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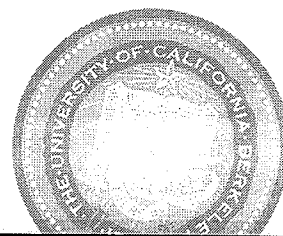
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**CAPITALIZATION OF INFLATION RISK**

**BY**

**YOON DOKKO  
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# Capitalization of Inflation Risk

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## INTRODUCTION

The objective of this note is to discuss how inflation risks are capitalized into asset values and returns. Capitalization is the process by which expected intertemporal cash flows are discounted to determine the present value of the asset. Research in this area focuses on how inflation (and other) risks affect the capitalization (discount) rate through the changes in the required risk premium, the differential between the required rate of return on the asset and the risk-free interest rate.

The quality and quantity of research about inflation risk capitalization vary significantly across asset markets. We will focus on three markets. The market which has received most research attention is the stock market. Bond and real estate markets have been less fully studied.

Our discussion is organized as follows: We commence with a schematic presentation of the intertemporal CAPM, which provides the theoretical paradigm for understanding the capitalization of inflation risks. Second, we discuss the interrelationship among inflation levels, inflation risks and economic activity. The last section focuses on empirical findings about inflation risk capitalization in each of stock, bond and real estate markets.

### MODELING THE RISK PREMIUM AND INFLATION RISK

The intertemporal CAPM developed by Merton (1973), and Cox, Ingersoll and Ross (1986) shows the relationship between the risk premium,  $A$ , and inflation and other risks:

$$A = \gamma\sigma_r^2 + \gamma \sum_i \left( \frac{\partial \log W}{\partial \theta_i} \right) \sigma_{ri} \quad (1)$$

where  $\gamma$  is the Pratt-Arrow measure of relative risk aversion,  $\sigma_r^2$  is the variance of the real asset return,  $W$  is wealth, and  $\sigma_{ri}$  is the covariance between the real asset return and economic state variable  $\theta_i$ . We employ a linear factor model, equation (2), to represent the state-dependent asset return:

$$r = \beta_o + \sum_i \beta_i \theta_i + \varepsilon \quad (2)$$

where  $\beta$ 's are regression coefficients and  $\varepsilon$  is the error term such that  $\sigma(\theta_i, \varepsilon) = 0$  for all  $i$ . We assume further, without loss of generality, that  $\sigma(\theta_i, \theta_j) = 0$  for all  $i \neq j$ . It follows that  $\sigma_r^2 = \sum \beta_i^2 \sigma_i^2 + \sigma_\varepsilon^2$  and  $\sigma_{r,i} = \beta_i \sigma_i^2$ ; where  $\sigma_i^2$  is the variance of  $\theta_i$ . Substituting these expressions for  $\sigma_r^2$  and  $\sigma_{r,i}$  into equation (1) yields

$$A = \gamma \sum_i (\beta_i^2 + w_i \beta_i) \sigma_i^2 + \gamma \sigma_\varepsilon^2 \quad (3)$$

where  $w_i \equiv \partial \log W / \partial \theta_i$ . Using equation (3), the intertemporal CAPM will be indistinguishable from the single period CAPM if  $w_i$  is equal to 0 for all  $i$ . If changes in state variables do not alter wealth, they will not affect the risk premium. However, if changes in state variables affect wealth, using the single period CAPM will not capture fully state variable impacts upon the risk premium.

#### INFLATION LEVELS, INFLATION RISKS, AND ECONOMIC ACTIVITY

In a neoclassical model, inflation is neutral. Inflation affects nominal prices of assets, but not their relative prices. This also implies that neither the risk premium nor real asset returns are affected by the level of inflation. Economists have suspected that inflation levels and inflation risks are closely linked to each other, and it is the latter that affects economic activity.

##### A. Inflation Levels and Risks

Vining and Elwertowski (1976) and Parks (1978), among others, find that higher levels of inflation are closely correlated with wider dispersions of relative price changes. Okun (1971), Logue and Willett (1976), and Pagan, Hall, and Trivedi (1983), among others, find that higher inflation rates tend to be more volatile. In support of this, the studies of the surveys of inflation forecasts, including Carlson (1977), Cukierman and Wachtel (1979), and Zarnowitz and Lambros (1987), find a strong correlation between the level of expected inflation and inflation risk as measured by the variance of inflation forecasts. In contrast, Engle (1983) finds, using monthly data for the 1970s in the U.S., a weak relationship between relatively high inflation rates and the conditional variance of inflation rates. But, Evans (1991) shows that Engle's conditional variance of monthly inflation rates is

a measure of *short term* inflation risk, and *long term* inflation risk is highly correlated with inflation levels.

