 59 percent, respectively. Given Tables I and II, the latter result should come as no surprise, since most industries are cyclical and thus the beta coefficients are of similar magnitude.

D. Industry Returns and Inflation: Prewar Evidence

Kaul's (1987) results regarding a reversal of the negative relation between expected inflation and stock returns in the prewar period warrant extending our analysis to this time period. Quarterly data on industry stock returns and inflation were obtained for the period 1926 to 1940. Following Kaul (1987), we use the cost of living index from the Survey of Current Business and model inflation as an integrated moving average of order (1, 1).[8]

We find that noncyclical industries no longer have higher expected inflation betas than cyclical industries in a regression of stock returns on fitted expected inflation (equation (1)). This result coincides with the predictions of our model to the extent that output and inflation are not negatively related in the prewar period. For example, the β coefficients are -2.80 for Food, -1.40 for Tobacco, and -0.04 for Utilities (the noncyclical industries), and 0.41 for Machinery and -1.48 for Transportation Equipment (the cyclical industries). There is no apparent pattern or ordering in the coefficients of other industries. The estimates are widely varied and generally quite negative; however, the standard errors are too large to make reasonable inferences. The corresponding standard errors for the results quoted above are 2.19, 1.90, 2.57, 2.98, and 3.37, respectively. The standard errors are large for two reasons. First, the explanatory power for inflation is very low during this period. Second, the sample size is somewhat limited, with a total of 60 quarterly observations. Therefore, we have little confidence in the point estimates, although the results are broadly consistent with the theory.

E. The Cross-sectional Relation Between Output and Inflation Revisited

In a representative agent production economy with constant returns to scale, dividend growth and output growth are synonymous (see, for example, Cochrane (1991)). Therefore, consider replacing dividend growth for each industry by its output growth in equation (7). We choose to do this substitution for two reasons. First, dividend growth is at the discretion of managers and, thus, may not represent actual cash flows generated from year to year. Although cash flow estimates are not readily available, output figures are widely available and presumably capture most of the variation in cash flows. Second, output growth fits into the analysis here because it can be related to

[8] The results that follow are qualitatively similar to those obtained using consumer price index data and a variety of models for inflation.

aggregate output and inflation, as is done in Section III.*B*. Existing evidence suggests that a negative correlation between inflation and output growth does, in fact, exist (see Table I for industry-by-industry results and Fama (1981) for economy-wide results). Given this observation, it follows that different assets will exhibit a different relation between stock returns and expected inflation. Tables II and III demonstrate exactly this phenomenon for industry portfolios. The question we want to ask is whether, when we calculate the coefficient in equation (7) using industry output data, the results are consistent with the regressions of returns on expected inflation.

While the evidence in Table I is suggestive of such a relation, the correlations in that table only describe estimates of ex post comovements of output growth and inflation. To coincide with equation (7), Table IV provides estimates of the correlations between expected output growth and expected inflation. The estimates of these correlations generally coincide with those given in Table I. For example, consider the Utilities, Food and Beverage, and Tobacco industries in comparison with the Nonelectrical Machinery, Electrical Machinery, and Transportation Equipment industries. The correlations between expected output growth and expected inflation for the noncyclical industries are 0.08, -0.04, and 0.02 in comparison with -0.00, -0.11, and -0.10 for the cyclical industries. Therefore, in terms of the effect on the regression coefficient β in equation (1), more cyclical industries (such as durables, construction, leisure,...) should show a larger impact than less cyclical industries (such as Food and Beverage, Utilities,...).

To show this, Table IV provides the *implied* coefficients using the approximation in equation (7). While the implied coefficients are much higher than the estimated coefficients in Table II, the overall pattern in the coefficients across industries is similar. Specifically, while most of the betas of the cyclical industries vary from 0.5 to 0.8, the noncyclical industries have coefficients closer to one. For example, noncyclical industries such as Utilities, Food and Beverage, and Tobacco have implied βs of 1.02, 0.99, and 1.04 versus 0.97, 0.71, and 0.68 for cyclical industries such as Nonelectrical Machinery, Electrical Machinery, and Transportation Equipment. As an informal test of the overall relation between the implied βs from Table IV and the actual βs from Table II, we calculate the cross-sectional correlation between the two sets of coefficient estimates. For the 22 industry portfolios, these estimates have a correlation of 0.37. This result suggests that, while the actual and implied coefficients are not perfectly aligned, they are positively related as the theory suggests.

Nevertheless, the differences in magnitudes between the estimated and implied beta coefficients indicate that the approximation in equation (7) falls short of a complete explanation. Even within the money-neutral setting, there are several possible reasons why the magnitudes of the implied coefficients may not correspond to the estimated coefficients. First, our measures of expected output growth and expected inflation are subject to misspecification. Second, the industrial production data only approximately measure true output. Third, the result in equation (7) assumes that expected price-dividend

Table IV

The Relation Between Stock Returns and Expected Inflation: Implications of the Fisher Model

This table provides evidence of the theoretical relation between stock returns and expected inflation, as implied by an approximation of the Fisher model. The implied betas (i.e., analytical coefficients from the theoretical regression of industry stock returns on expected inflation under the null hypothesis of the Fisher model) are given in column 4. Also provided in the table are estimates of the relation between expected output in each industry and expected aggregate output and expected inflation. In particular, the correlation between the expected growth of industrial production for twenty-two industries and the expected growth of aggregate industrial production, and the correlation between these industries' expected production growth and expected inflation are provided. Expected inflation is based on a time-series model using past inflation and the current risk-free rate, while expected production growth is modeled as a function of lagged own production growth and lagged aggregate production growth. All estimation is performed jointly. The sample covers quarterly data over the 1953 to 1990 period.

Industry	Expected Aggregate Output Correlation	Expected Inflation Correlation	Fisher Model Implied Beta
Tobacco	−0.232	0.020	1.037
Petroleum Products	0.645	0.037	1.026
Utilities	0.738	0.076	1.022
Food and Beverage	0.624	−0.039	0.985
Nonelectrical Machinery	0.877	−0.009	0.971
Lumber	−0.477	−0.081	0.939
Leather	0.084	−0.101	0.885
Apparel	0.770	−0.142	0.882
Printing and Publishing	0.916	−0.192	0.849
Textiles	0.151	−0.088	0.798
Rubber and Plastics	0.999	−0.150	0.780
Instruments	0.960	−0.131	0.769
Mining	0.708	−0.211	0.726
Paper	0.703	−0.197	0.730
Electrical Machinery	0.908	−0.113	0.711
Metal Products	0.935	−0.121	0.699
Transportation Equipment	0.821	−0.103	0.679
Clay, Glass, and Stone	0.947	−0.205	0.676
Furniture	0.858	−0.214	0.597
Chemical	0.848	−0.277	0.562
Miscellaneous Manufacturing	0.825	−0.228	0.522
Primary Metals	0.698	−0.161	0.493

ratios do not change much through time. There is a growing body of evidence that suggests this may not be the case (see Whitelaw (1994)). Note that changes in price-dividend ratios will reflect expected changes in the infinite sum of all future comovements between individual output growth and aggregate output growth (see equation (5)). Thus, the degree of correlation between industry and aggregate output in Table I may be proxying for changes in price-dividend ratios, which in turn may explain the magnitude of the beta coefficients reported in Table II.

Table V

The Relation Between Industry Portfolio Returns and Expected Inflation: Long-Horizon Evidence

The table reports each industry's expected inflation beta (i.e., the coefficient from the regression of industry returns on expected inflation) and its corresponding standard error using annual data (overlapping quarterly) over the 1953 to 1990 period. Expected inflation is based on a time-series model using past inflation and the current risk-free rate. All estimation is performed jointly, and the standard errors are adjusted for heteroskedasticity and overlapping data.

	Expected Inflation	
Industry	Beta	(Std. Error)
Leather	2.073	(0.897)
Tobacco	1.556	(0.530)
Apparel	1.453	(0.964)
Electrical Machinery	1.323	(0.949)
Furniture	1.285	(0.799)
Instruments	1.139	(0.919)
Food and Beverage	1.025	(0.529)
Rubber and Plastics	1.010	(0.873)
Metal Products	0.971	(0.788)
Transportation Equipment	0.930	(0.826)
Miscellaneous Manufacturing	0.796	(0.811)
Printing and Publishing	0.775	(0.633)
Textiles	0.745	(0.867)
Chemical	0.724	(0.632)
Utilities	0.501	(0.433)
Clay, Glass, and Stone	0.519	(0.783)
Nonelectrical machinery	0.331	(0.931)
Lumber	0.287	(1.221)
Petroleum Products	0.034	(0.939)
Paper	0.015	(0.723)
Mining	−0.067	(1.468)
Primary Metals	−0.227	(0.931)

F. Stock Returns and Expected Inflation at Short and Long Horizons

Recall that in Section II we provide a possible explanation for the differences between the short-horizon and long-horizon relation between stock returns and inflation (see Boudoukh and Richardson (1993)). As complementary evidence, Table V provides estimates of the relation between stock returns and expected inflation using annual data for each industry. As can be seen from a comparison of Table II (i.e., quarterly data) with Table V (i.e., annual data), there is a tendency for the regression coefficients to approach one for longer horizons. For example, the average beta coefficient over the 22 industries is −0.91 for quarterly horizons but 0.77 for annual horizons. As representative industries, note that the Transportation Equipment's beta changes from −1.45 to 0.93, while the Food and Beverage industry's beta changes from 0.04 to 1.02. Such changes in the estimates of beta are typical across the sample of industry portfolios.

IV. Conclusion

In this article, we present a model that is consistent with a money-neutral world and captures many of the salient features of the relation between stock returns and inflation; namely, the negative relation at short horizons, the cross-sectional variation in this relation across industries, and the positive relation at long horizons. These characteristics of the data are consistent with expected inflation rates partly proxying for future real rates. This article has not taken a stand in the debate on whether money is neutral. What role monetary policy has on the real economy, and the issue of whether these effects are *quantifiably important*, remains an open question.

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