## B. Inflation Risks and Economic Activity

Lucas (1973), in his pioneering work about the effect of inflation risk on employment and output, suggests that uncertainty about the course of relative prices is a principal determinant of the degree to which unanticipated changes in demand affect economic activity. Friedman (1977) avers in his Nobel laureate lecture, greater inflation risk depresses economic activity because increased inflation risk shortens the average duration of contracts and reduces the efficiency of the price system in allocating resources (by making it more difficult to extract the signal about relative prices from the absolute prices). Cukierman and Wachtel (1979), Mullineaux (1980), Levi and Makin (1980), and Zarnowitz and Lambros (1987) provide empirical support for Friedman's argument. A survey of the firms listed on the New York Stock Exchange (NYSE), conducted by Blume, Friend and Westerfield (1981), finds that inflation risk influences corporate capital budgeting decisions. Corporate managers believe that inflation risk is one of the key factors depressing capital expenditures, and they attribute the adverse effect of inflation risk to increased uncertainty of sales, prices, wages, and the cost of financing.

## INFLATION RISK CAPITALIZATION AND ASSET MARKETS

### A. Stock Market

There are many competing explanations about the observed negative stock return-inflation relation. Since inflation risk adversely affects real economic activity, which should be a principal determinant of the real stock market price, Malkiel (1979), Friend (1981), Dokko (1989), and Dokko and Edelstein (1987, 1991), among others, maintain the position that increased inflation risk, a correlate with a higher inflation level, increases stock market risk and depresses stock prices. This does not necessarily imply a *causal* relationship from inflation to stock prices.

For the 1960–1985 time period, using the intertemporal CAPM with semiannual data of the U.S. stock market, Dokko and Edelstein (1991) demonstrate that inflation and production risks are important determinants

of the required risk premium for common stocks. They find that a 100% increase in inflation or production risk causes the risk premium for common stocks to rise by 1–2%.

Some strains of research claim no relationship between inflation risks and the risk premium. These approaches are fundamentally flawed. For example, Pindyck (1984) argues that when inflation risk increases, the risk premium decreases, and thus the real stock price increases. Pindyck assumes erroneously that production risk is independent of inflation risk. See Dokko and Edelstein's (1991, pp. 14–16) recalculation of Pindyck's data.

Poterba and Summers (1986) contend that since changes in stock market return volatility decay rapidly, risk-induced changes in stock prices are unlikely. This notion is apparently confirmed by French, Schwert and Stambaugh (1987), who find that even though there is a strong positive association between the risk premium and stock return volatility, a 100 percent increase in stock return volatility engenders less than a 1 percent decline in stock prices. These results hinge critically upon the *single* period CAPM, in which stock return volatility is the *only* determinant of the risk premium. In the context of the intertemporal CAPM, Dokko and Edelstein (1991) find that changes in inflation risk are persistent determinants of stock price fluctuations for the 1960–1985 time period.

## B. Bond Market

While many studies have examined the relationship between the real interest rate and expected inflation, relatively few studies have been concerned with the relationship between the real (or nominal) interest rate and inflation risk. Levi and Makin (1979) are the first to introduce inflation risk as an explanatory variable for the real interest rate. In theory, the real interest rate in the bond market is determined by the demand for and the supply of loanable funds. Increased inflation risks reduce corporate capital outlays and thus the demand for loanable funds, thereby decreasing *ceteris paribus* the real interest rate. The effects of increased inflation risks on the supply of loanable funds are unclear. Increased inflation risks (i.e., increased uncertainty about the future) may increase or decrease savings, depending upon the marginal rate of intertemporal substitution for consumption, whereas increased inflation risks will increase the required risk premium for each level of savings, thereby increasing *ceteris paribus* the real



interest rate. Therefore, the effects of inflation risks on the market clearing real interest rate for loanable funds are *a priori* unclear. Levi and Makin (1979), and Bomberger and Frazer (1981) find that increased inflation risks reduce the real interest rate. In contrast, Hoffman and Schlagenhauf (1985) find ambiguous effects of inflation risk on the real interest rate for Canada, United Kingdom, United States, and West Germany.

### C. Real Estate Market

Research about the relationship between real estate returns and inflation has been hampered by significant data limitations. It is folklore that real estate outperforms expected inflation as well as unexpected inflation, the latter being a surrogate for inflation risk. As spokesmen of this position, using appraisal-based real estate value data, Hartzell, Hekman and Miles (1987) find that their "results ... provide strong evidence that diversified portfolios of commercial real estate have been a complete hedge against both expected and unexpected inflation ... (p. 634)." Geltner (1989) and Wheaton and Torto (1989) find that appraisal valuation data may generate biased returns. Attempts to circumvent the use of appraisal data by employing stock market transaction of Real Estate Investment Trusts (REIT) equities are not without pitfalls. REIT equity values may not reflect real estate asset market values because they are closed-end mutual funds that are typically sold at discount, and are subject to federal income tax pass-through provisions by which desired dividends are not likely to be synchronized with cash flows from real estate. More recently, Dokko, Edelstein, Pomer, and Urdang (1991) provide some evidence that real estate need not outperform expected inflation, and unexpected inflation may affect real estate returns. Because real estate is heterogeneous, they find that the impacts of expected inflation and inflation risk on returns depend upon interactions among parcel specific characteristics, local real estate market conditions and the macroeconomic environment.

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